

Neuroimaging in severe traumatic brain injury

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Injury Conference Auckland 2014

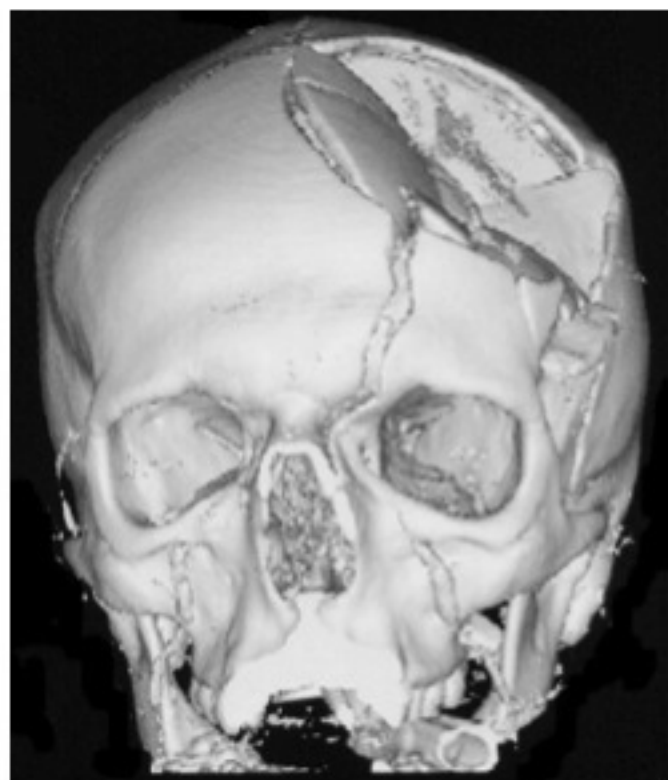
Define problem

Old and new diagnostic tools

JHH experience with CTP

Cases

Future direction



Severe TBI

- GCS <9 before intubation
- Single largest cause of death and disability
- 40% of trauma related death in HNE
- Age:
 - 10% <20yrs
 - 50% 20-39yrs
- Sex: 74% M

Prevention

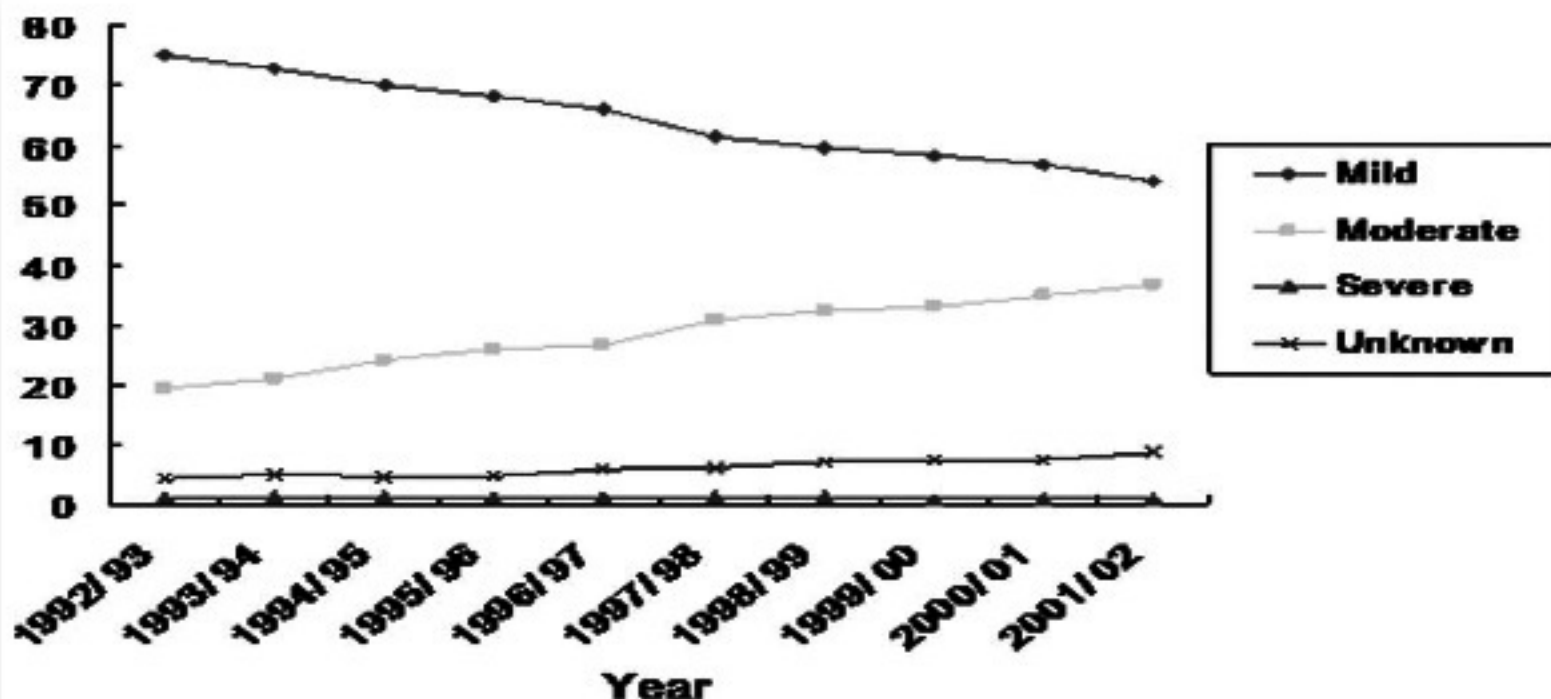


Fig. 1. *TBI Admissions in Ontario Acute Care Hospitals: % of admissions by level of severity based on AIS coding.*

injuries fell from 1.3% of the total to 0.8%. This trend was

Mortality

1987	US	36%
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1995	European	40%
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1992	Westmead	31%
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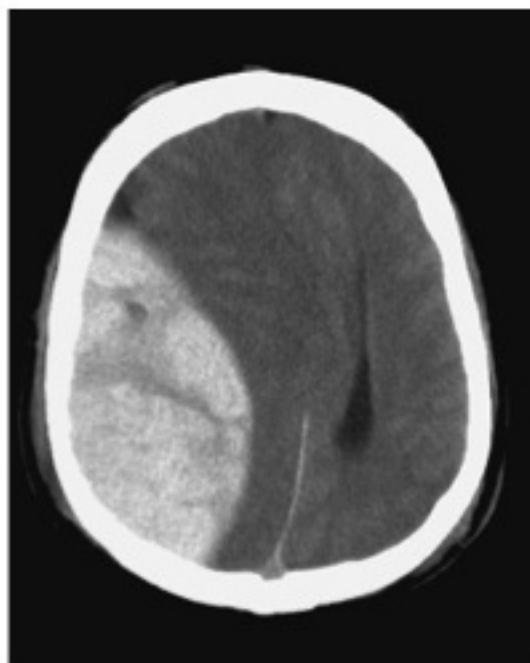
2000	Australasian	32%
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Poor outcome at 12 months

1987	US	57%
1995	European	60%
1992	Westmead	45%
2000	Australasian	55%

Non-contrast head CT

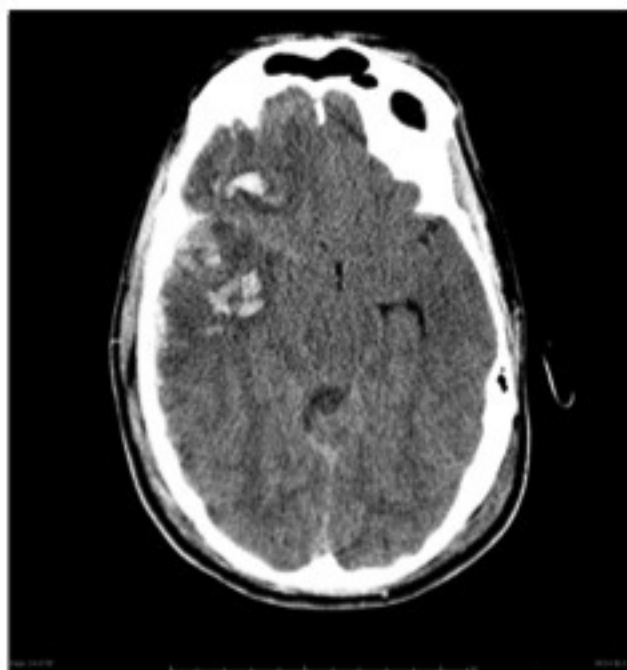
- Standard imaging for diagnosis and follow up
- Anatomic findings
- Marshal scale



*Modified Marshall CT grade:			
I	Diffuse Injury	No visible pathology	1
II	Diffuse Injury (with present cisterns, midline shift 0-5mm and/or small (<25cc) high or mixed density lesions	No lesions	2a
		Only one lesion	2b
		≥2 unilateral lesions	2c
		Bilateral lesions	2d
III	Diffuse injury and swelling	I – II + compressed or absent cisterns	3
IV	Diffuse injury and shift	I-III + midline shift >5mm	4
V	Evacuated mass lesion	Extradural	5a
		Subdural	5b
		Intracerebral	5c
		≥2 intra + extracerebral	5d
VI	Non-evacuated mass lesion >25cc)	Extradural	6a
		Subdural	6b
		Intracerebral	6c
		≥2 intra+extracerebral	6d

Non-contrast head CT

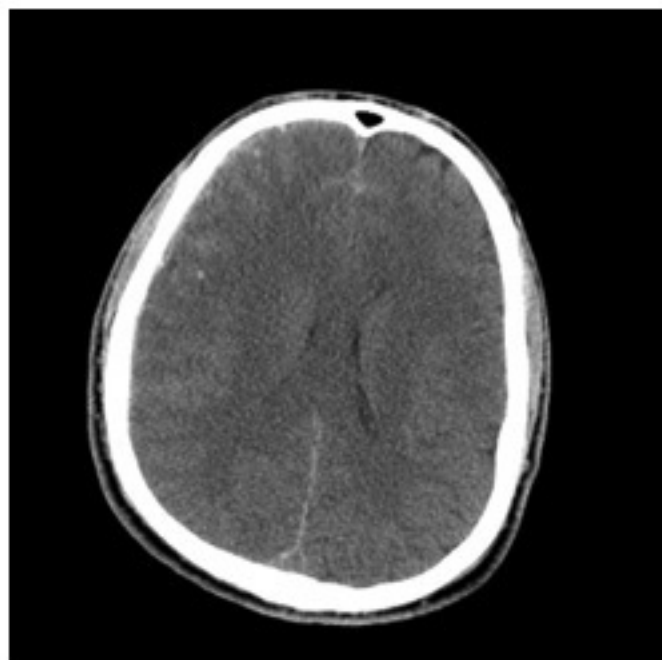
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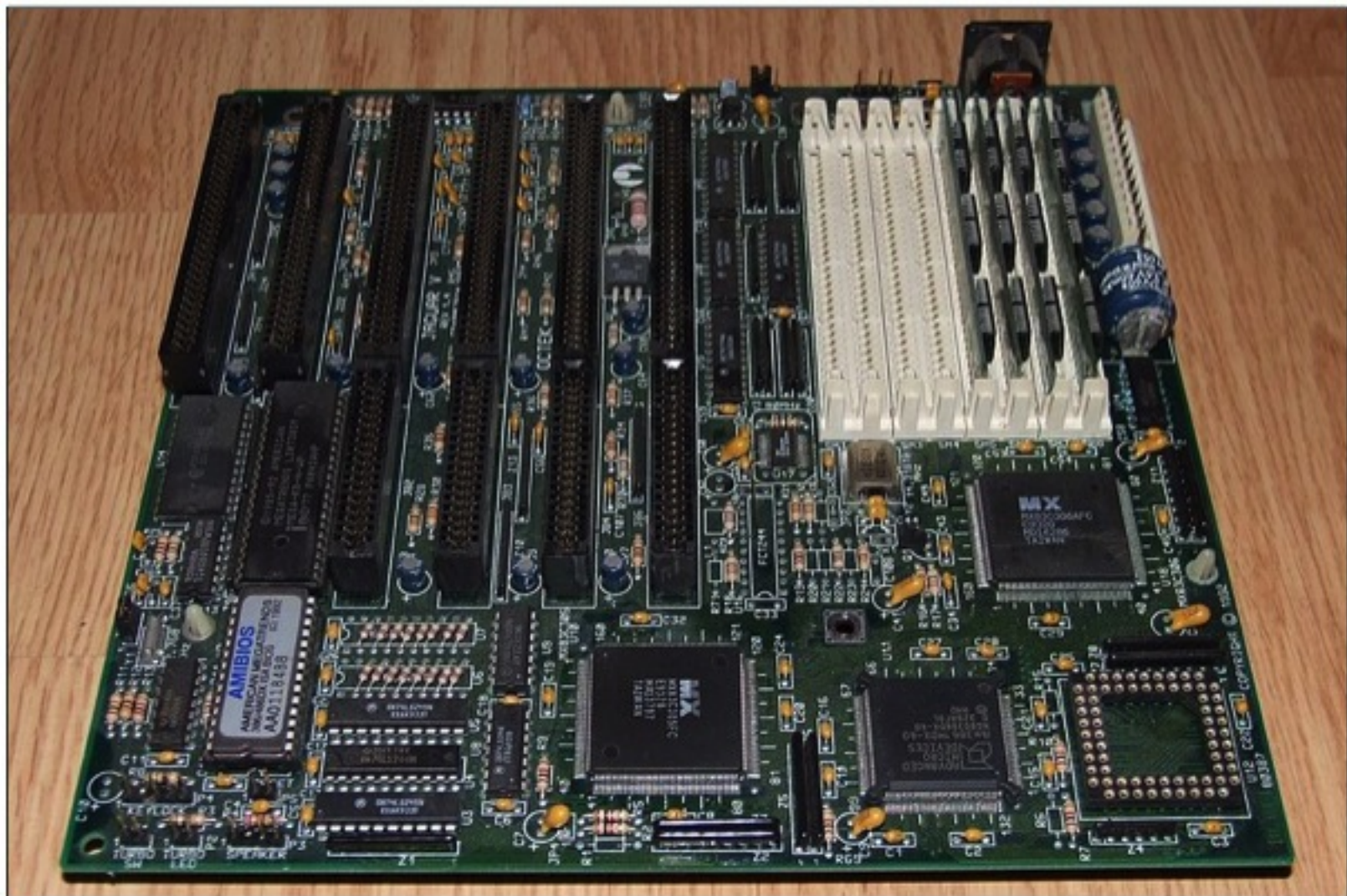


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Limits of non-contrast head CT

- Anatomical (but does not observe circulation)
- Not functional
- Underestimates
 - DAI
 - Contusion
- Poorly predicts
 - ICP
 - further haemorrhage
 - outcome

Does it work?



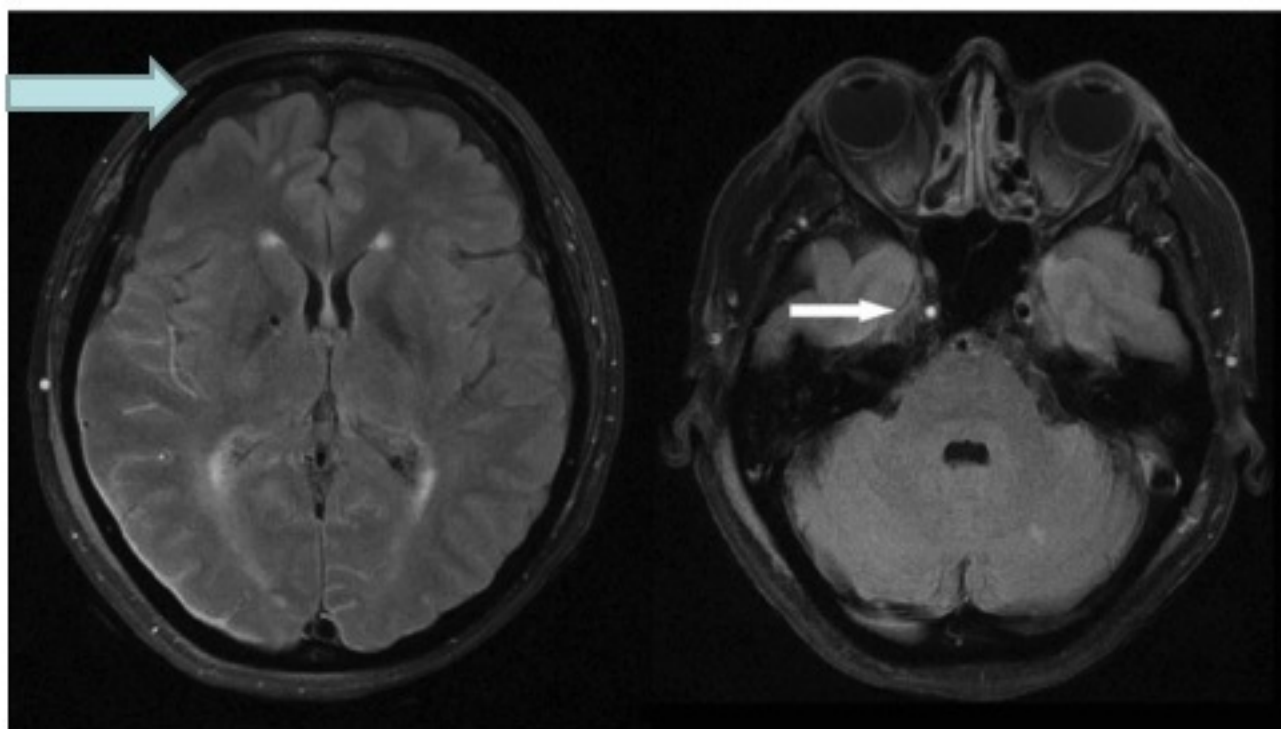
CT angiogram

- Define major vessels in penetrating trauma
- Screen for cerebrovascular injuries in blunt trauma:
 - near hanging, direct blunt force, hyperextension-flexion
 - seatbelt mark, carotid bruit, focal neurology
 - base of skull or vertebral canal #
 - focal neurology
- Denver criteria
- Auckland criteria



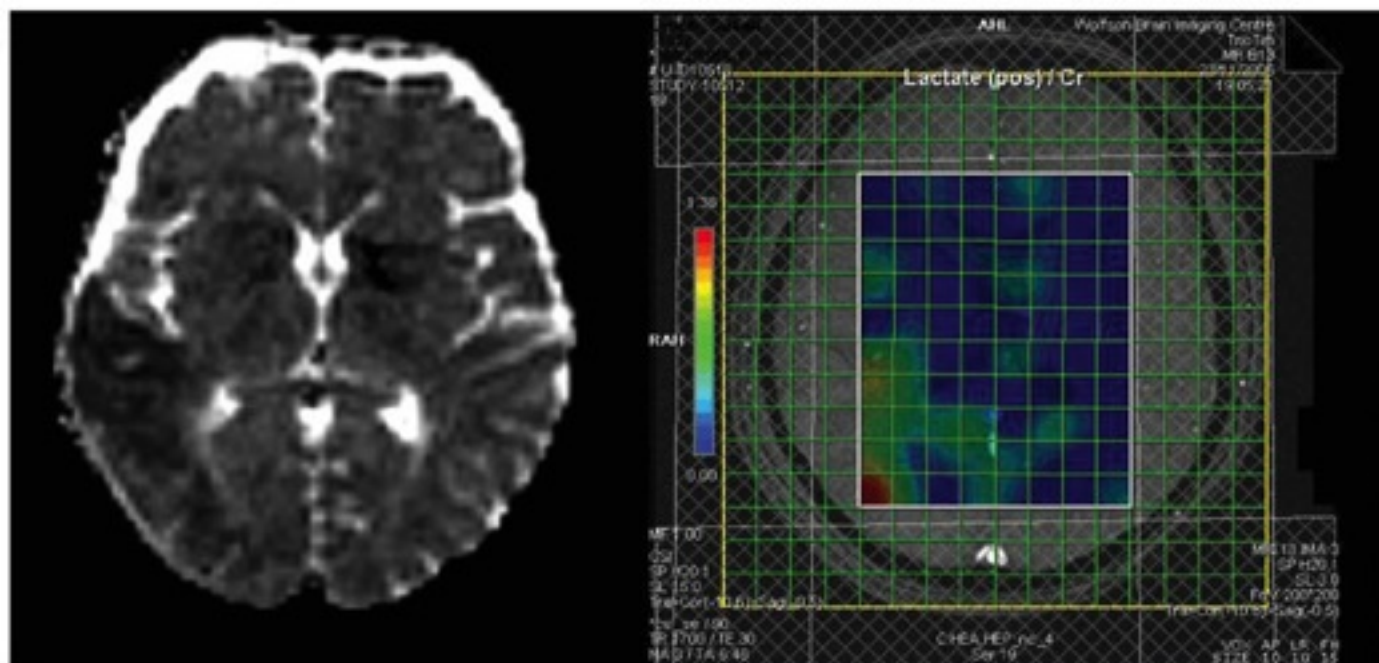
MRI

- Can study structure and function across brain
- Detailed and specific
- Logistically demanding



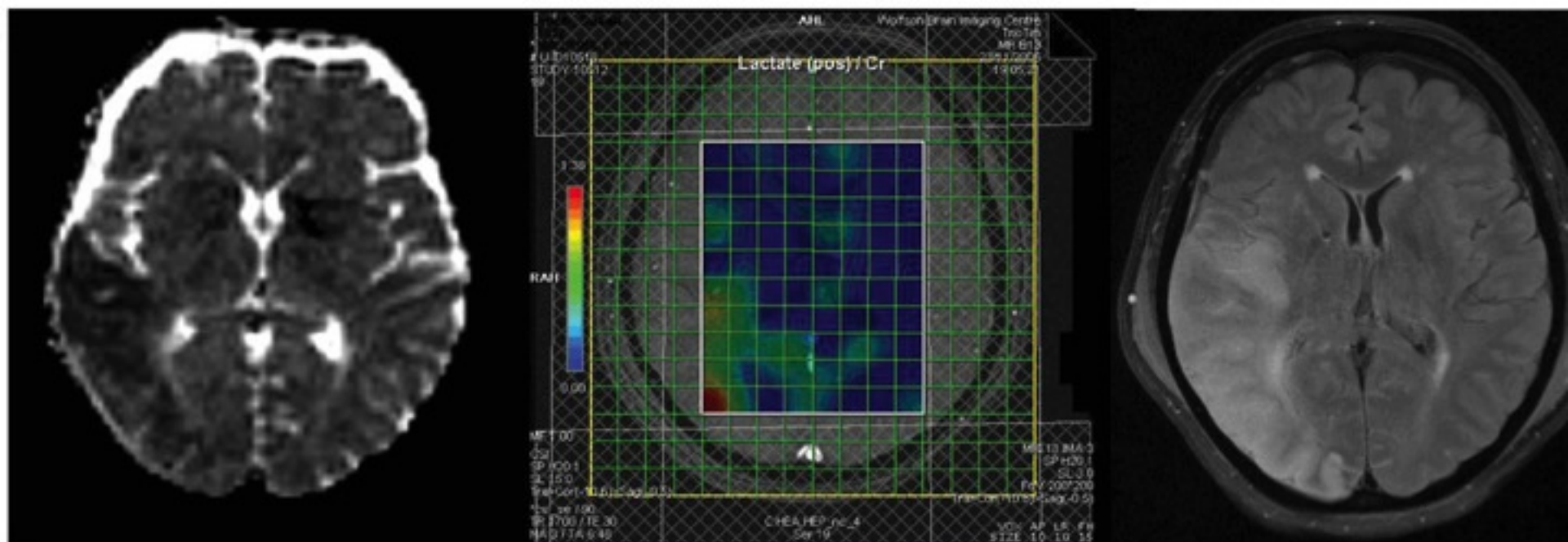
MRI spectroscopy

- Investigate biochemical pathology (lactate)



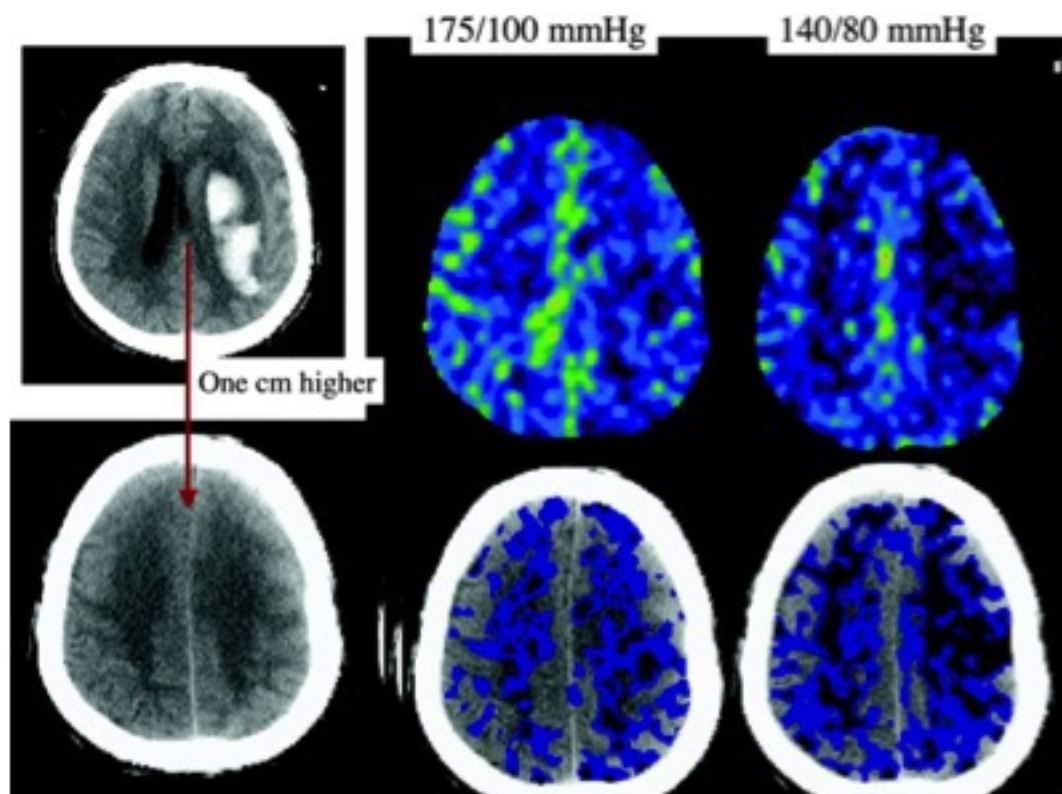
MRI spectroscopy

- Investigates biochemical pathology



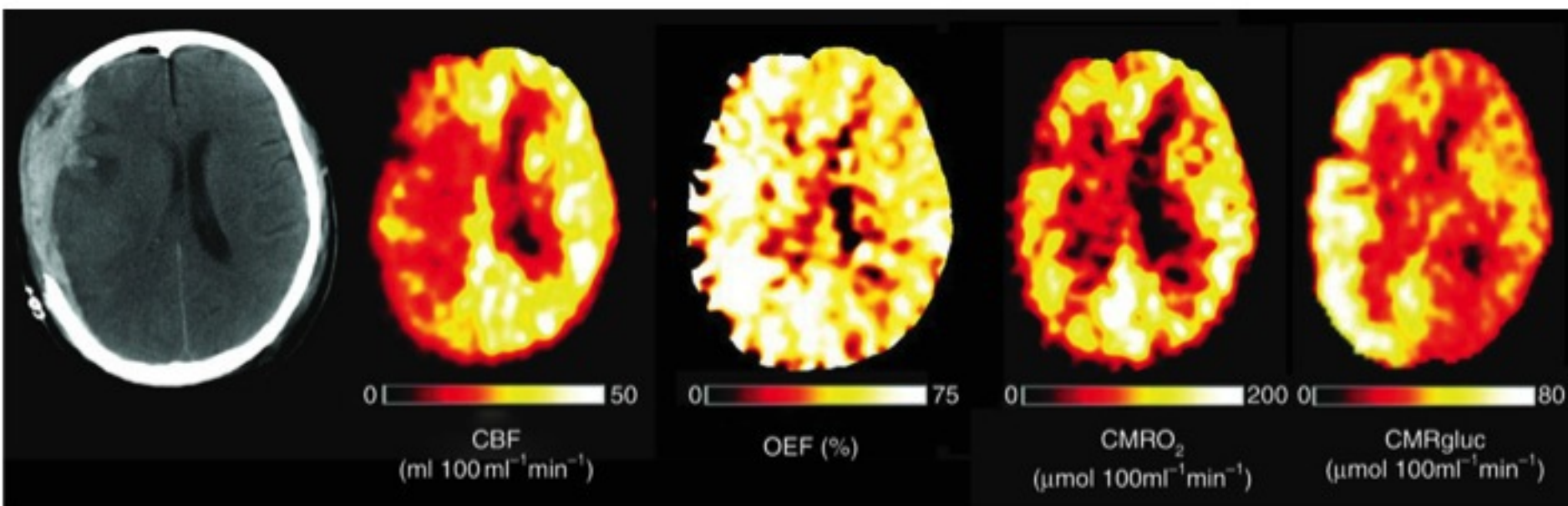
Xenon-enhanced CT

- 28% Xe
 - Increases Blood flow
 - Sedative
 - Logistically demanding



PET

Investigates cerebral metabolism with isotopes such as ^{15}O and 18-fluorodeoxyglucose (^{18}F FDG)



Evacuated
haematoma

↓ blood
flow

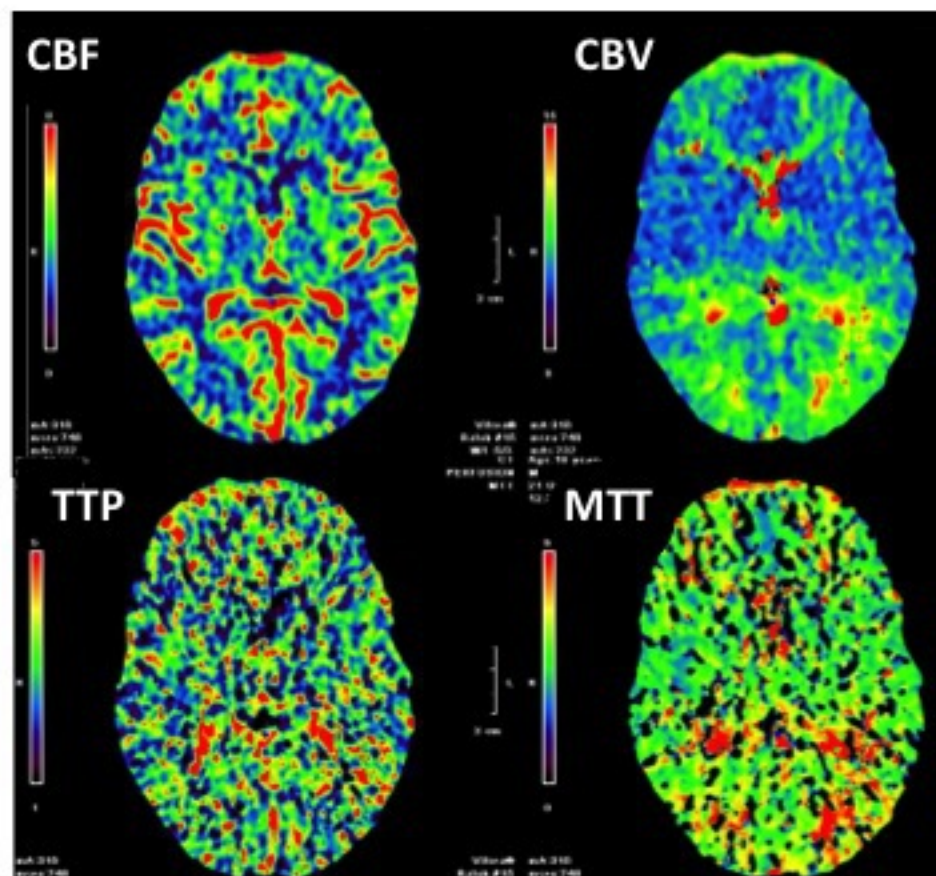
↑ O₂
extraction

↓ O₂
metabolism

↑ glucagone
metabolism

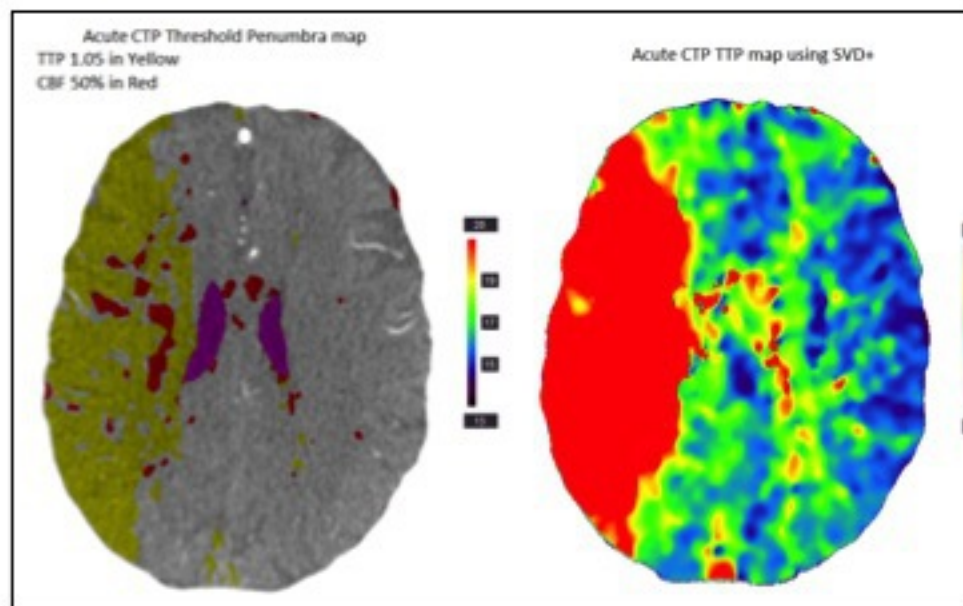
CT Perfusion

- Multidetector CT tracks the flow of IV contrast
- Software creates maps:
 - Blood flow
 - Blood volume
 - Time to peak
 - Mean transient time



CT Perfusion in stroke

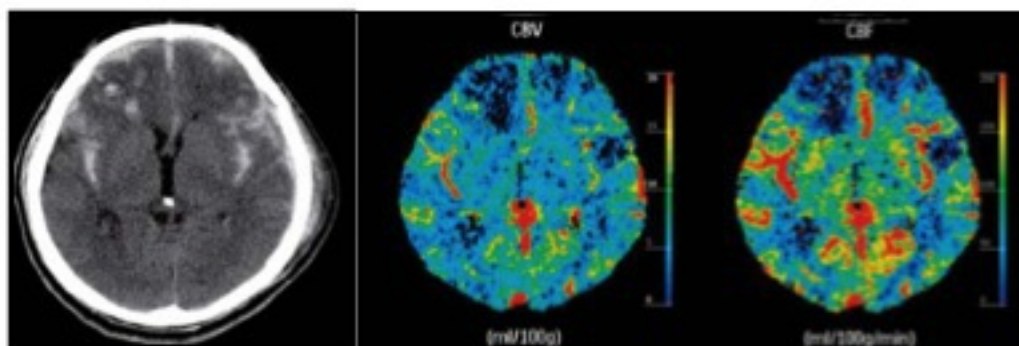
- Distinguish infarct core from penumbra
- Together with CTA prompts use of thrombolysis



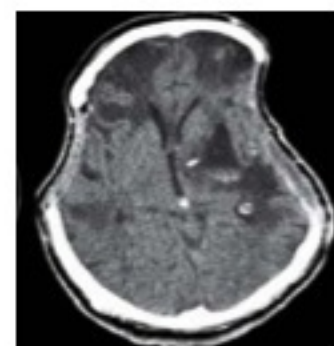
CTP in contusions

33 patients

Acute CBV/CBF maps were congruent with NC-CT d7

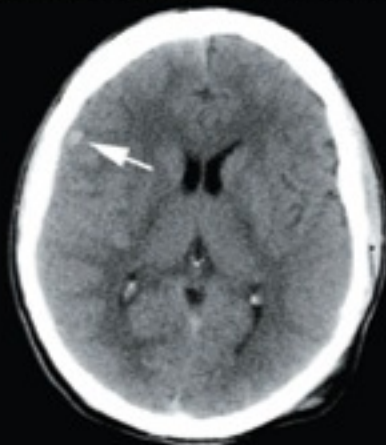


d0

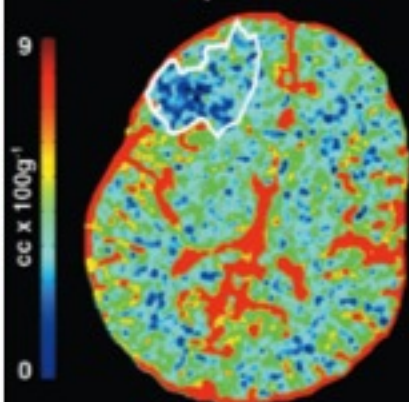


d7

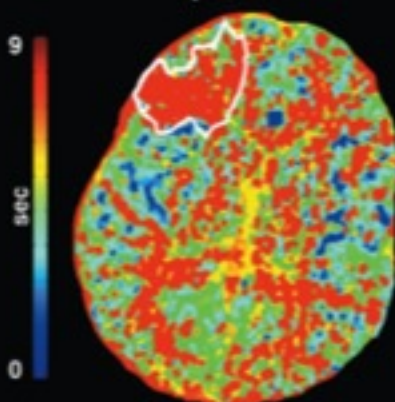
Admission noncontrast CT



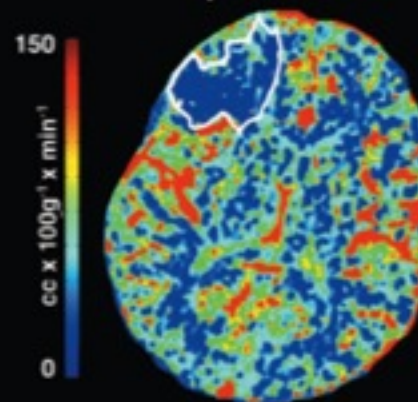
Admission perfusion-CT rCBV



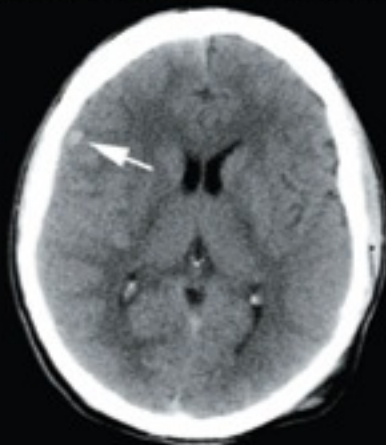
Admission perfusion-CT MTT



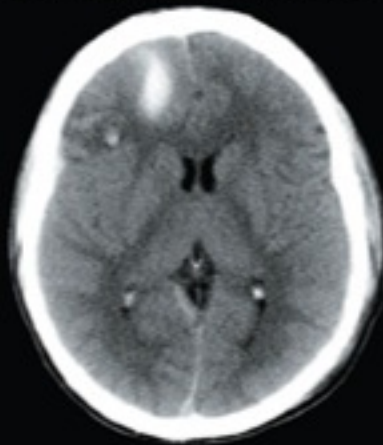
Admission perfusion-CT rCBF



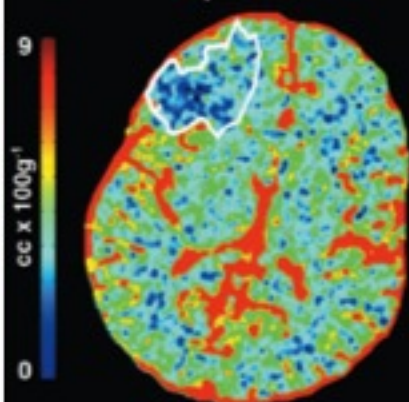
Admission noncontrast CT



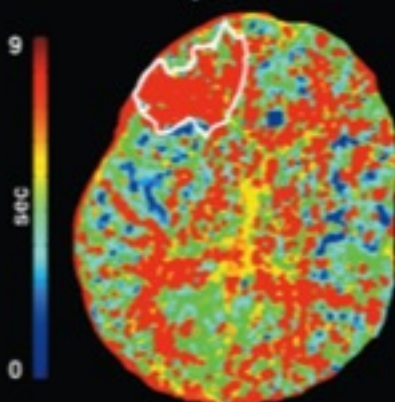
24-hour noncontrast CT



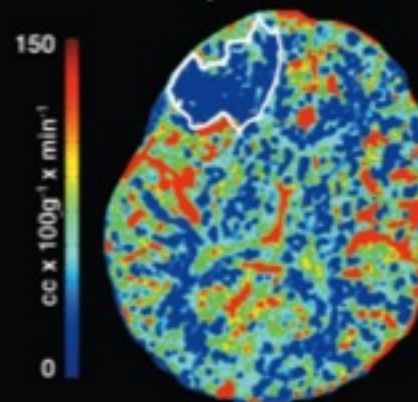
Admission perfusion-CT rCBV



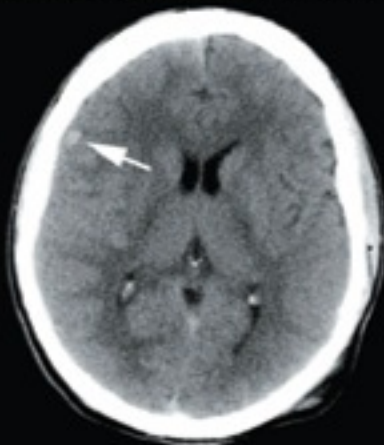
Admission perfusion-CT MTT



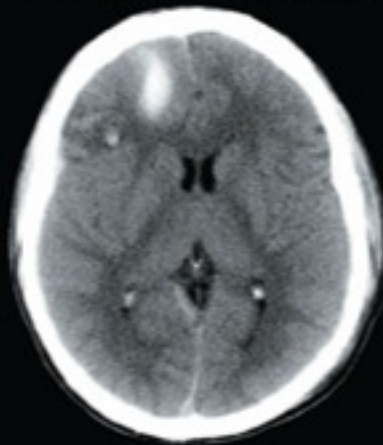
Admission perfusion-CT rCBF



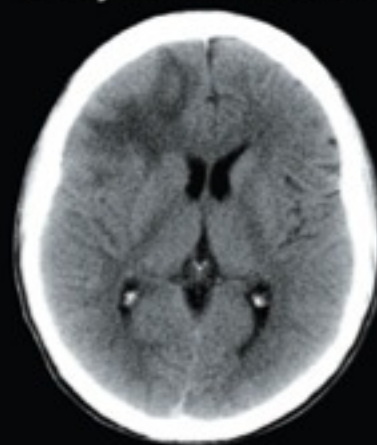
Admission noncontrast CT



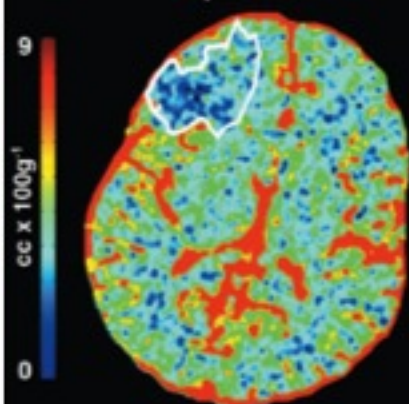
24-hour noncontrast CT



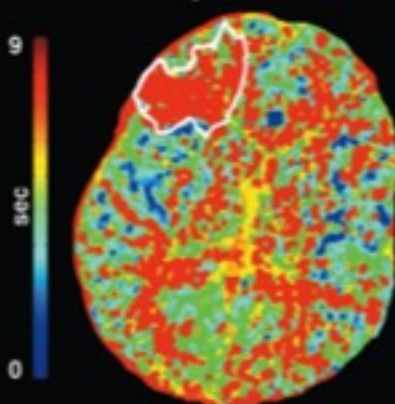
15-day noncontrast CT



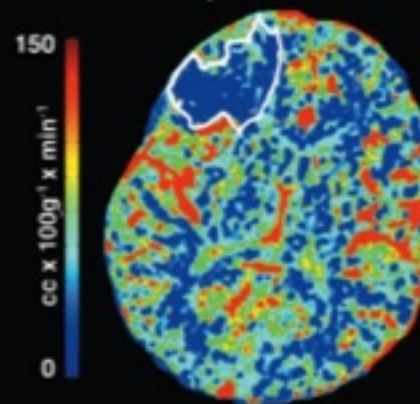
Admission perfusion-CT rCBV



Admission perfusion-CT MTT

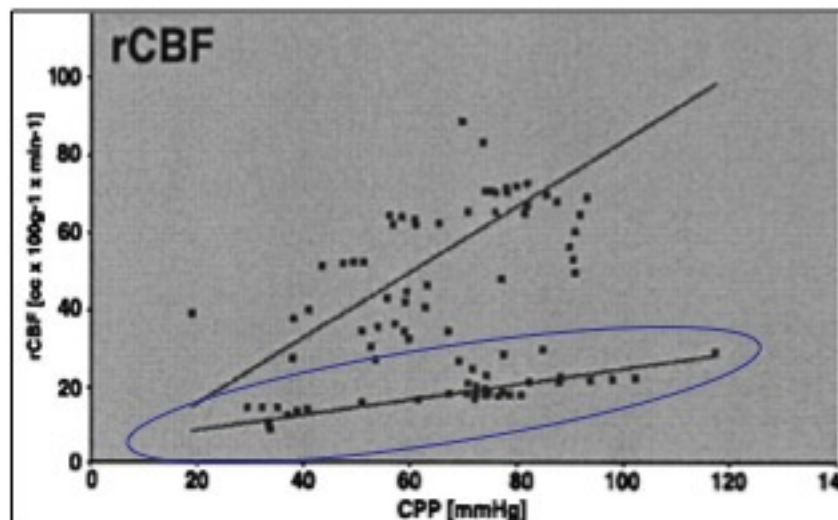


Admission perfusion-CT rCBF



CT Perfusion in STBI

- 130 pts
- Poor functional outcome if:
 - Low CBV
 - Weak dependence of CBF to CPP

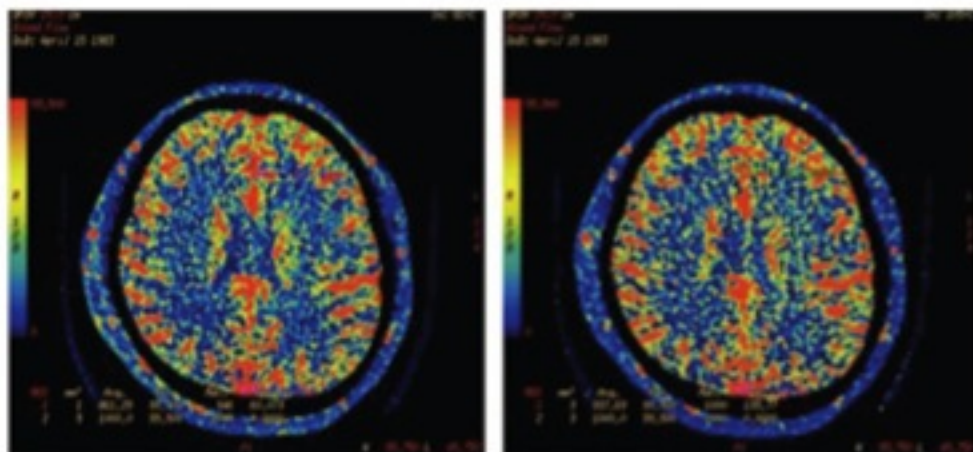


CTP to study autoregulation

33 patients with ICP

CTP before and after 20mm Hg increase of CPP:

- Intact autoregulation: 75%

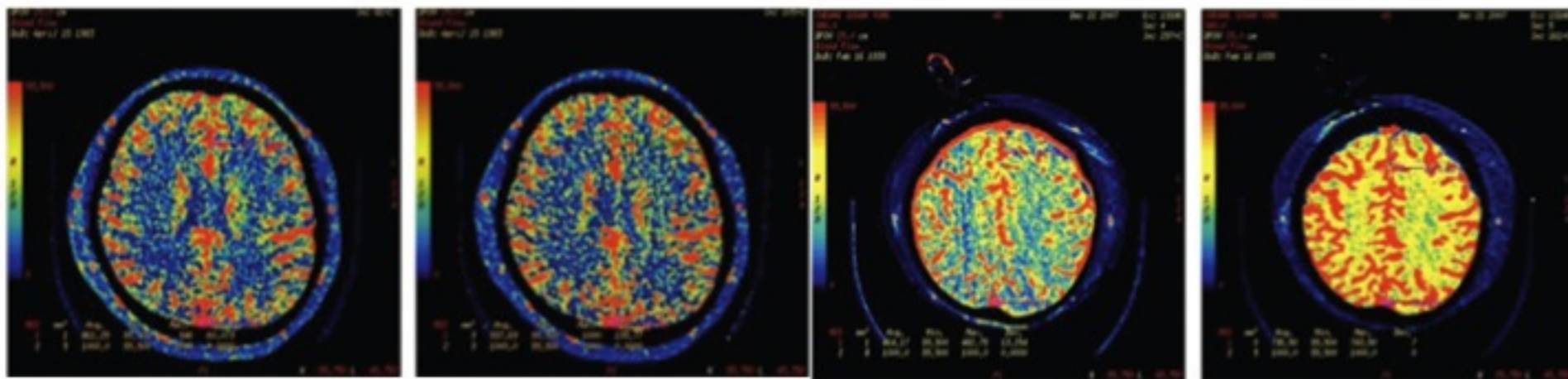


CTP to study autoregulation

33 patients with ICP

CTP before and after 20mm Hg increase of CPP:

- Intact autoregulation: 75%
- Disrupted autoregulation: 25%



OUR EXPERIENCE

Did not perform CTP on admission

CTP ordered only if a second NC-CT requested <48hrs

Stroke protocol

Toshiba Aquilion One 320

Outcome measures:

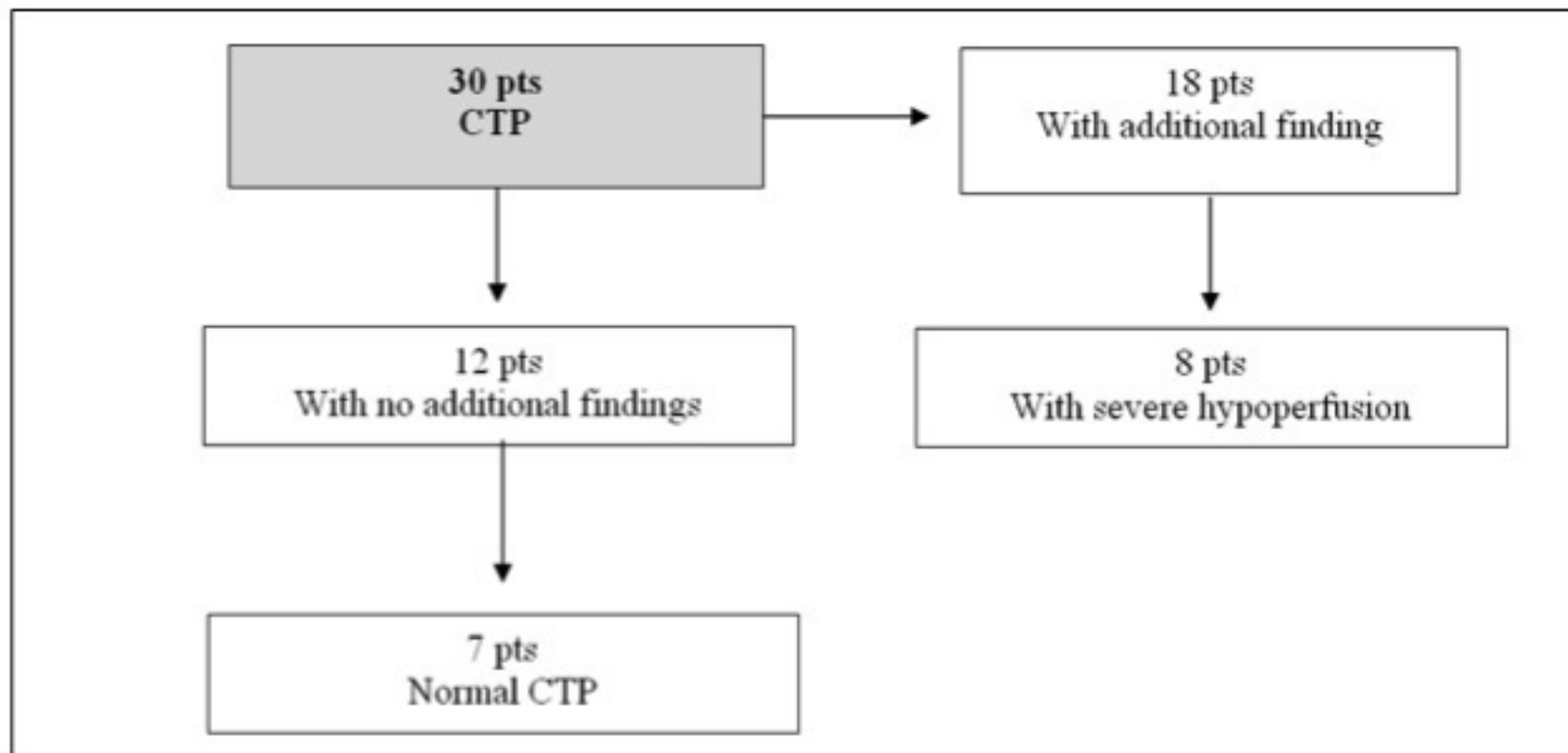
Abnormal CTP

Additional information

Severe hypoperfusion ($TTP > 2\text{secs}$)

Findings influenced clinical management

CTP findings



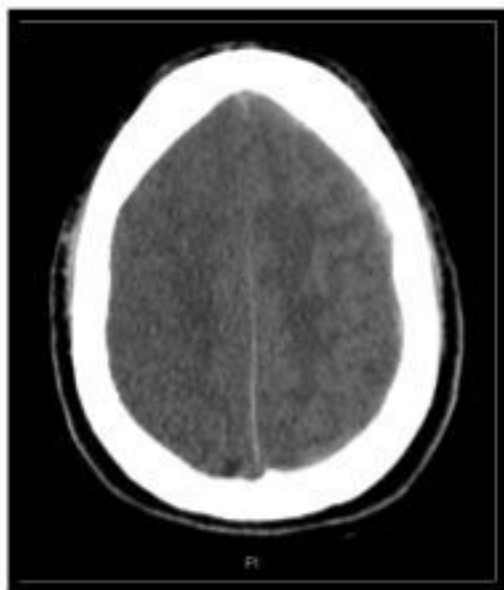
Additional findings on CTP

	Yes (n=18)	No (n=12)	P value
Age (\pm SD)	41.7 (16.9)	27.7 (12.8)	0.02*
Lowest GCS (\pm SD)	5.2 (2.6)	5.3 (1.3)	0.90
ISS (\pm SD)	28.7 (8.9)	34.0 (8.6)	0.11
AIS-HN (median)	4	4	0.23
Days in ICU (\pm SD)	11.5 (7.0)	8.4 (4.6)	0.24
Highest ICP (\pm SD)	31.5 (18.3)	28.8 (6.8)	0.74
Death (n)	4	1	0.6

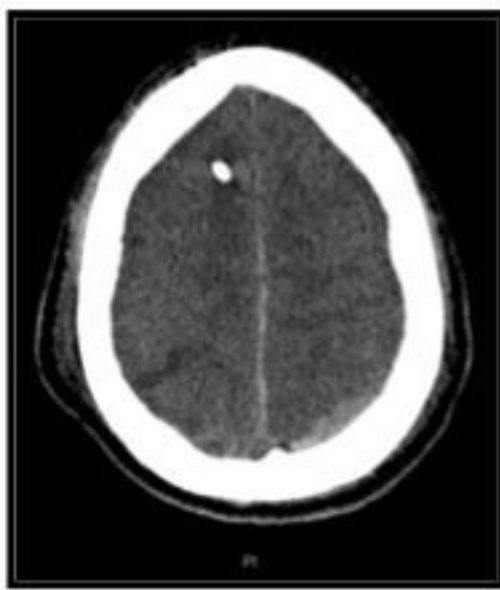
Additional findings on CTP

	Yes (n=18)	No (n=12)	P value
Normal	3	1	0.62
DAI	1	6	0.008*
Haematoma	6	4	0.69
Intracerebral contusion	8	1	0.04*

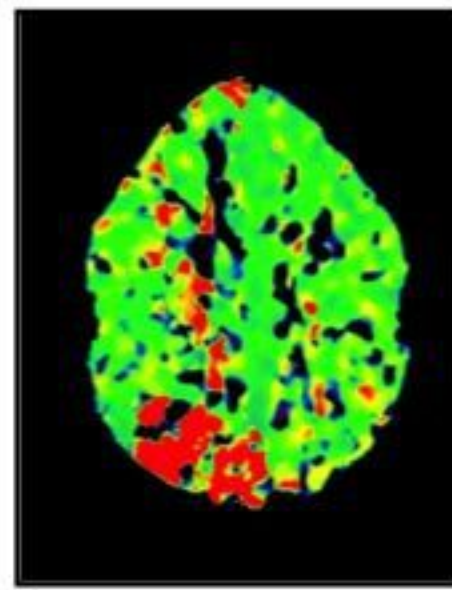
CASE 1: ■■■, MBA



d0

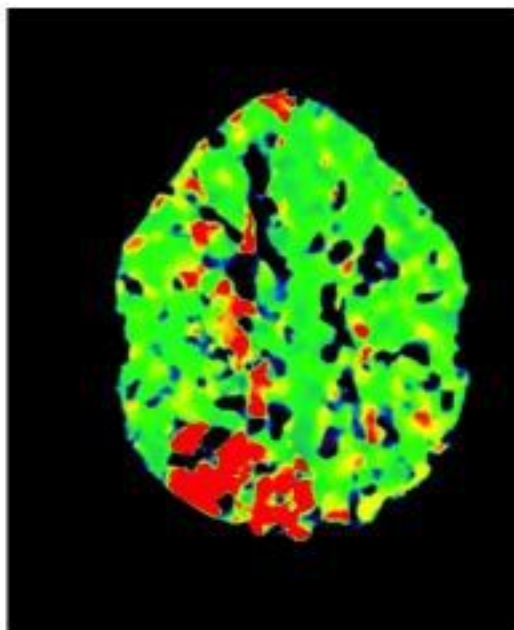


d1

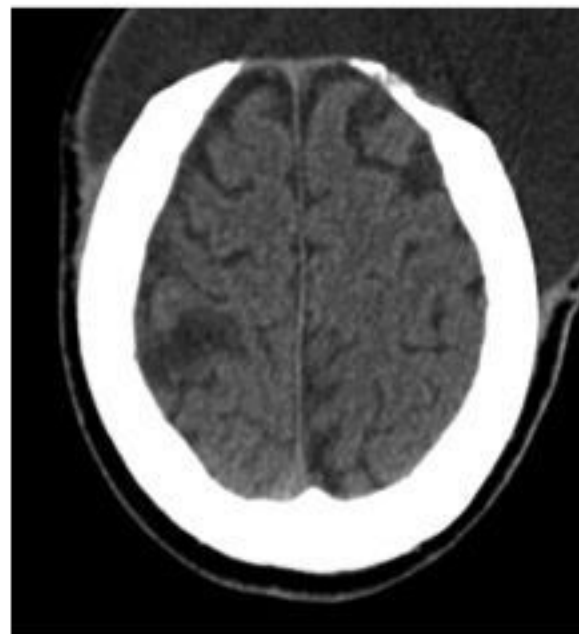


d1

CASE 1: ■■■, MBA



d1

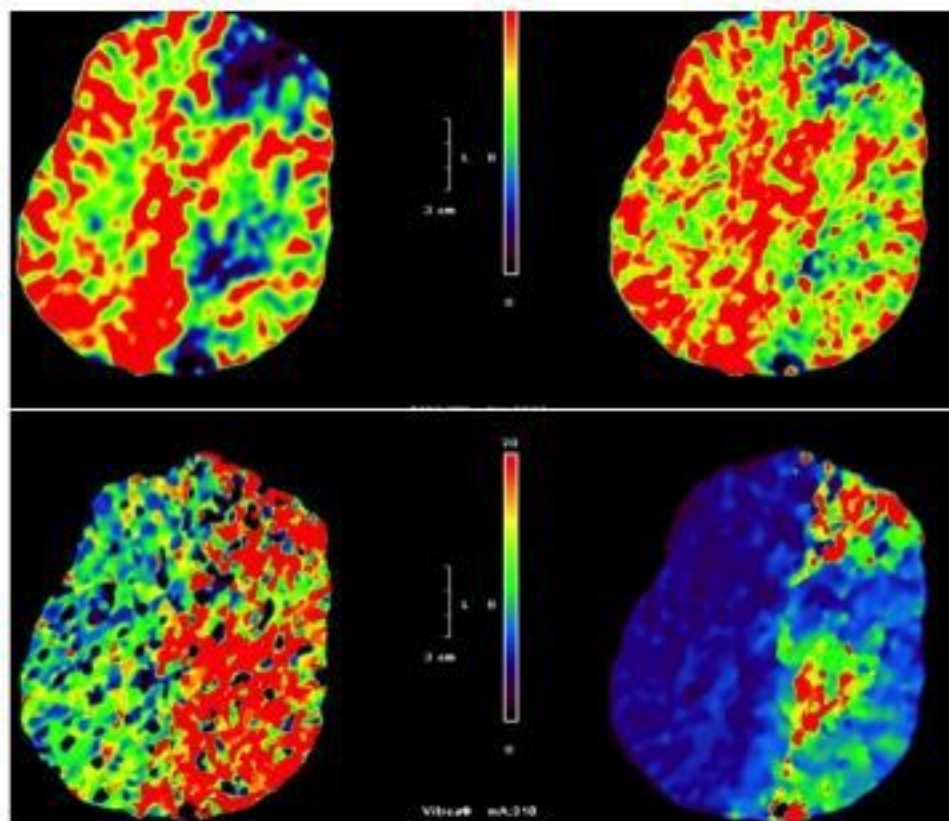


d17

Case 2: [REDACTED], MBA



d1



d1

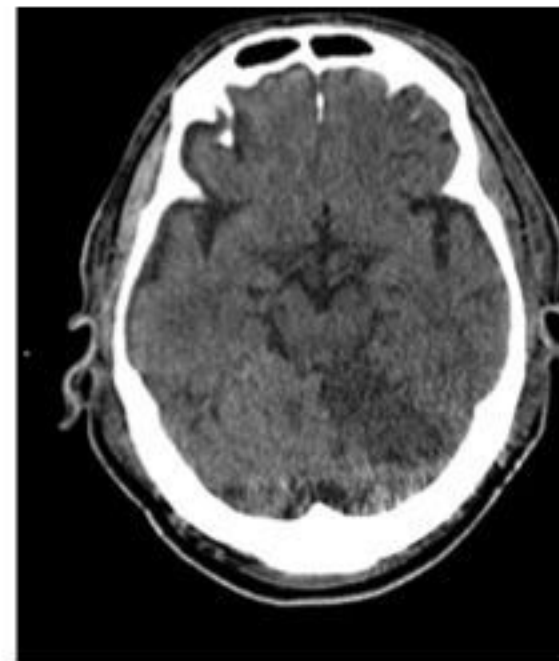
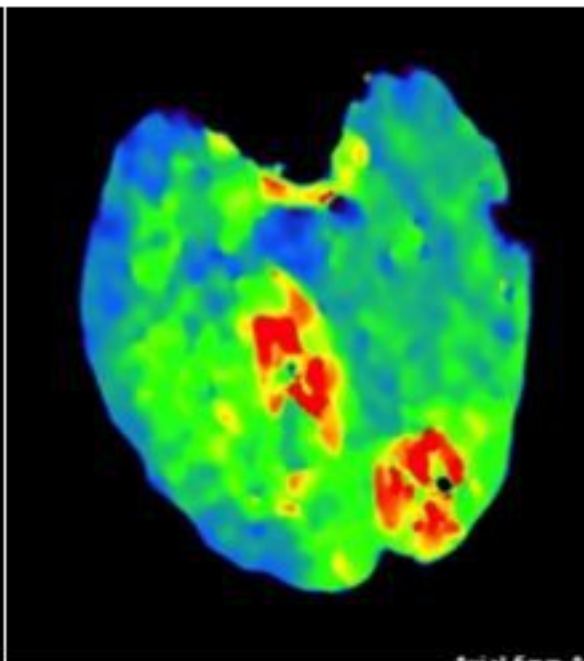
Case 2: [REDACTED], MBA



Case 3: MVA, [REDACTED]



d1



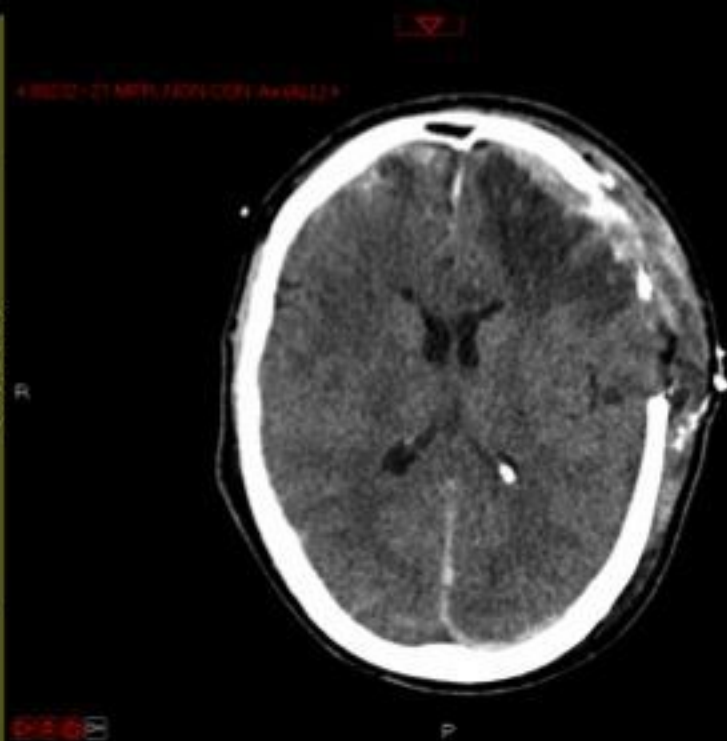
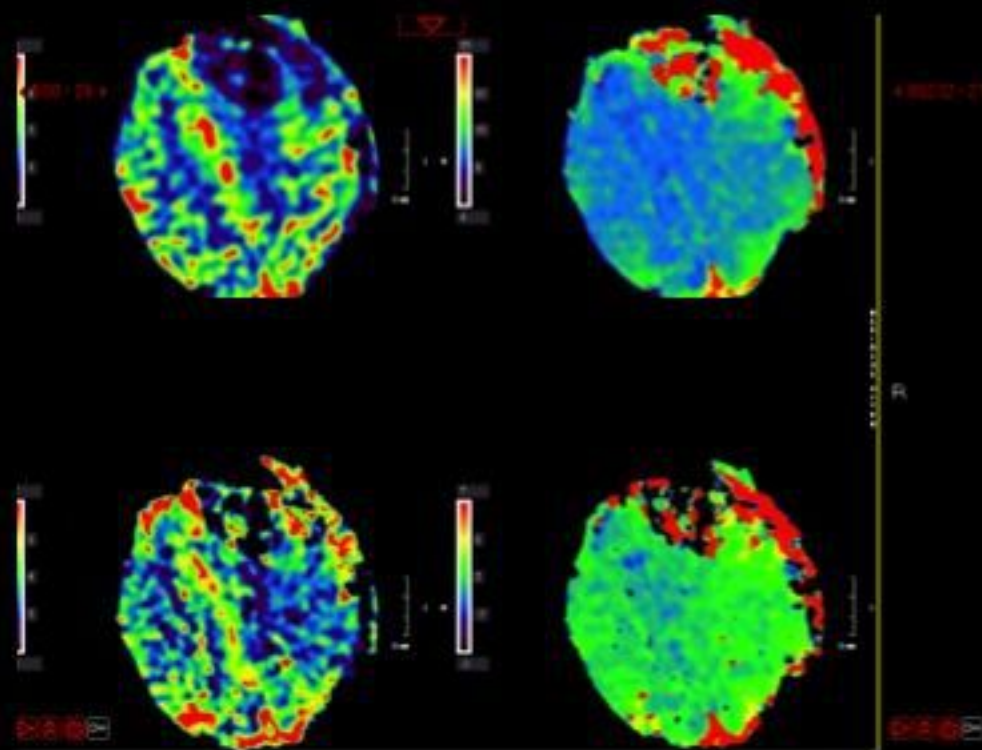
d7

Conclusion of this study

- Early CTP commonly abnormal
- Ischemic range in 30%
- Additional information in 60%
- Clinically relevant information in 10%

Preliminary Data

	Normal CTP		Abnormal CTP		P- Value
	Mean	(St Dev)	Mean	(St Dev)	
N	6		25		
Males	6		22		
Age	28	(11)	39	(18)	0.19
GCS	5.50	(1.38)	4.54	(1.84)	0.21*
Injury Severity Score	35.4	(8.65)	30.5	(8.97)	0.27
ICU LOS	5.50	(7.15)	12.64	(7.15)	0.02
GOSE	6.50	(1.52)	3.28	(2.30)	0.007*



FUTURE

- Early functional imaging
- Early definitive outcome prognostication
- Individualized CPP management
- Revascularization of ischemic area