Advanced Imaging:
What is it and What does it mean?

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Disclosure

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What CT Tells Us

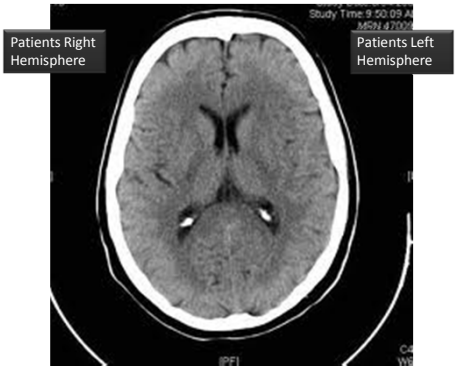
- Is there hemorrhage?
- Are there other causes of symptoms?
- Is there visible infarct?

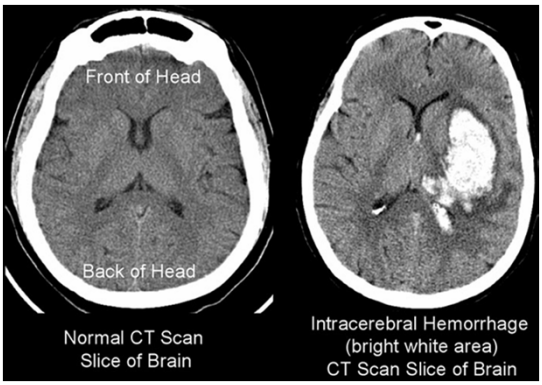
- Does not tell us if the patient is having an acute stroke

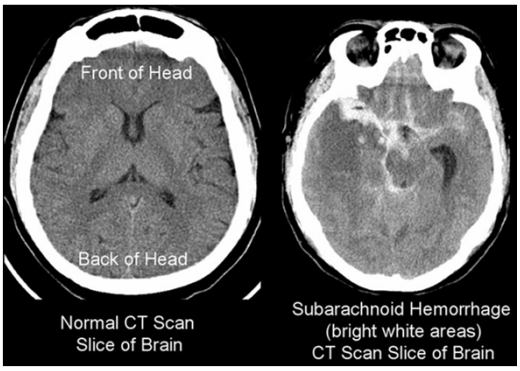
What are we looking at?

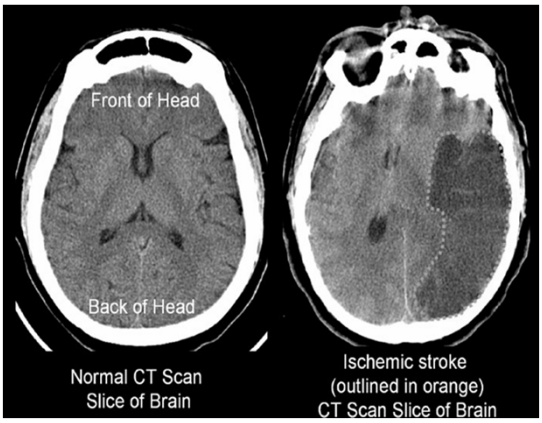
- Old or subacute ischemic tissue - hypodensity or dark
  - Indicates irreversible ischemic brain damage.
- Acute blood - hyperdense or bright
  - Can be seen immediately
- A subarachnoid bleed - diffuse hyperdensity

Left is Right and Right is Left

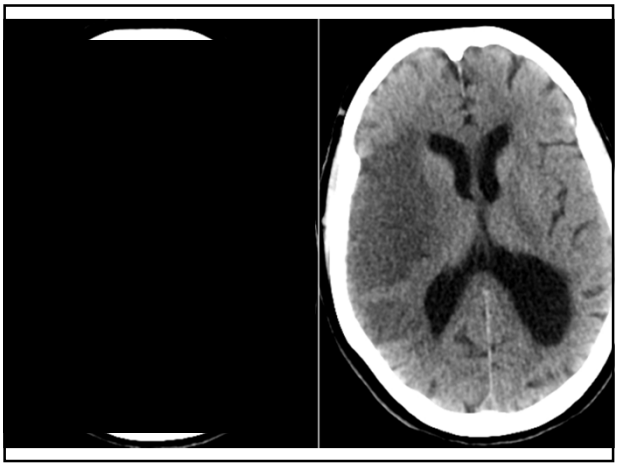


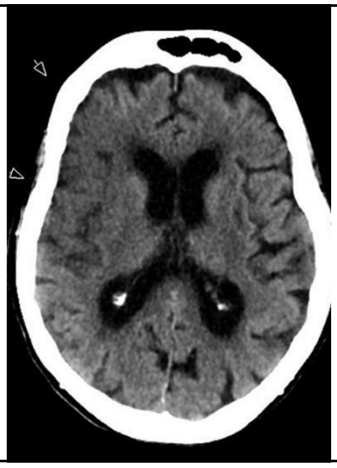




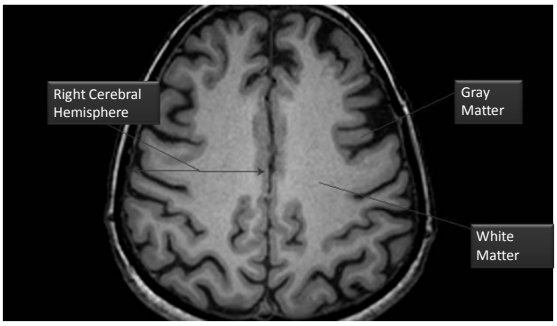


Early signs of ischemia may be seen within the first 6 hours but pronounced hypodensity does not occur till 12 to 24 hours post infarct





Anatomy



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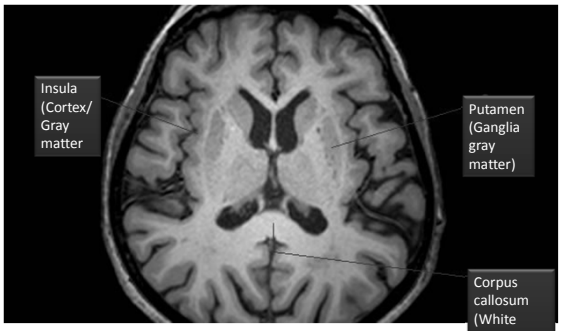
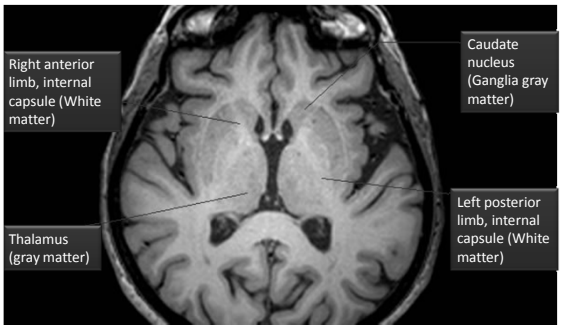
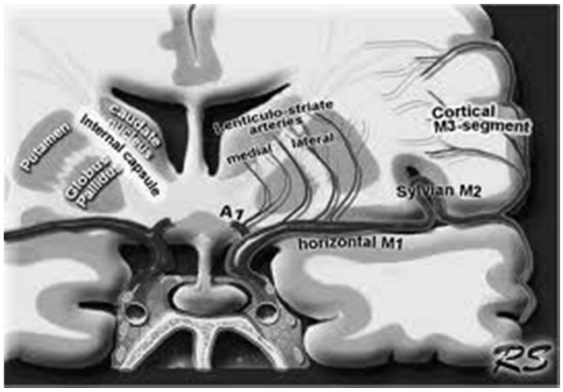


Anatomy



Pathophysiology of Ischemia

An MCA occlusion will cause hypoperfusion of the most distal branches first. These small vessels are known as lenticulostriate branches. This region is very sensitive to ischemia as these branches are end arteries without collateral flow.

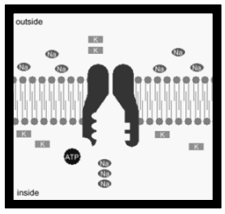


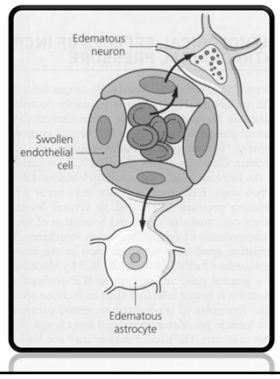
Pathophysiology

Failure of the ion pump during ischemia causes cytotoxic edema leading to sulcal effacement and hypodensity

Edema

Cytotoxic
(cellular ischemia)





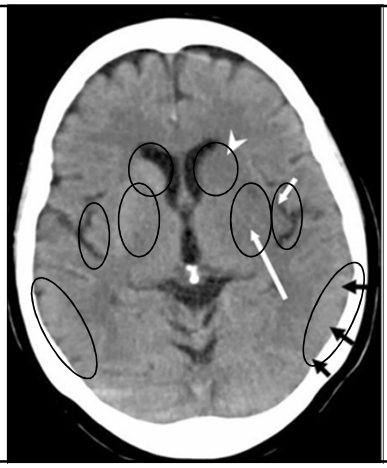
CT scan demonstrates

lentiform nucleus obscuration (long white arrow)

caudate nucleus (arrowhead)

loss of insular ribbon (short white arrow)

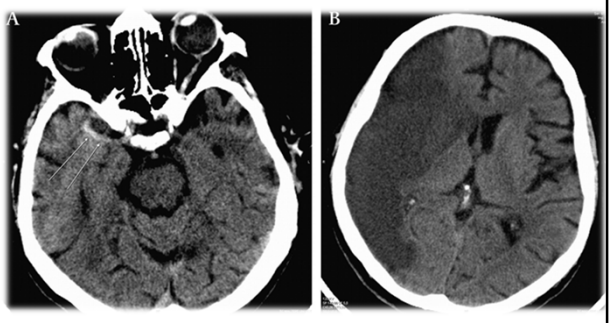
sulci effacement of MCA territory (black arrows).



Hyperdense Sign

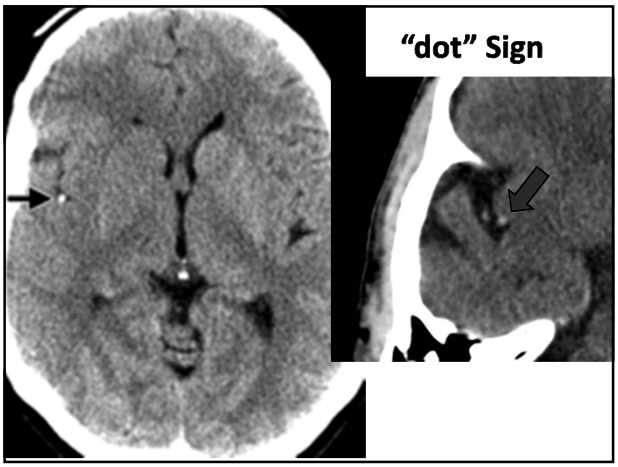
- Hyperdense vessel is seen when a thrombus is located in an intracranial vessel showing a high attenuation causing it to look bright white
- Hyperdense MCA sign has a high specificity indicating clot in the M1 branch but has poor sensitivity occurring only 38% of the time on CT

Hyperdense Sign



"dot" Sign

An MCA "dot" sign is seen as a dot in the Sylvian fissure and indicates thrombosis in the M2 or M3 MCA branch



What does this mean to treatment?

These early ischemic changes occur in the first 2 to 3 hours and **DO NOT** exclude the administration of IV rt-PA.

The Radiologist reads the scan as Normal

AND the patient is still having symptoms
Treat with IV tPA
if patient is within the 3-4.5 hour window

Bhatia et al. (2010)

Rates of acute recanalization with IV rt-PA
- 4.4% in distal intracerebral artery
- 32.3% in M1-MCA
- 30.8% in M2-MCA

Further acute interventional endovascular therapy may be warranted to achieve optimal clinical outcomes

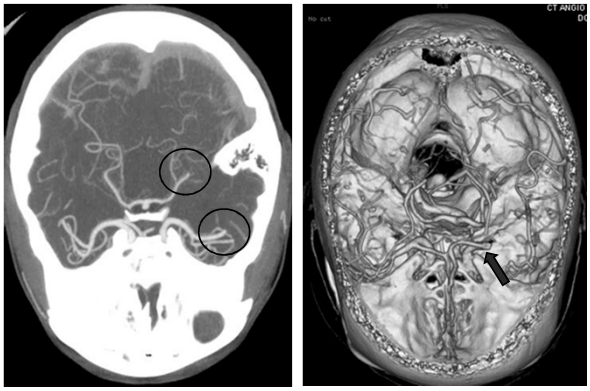
CT Angiogram and CT Perfusion

- CTA – confirms the location of the thrombus
- CTP – indicates the viability of the cerebral parenchyma

CTA and CTP

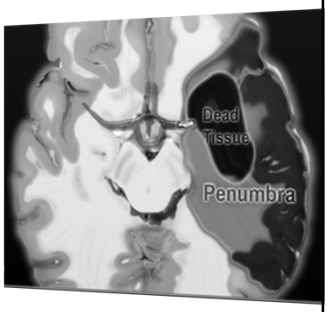
- Requires injection of contrast
  - Contrast allergy
  - Renal function
- Visualize and reconstruct in 3 dimensional display
- Detect large vessel thrombi and vascular stenosis
- Determine if further therapy is warranted

CTA



What are we looking for?

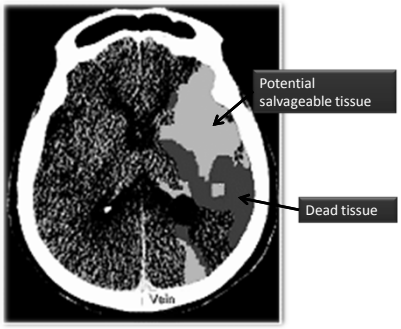
- **Penumbra** - an area peripheral to one of ischemia where metabolism is active but blood flow is diminished
- **Salvageable tissue**

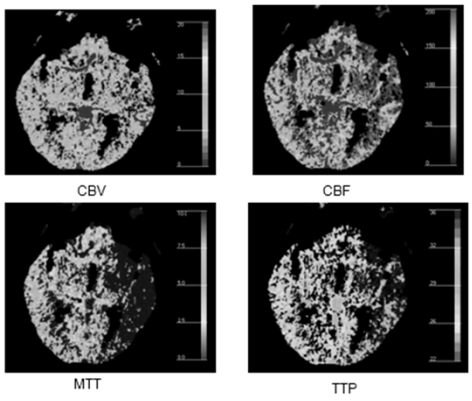


CTP Viability Map

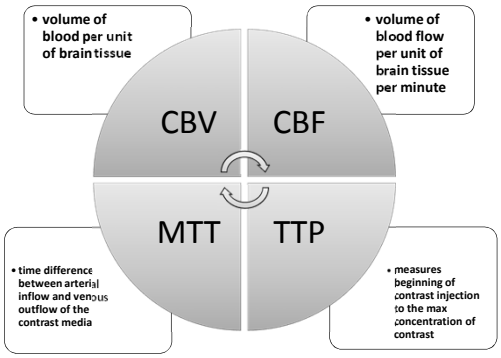
Green – Indicates Penumbra

Red – Indicates Infarct

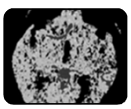




Perfusion

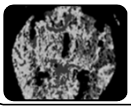


Primary Indicators



Cerebral Blood Volume (CBV)

- If CBV is preserved there will likely be salvageable tissue.
- Patients BP can elevate and vessels dilate to attempt to preserve the amount of volume to cerebral tissue.
- Normal range 4-5 mL/100 g/min



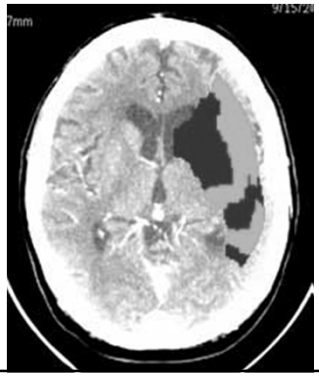
Cerebral Blood Flow (CBF)

- Amount of blood flow to the brain tissue.
- Normal range 50-60 mL/100 g/min

Mean Transit Time (MTT)

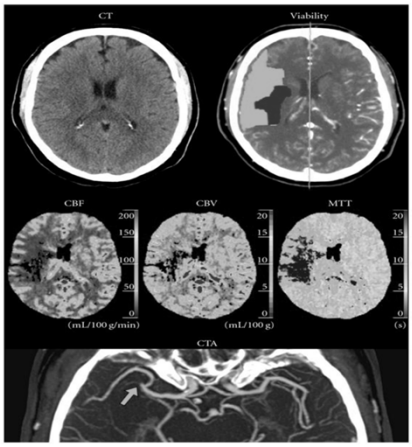
- Represents the period of time the contrast is in the cerebral artery to the cerebral vein.
- MTT is increased because the flow is very slow and contrast dye remains in the vessels longer.
- MTT=CBV/CBF x 60, Normal 5 seconds

CTP Viability Map



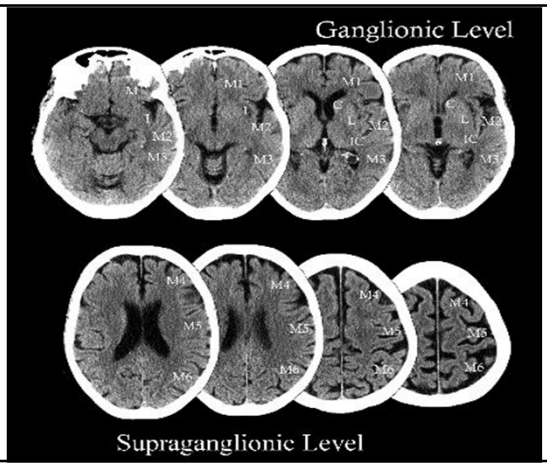
CT Perfusion Data Analysis

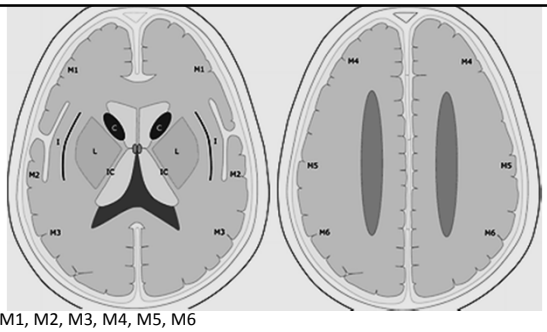
Pathology of Tissue	MTT	CBF	CBV
No ischemia	Normal	Normal	Normal
Tissue viable	Increased	Moderately Reduced	Normal or Hyperemia
Tissue at Risk	Increased	Markedly reduced	Moderately reduced
Tissue irreversible	Increased	Severely reduced	Severely reduced



Alberta Stroke Program Early CT Score (ASPECT)

- 10 point quantitative topographic CT scan score to assess early ischemic changes of the MCA region
- Assessed at 2 standardized regions
  - Ganglionic Level where the thalamus, basal ganglia and caudate are visible
  - Supraganglionic level which includes the corona radiata and centrum semiovale





- M1, M2, M3, M4, M5, M6
- caudate nucleus *(C)*
- lentiform nucleus *(L)*
- internal capsule *(IC)*
- insular cortex *(I)*

For each area involved in ischemia depicted at unenhanced CT, one point is subtracted from the total score of 10.

ASPECT score

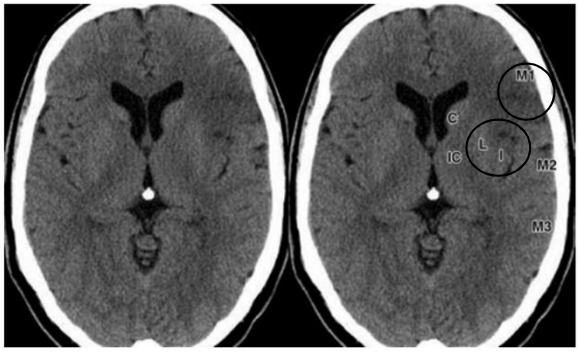
Normal ASPECT score is 10

Deduct 1 point for each area involved.

A score of 7 or less

Correlates with poor functional outcome and hemorrhage.

*Limitation – Only scores the MCA

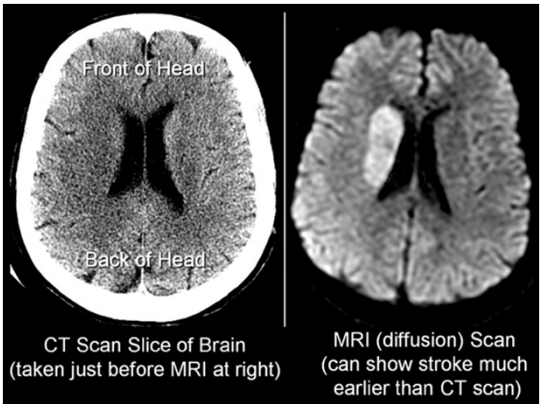


Unenhanced CT images in a 56-year-old man with right hemiparesis (**a** at a lower level than **b**) demonstrate involvement of the M1 region, insular cortex *(I)*, and lentiform nucleus *(L)*. Thus, three points are subtracted from the 10-point ASPECTS, and the final score is seven points. *C* = caudate nucleus, *IC* = internal capsule.

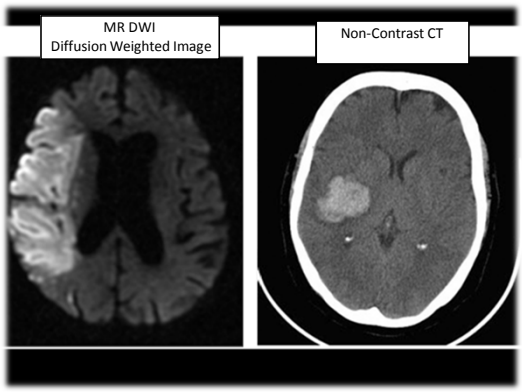
What about MRI?

Infarct on MRI

Conventional MRI plays a relatively minor role in evaluating acute cerebral ischemia, however since the development of *diffusion-weighted* MRI, it has become the most sensitive tool for detecting early ischemia



Hyperintensity vs. Hyperdensity



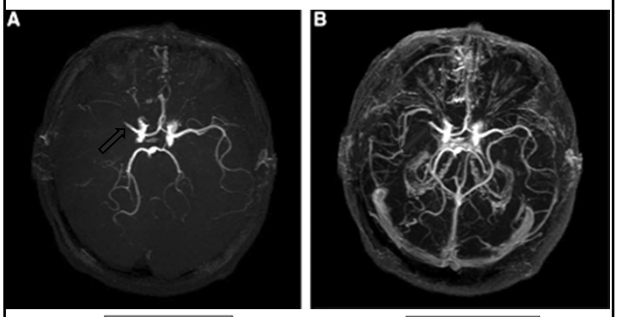
MRA

MR angiography or MRA provides information on the status of the blood vessels including detection of a high-grade stenosis or thrombotic occlusion

A low- or high-intensity vessel sign on an MR T2-weighted gradient echo may indicate a thrombus similar to a hyperdense vessel sign on CT

Normal MRA head

Right MCA occlusion



Precontrast MRA

Postcontrast MRA

DWI vs. PWI

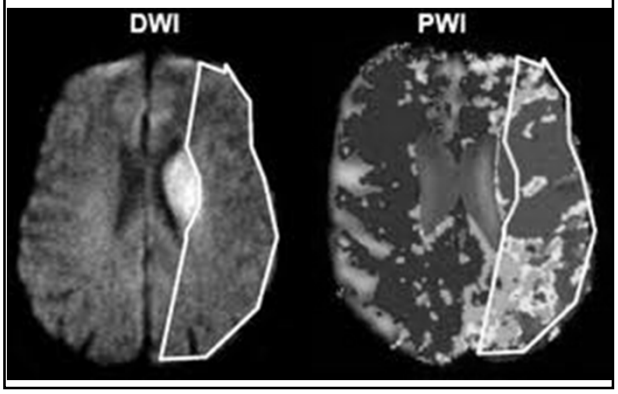
- Diffusion Weighted Image or DWI
  - Lesions on a DWI are considered irreversibly damaged tissue
- Perfusion weighted image or PWI
  - Lesions on a PWI shows hypoperfused or hypoxic tissue

Mismatch

The volume difference between the DWI and PWI is referred to as a PWI/DWI mismatch.

The mismatched tissue is considered to be the penumbra

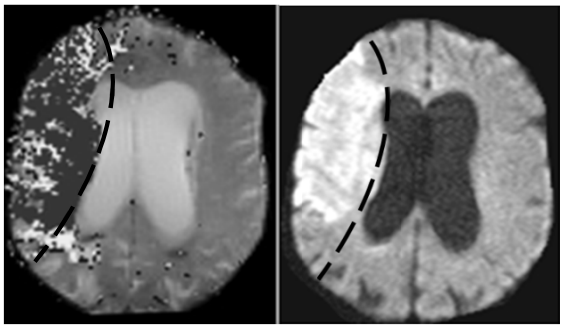
Mismatch



No Mismatch

When the area on the DWI and PWI are the same size, this is indicative of irreversible infarcted tissue and treatment would not be recommended.

No Mismatch



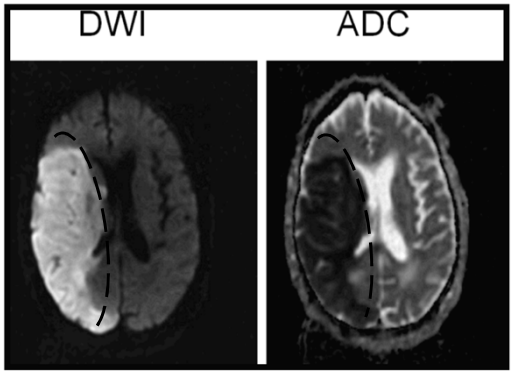
PWI DWI

Role of the ADC map

Apparent Diffusion Coefficient (ADC) map as a post processing of the DWI data that produces images showing abnormal tissue as darker than normal tissue.

The purpose of ADC mapping is to differentiate T2-signal (T2 shine through) effect or artifact from true ischemic lesions.

True Ischemic Tissue



So What is better, CT or MRI?

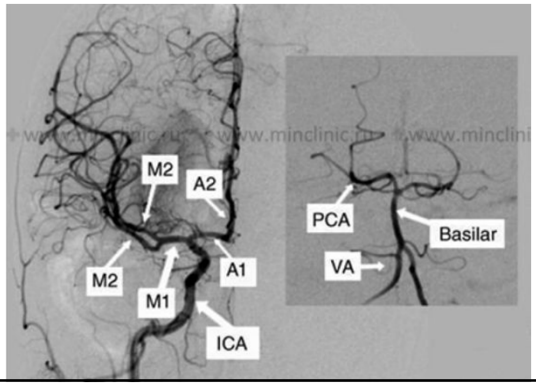
The Debate Continues.

But…..
here are some pros and cons

	CT	MRI
Scan Time	5-10 minutes	20-30 minutes
Availability	Widely available	Limited availability
Screening	None	Required
Contraindications	Renal insufficiency	Claustrophobia Some pace-makers and metal
Cost	Less expensive	More expensive
Motion Intensive patient monitoring	Not as sensitive Feasible	Very sensitive to patient motion Difficult
Radiation exposure	Yes	No
Identification of early ischemia	Poor	High
Recognition of mismatch	Yes	Yes
Visualize Posterior fossa and brain stem	Poor	Good

Beyond Diagnostic Imaging

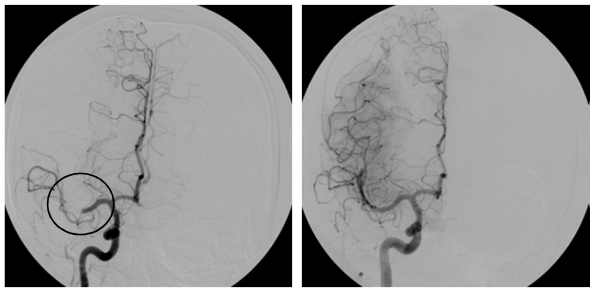
Cerebral Arteries



Treatment Options

- IV rt-PA within 3 – 4.5 hours of onset
- IA rt-PA (off label use) within 6 hours
- Mechanical clot retrieval within 8 hours
  - MERCI retriever
  - Penumbra retrieval system

Recanalization of Rt MCA using IA t-PA



Case: MERCI Retrieval (L MCA)

Thank you!!

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