

Investigations in Neurology

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Scenarios

- ?stroke
- ?MS
- ?Seizure
- ?neuropathy
- ?GBS (acute flaccid paralysis)
- ?myasthenia
- ?myopathy/MND
- Miscellaneous/movement disorders

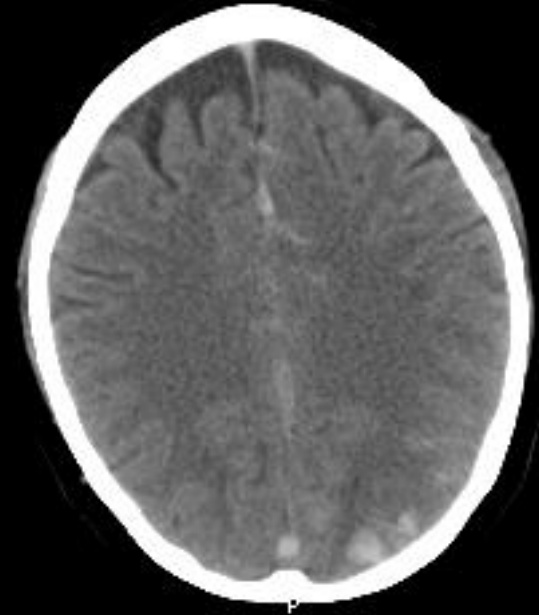
?Stroke

- Non-contrast CT brain – rate-limiting step for treatment
- Loss of grey-white differentiation (especially caudate, lentiform, insula)
- Hyperdense artery (when asymmetrical) = acute clot
- CT angiography now regarded as standard
 - large vessel occlusion for clot retrieval
 - helps improve diagnostic certainty/risk stratify mild stroke
- CT perfusion required for thrombectomy >6h, thrombolysis >4.5h
 - helps improve diagnostic certainty vs mimics/risk stratify mild stroke/prognosticate e.g. large core/plan e.g. hemicraniectomy
→ recommended for all suspected stroke

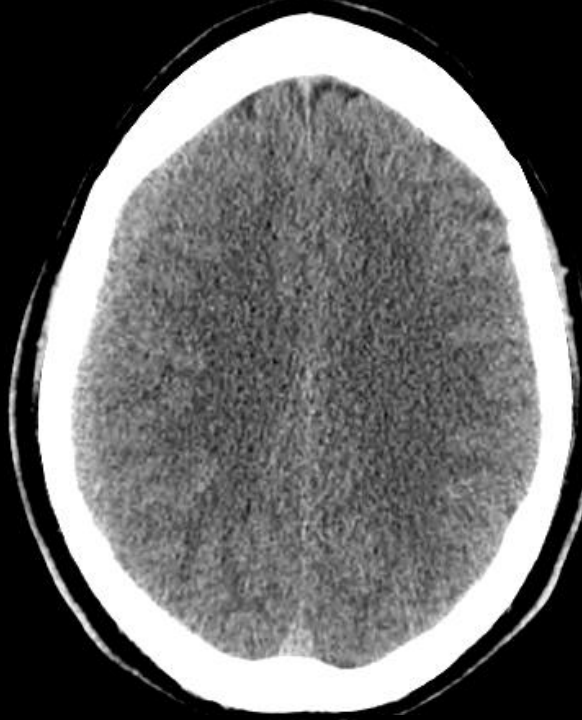
Non-contrast CT Brain



Suspicious ICH



CT angiogram has ~15% diagnostic yield in ICH (w/o SAH) Delgado Almandoz AJNR 2009
– have a low threshold for ordering a CTA or CT venogram as appropriate



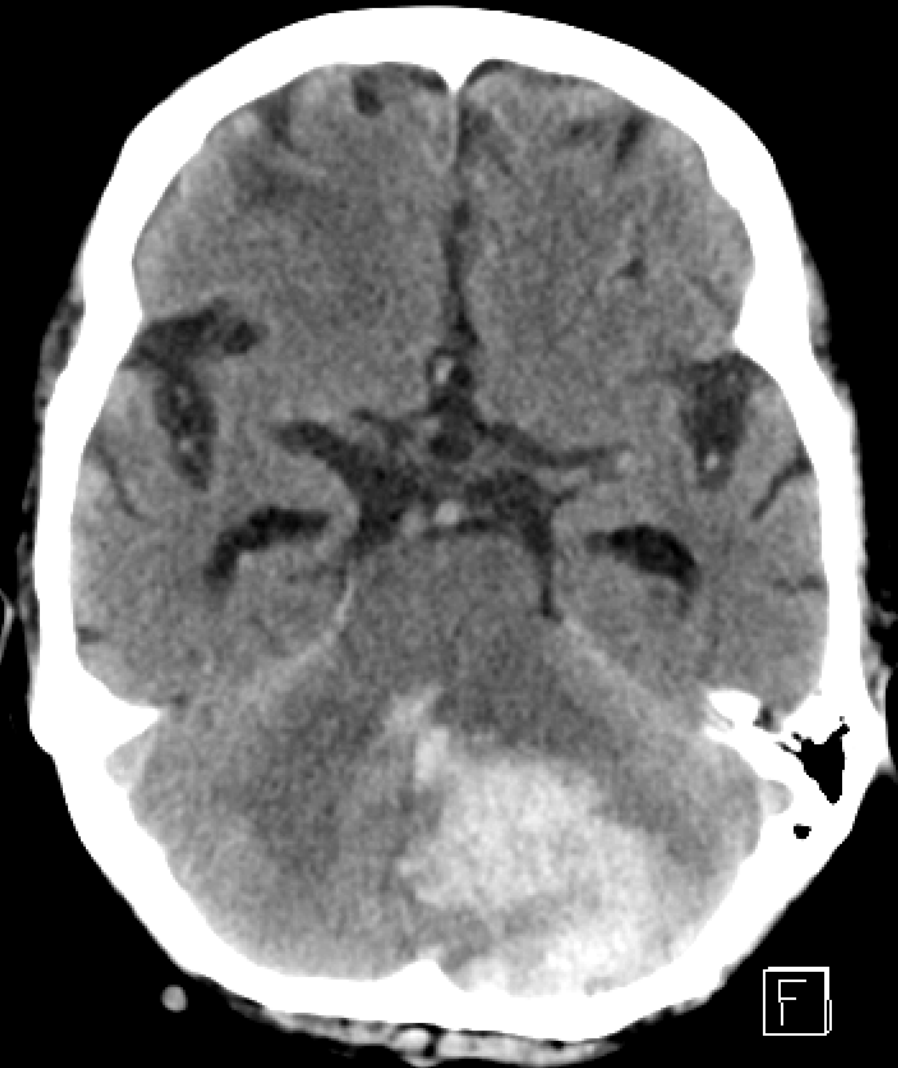
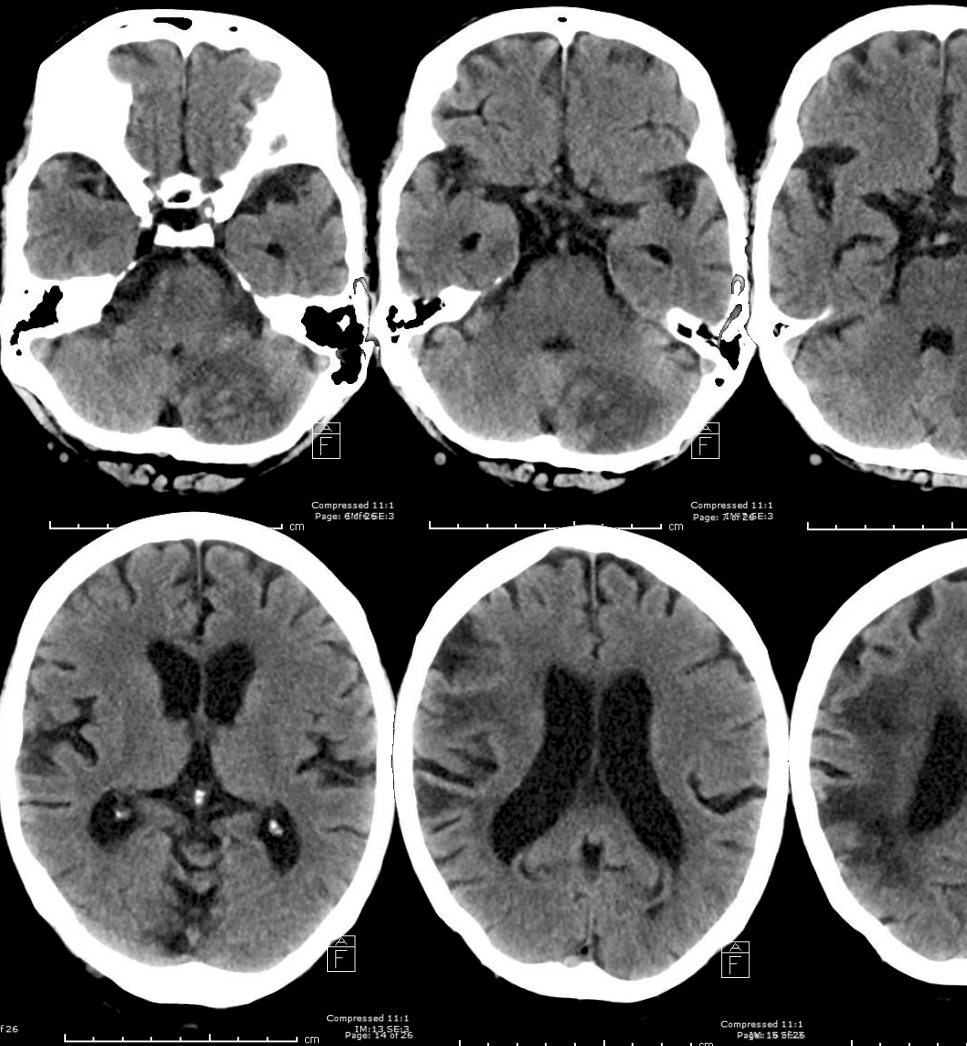
C₀

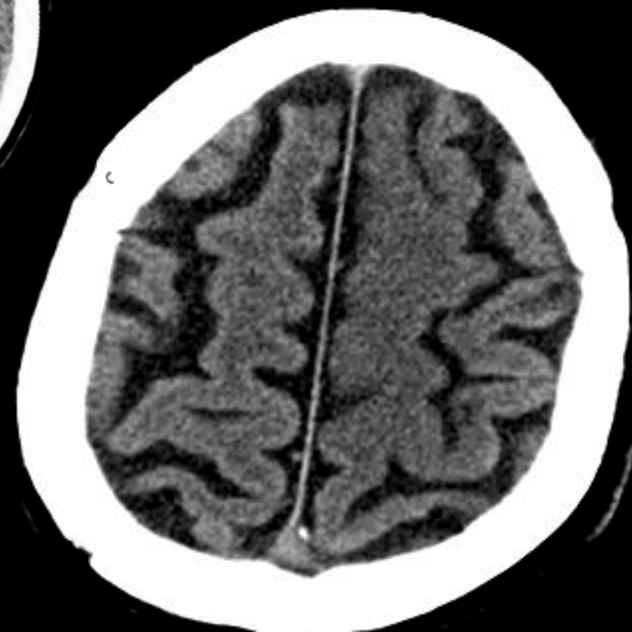


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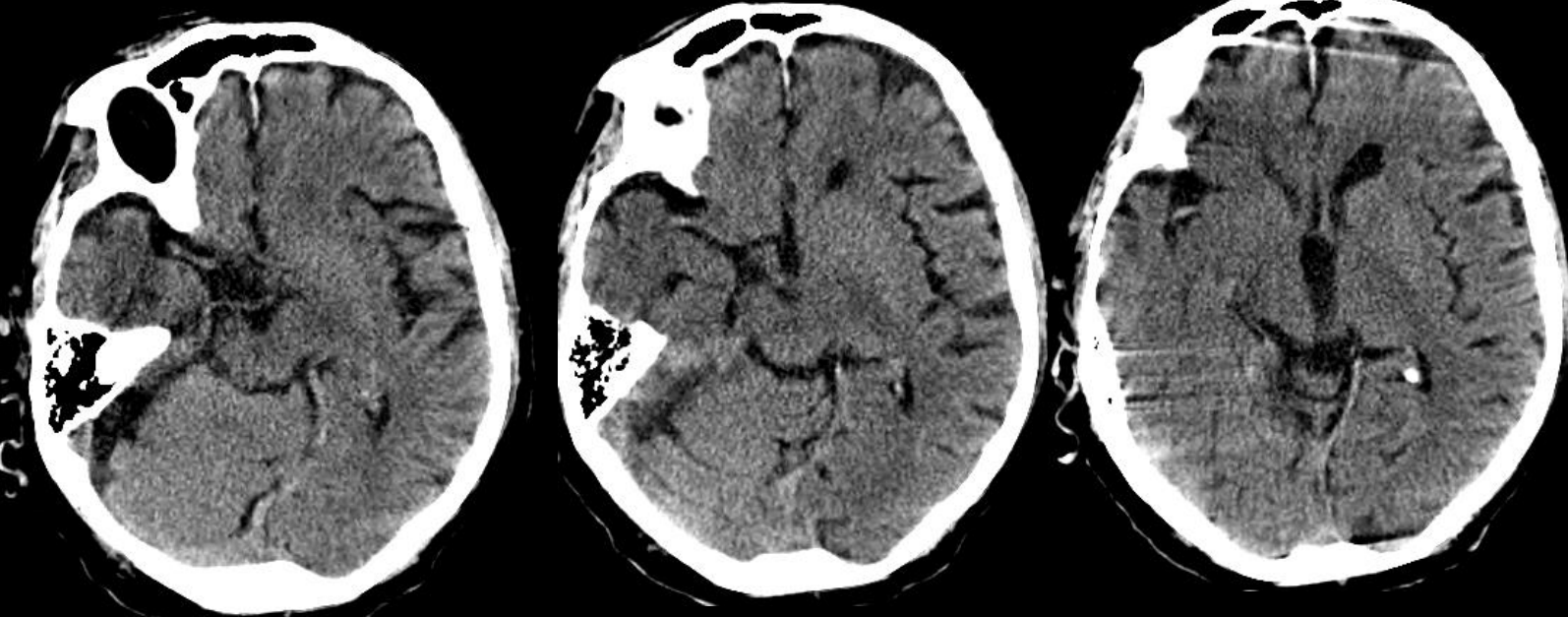
but more common:

72yo F left hemiparesis and dysarthria





STANDARD 5mm

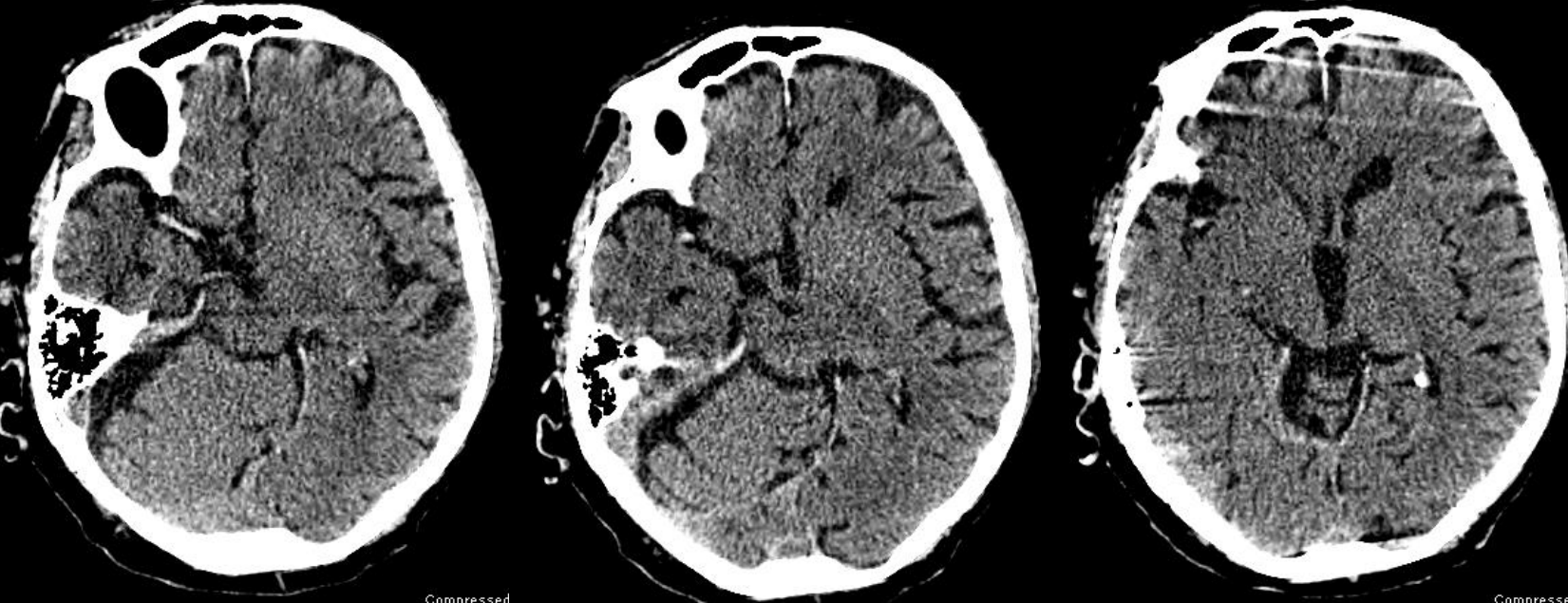


“partial volume effect”

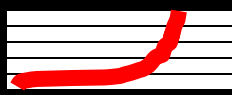
5mm thick



THIN reformat 1mm



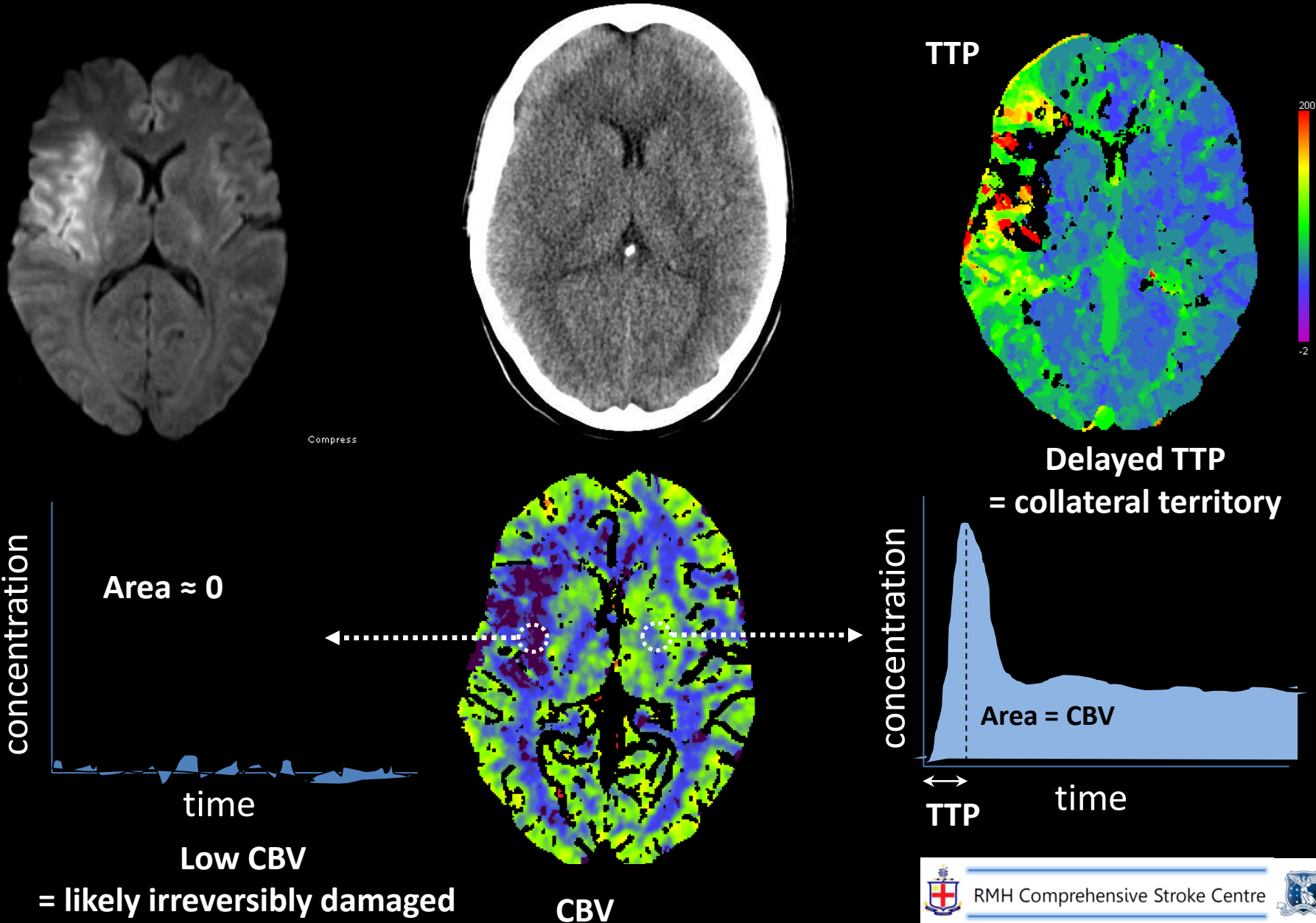
1mm thick



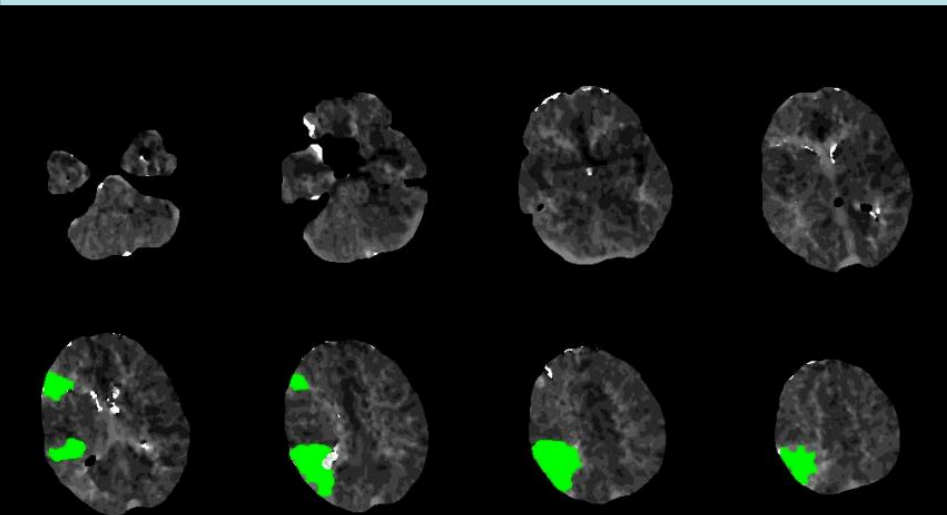
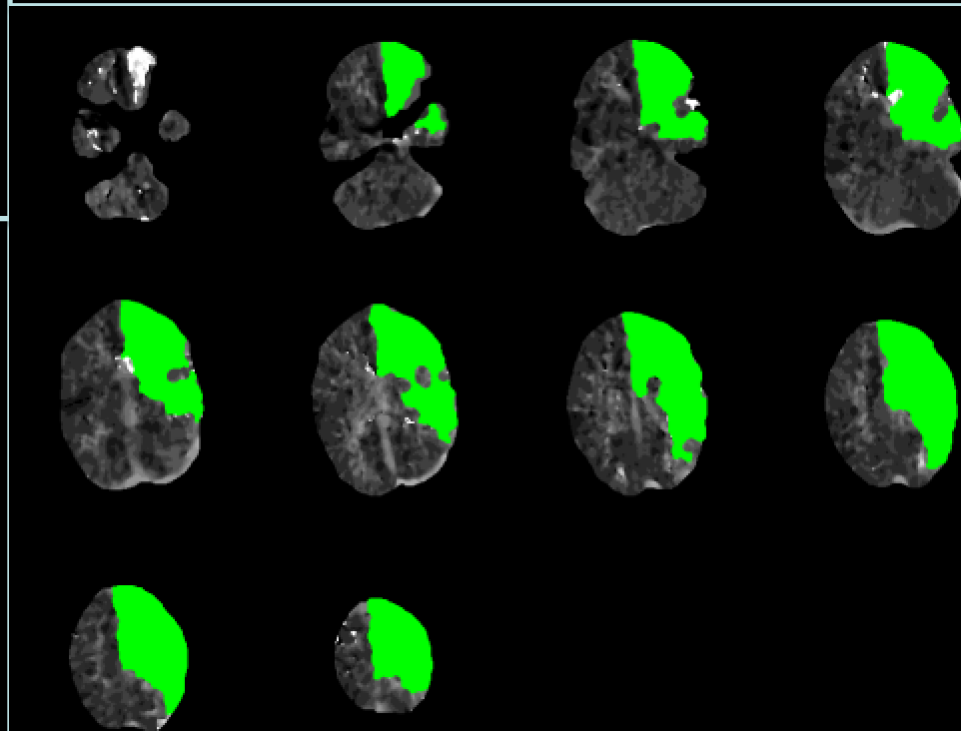
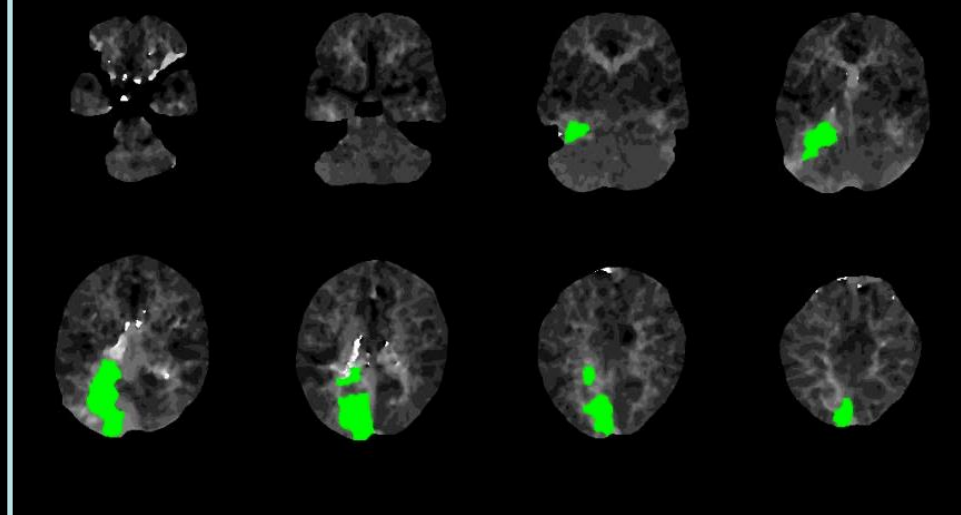
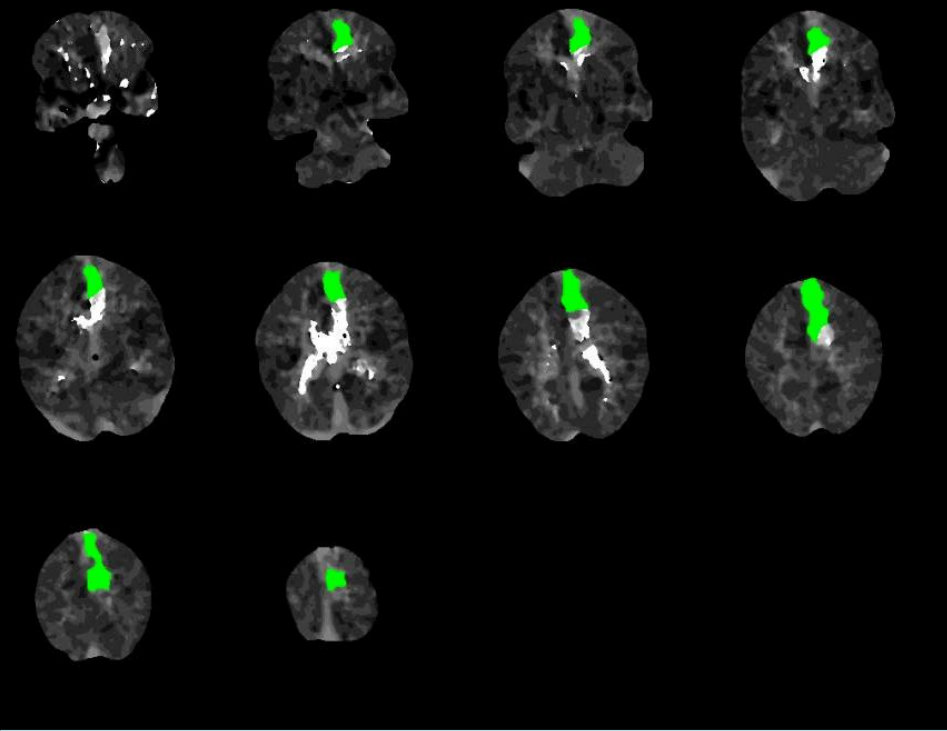
Compressed

Compressed

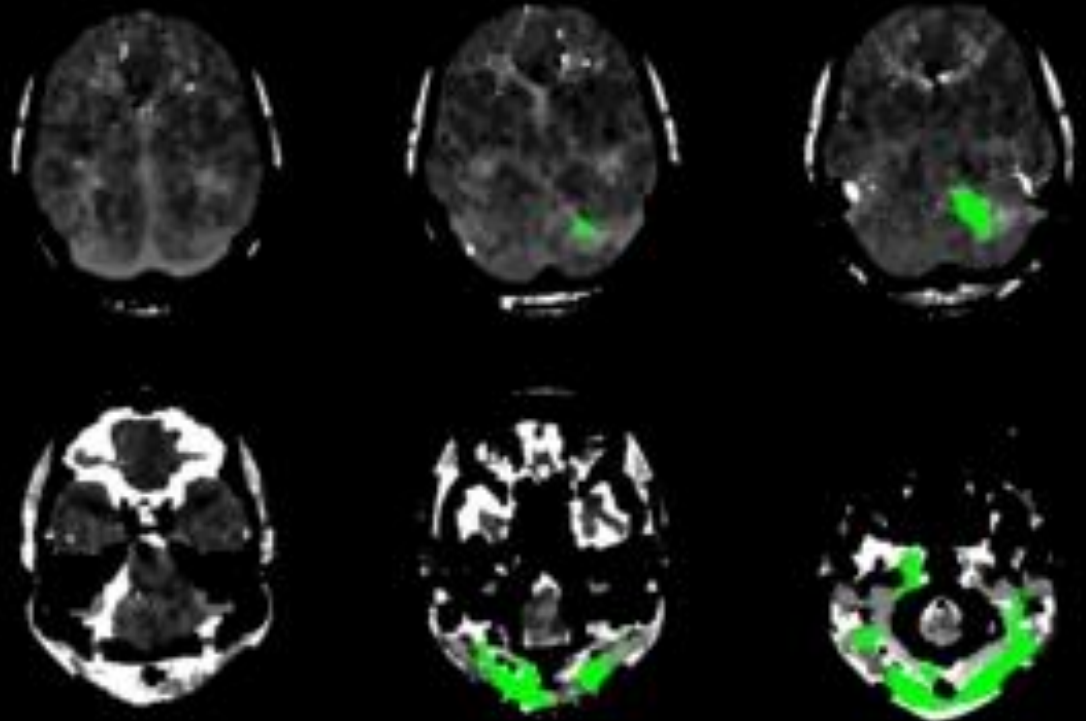
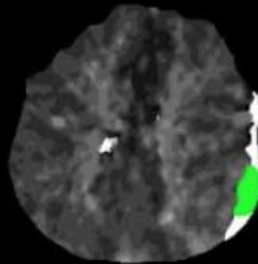
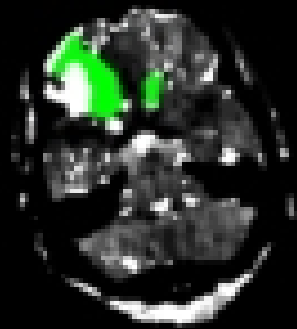
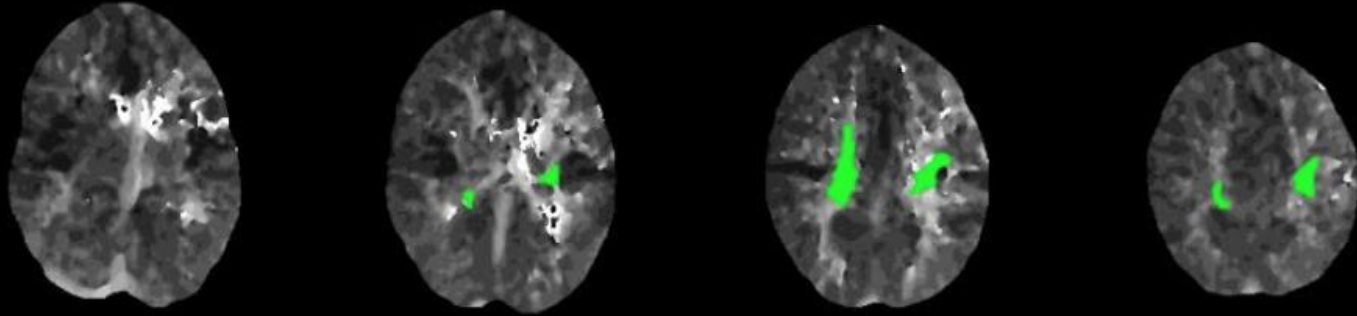
- Principles of CT perfusion



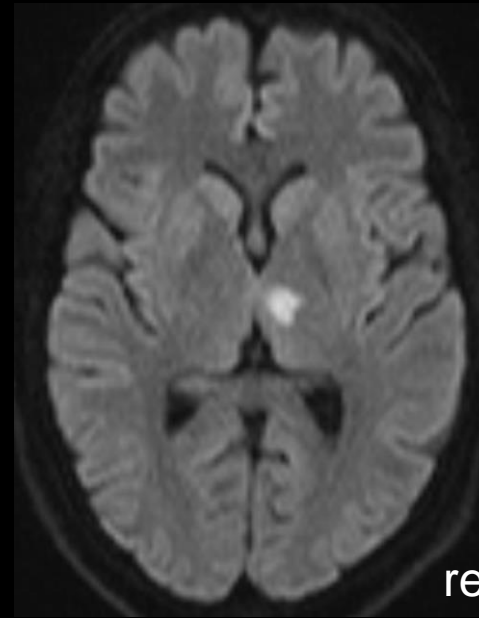
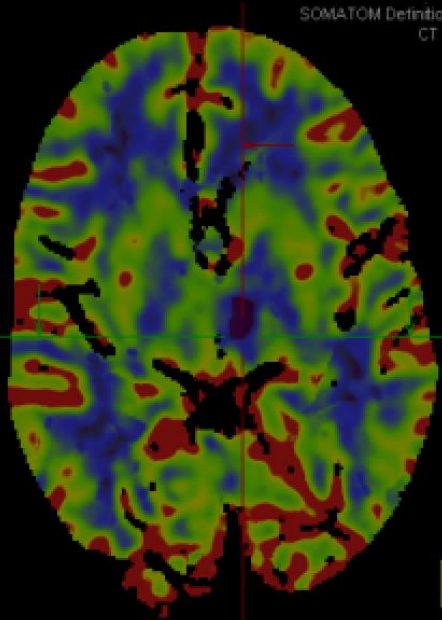
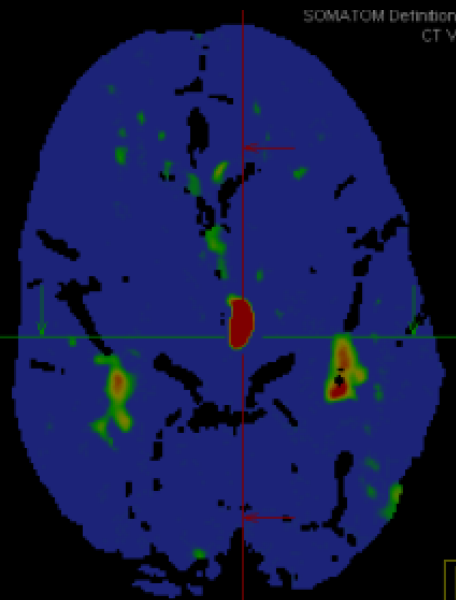
CTP pattern = occlusion site



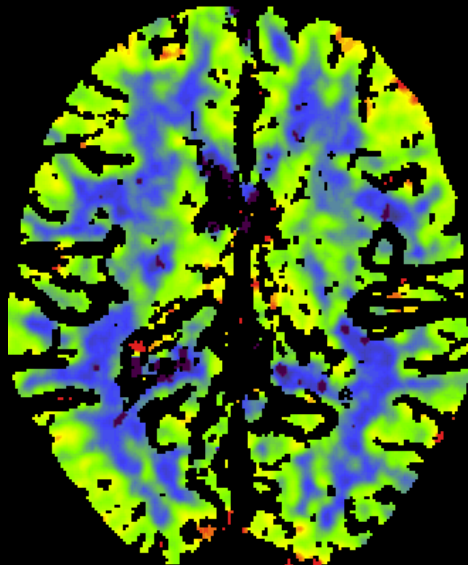
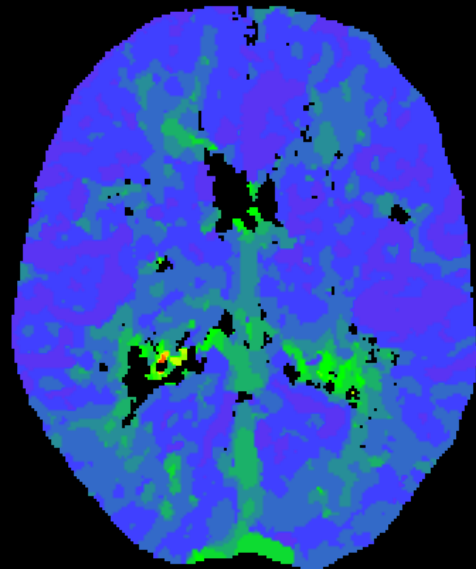
artefacts (non-arterial territory)



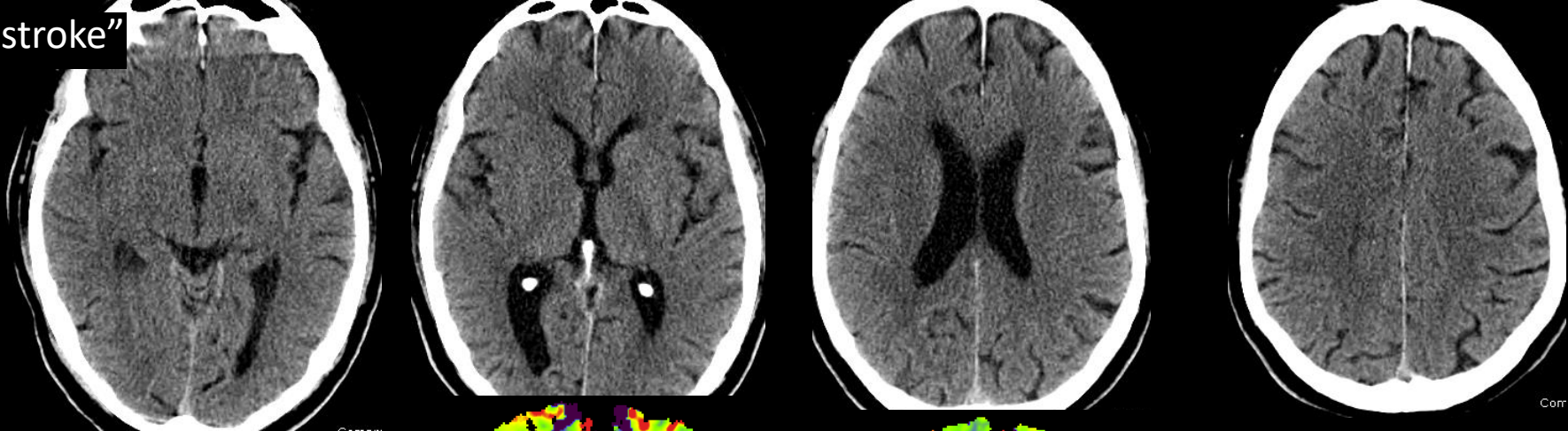
Lacunar infarction



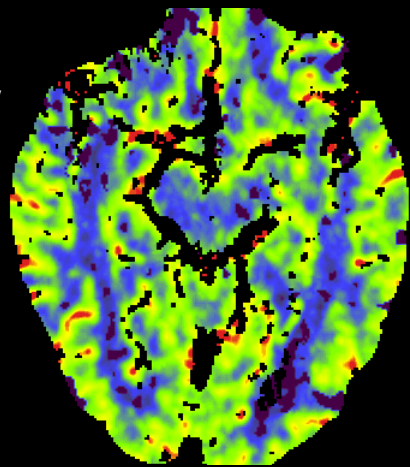
requires excellent image quality (dose) and sharp eyes!



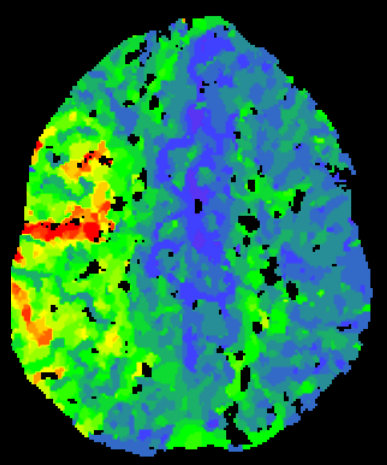
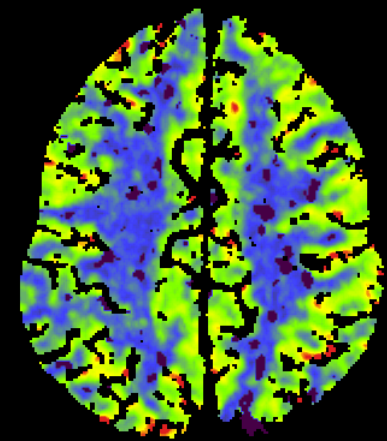
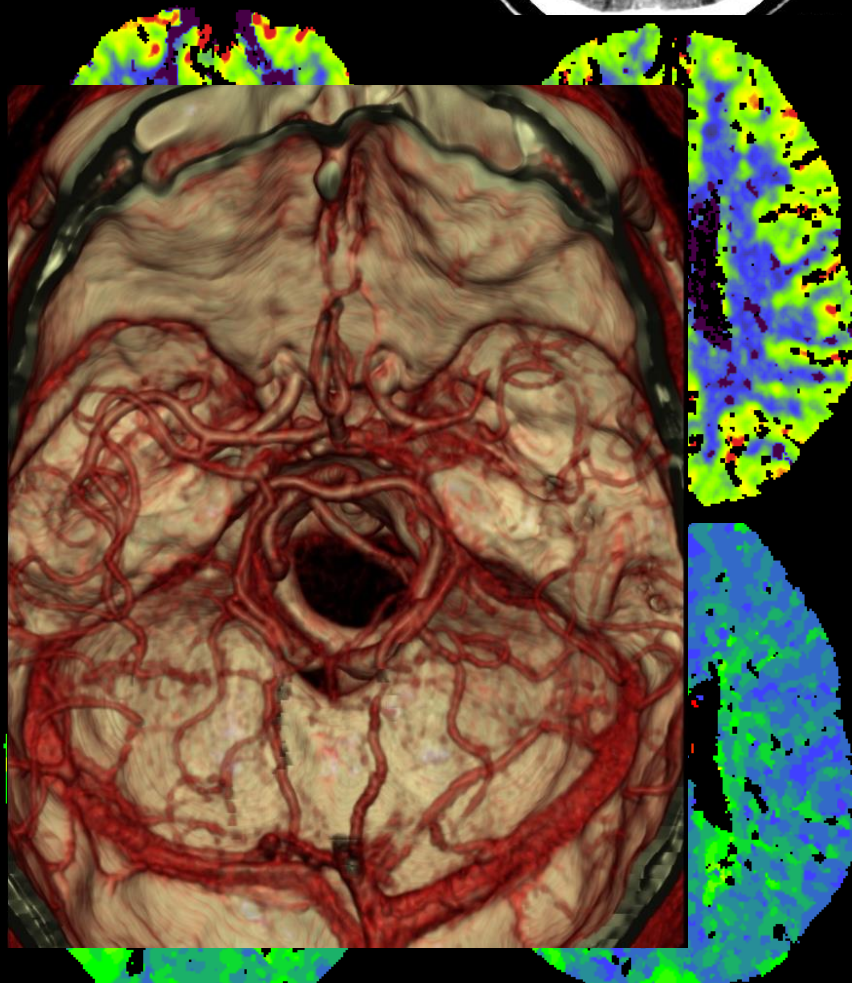
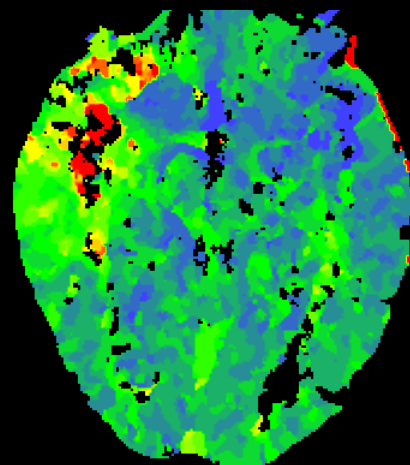
"mild stroke"



CBV



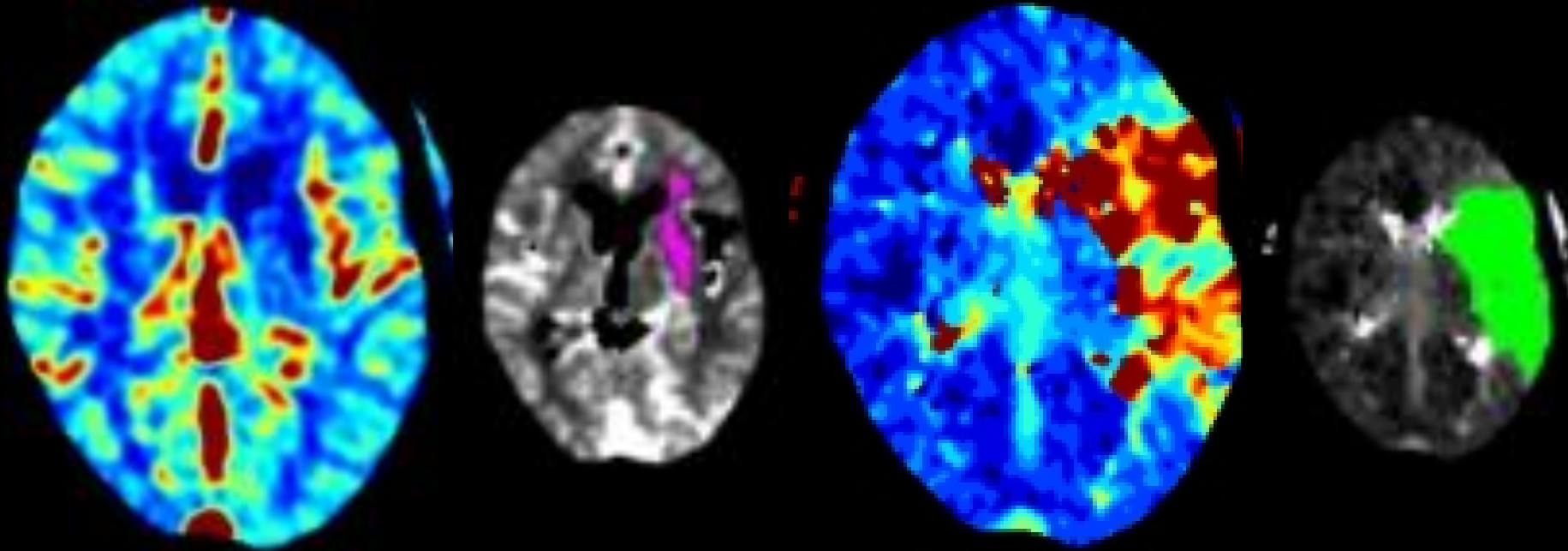
TTP



Cor

CT perfusion imaging –

beyond diagnosis to tissue viability & late-window reperfusion

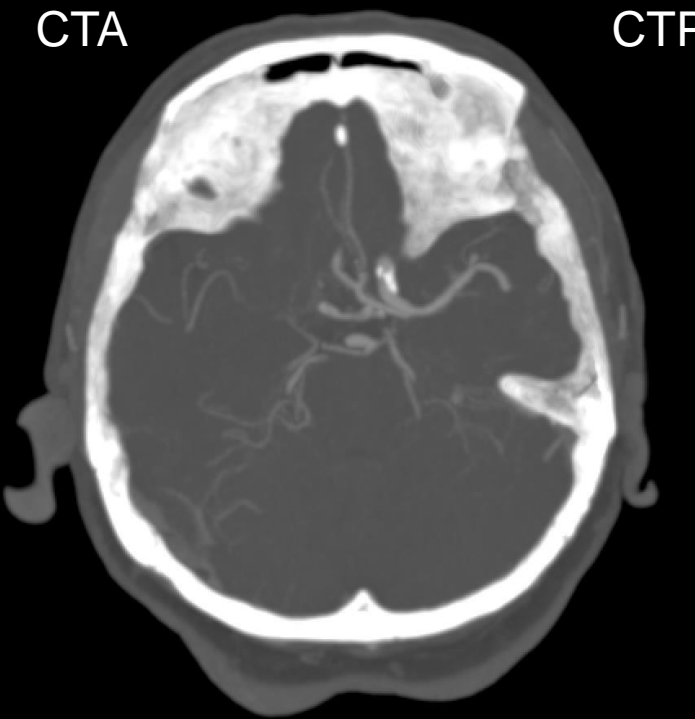


“How much blood supply”
(severely reduced \approx dead)

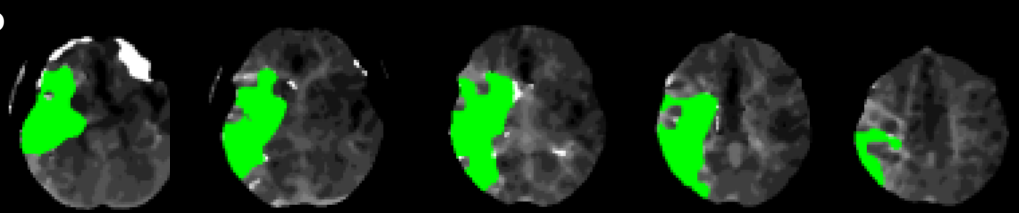
“How delayed is the blood supply”
(severely delayed \approx at risk)

* time to reperf & grey vs white matter

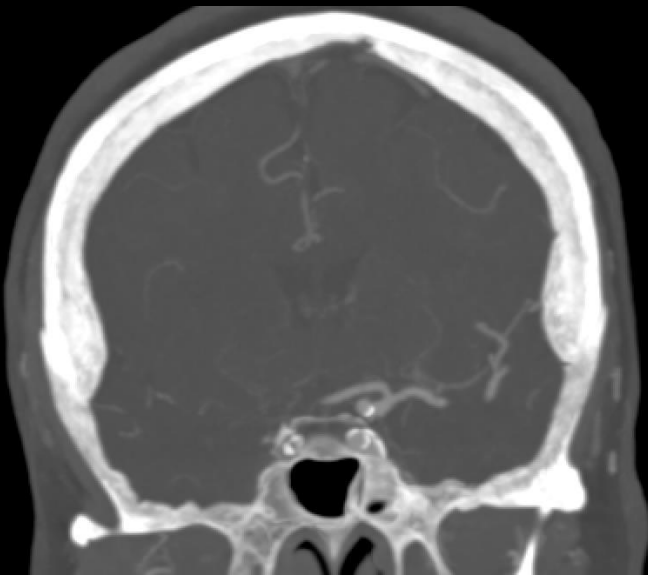
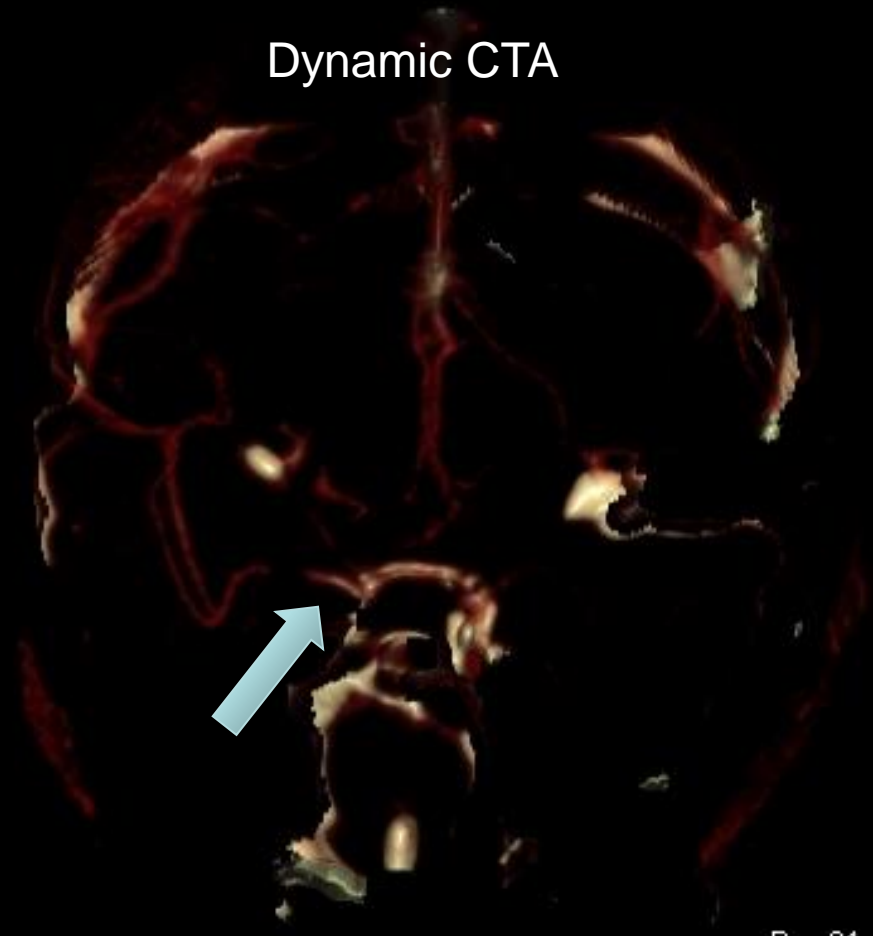
CTA



CTP



Dynamic CTA



30



B 81 W 279
O 52 C 215
IM: 30

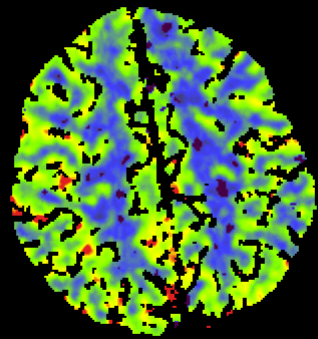
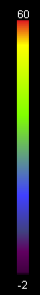
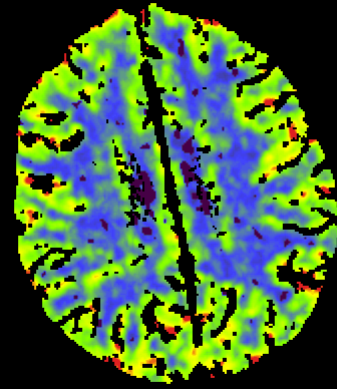
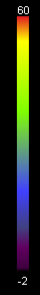
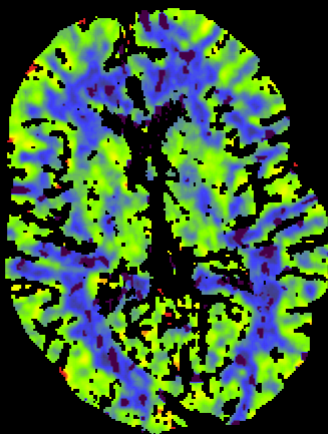
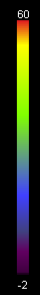
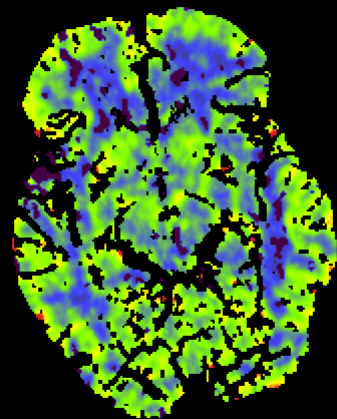
Migraine

AH

AH

AH

AH



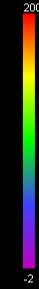
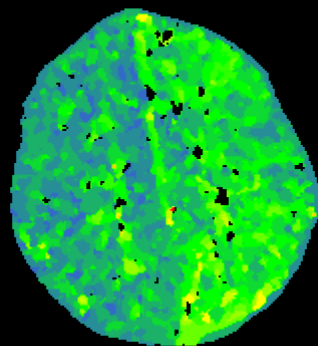
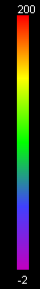
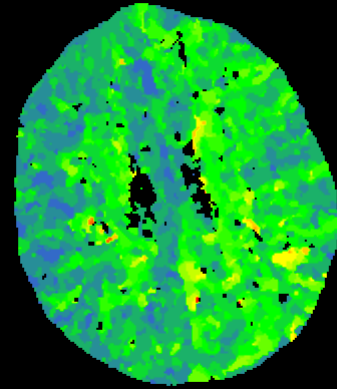
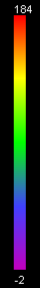
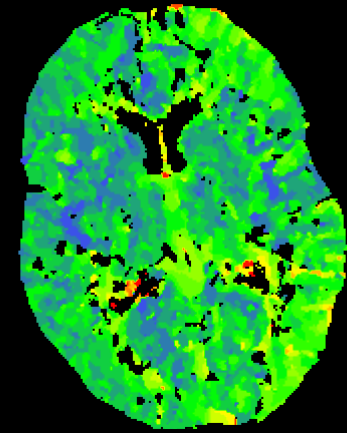
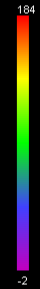
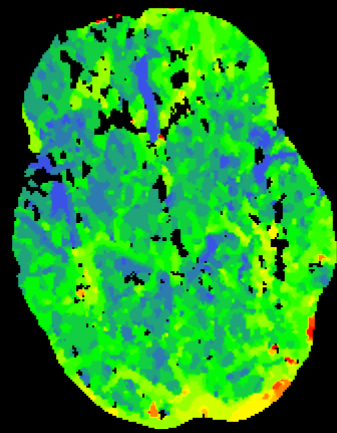
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IM:5 SE:606 of 8

IM:6 SE:60 page: 5 of 8

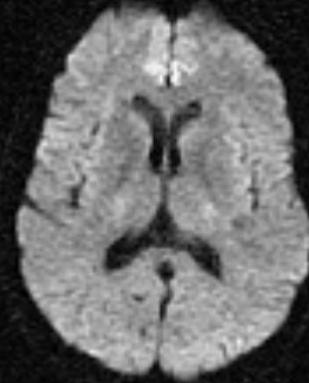
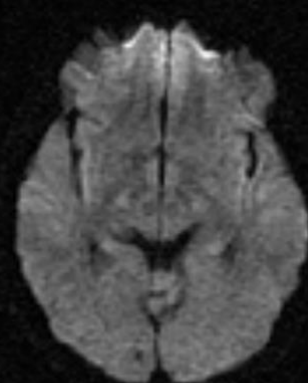
IM:5 SE:607 8

IM:6 SE:607

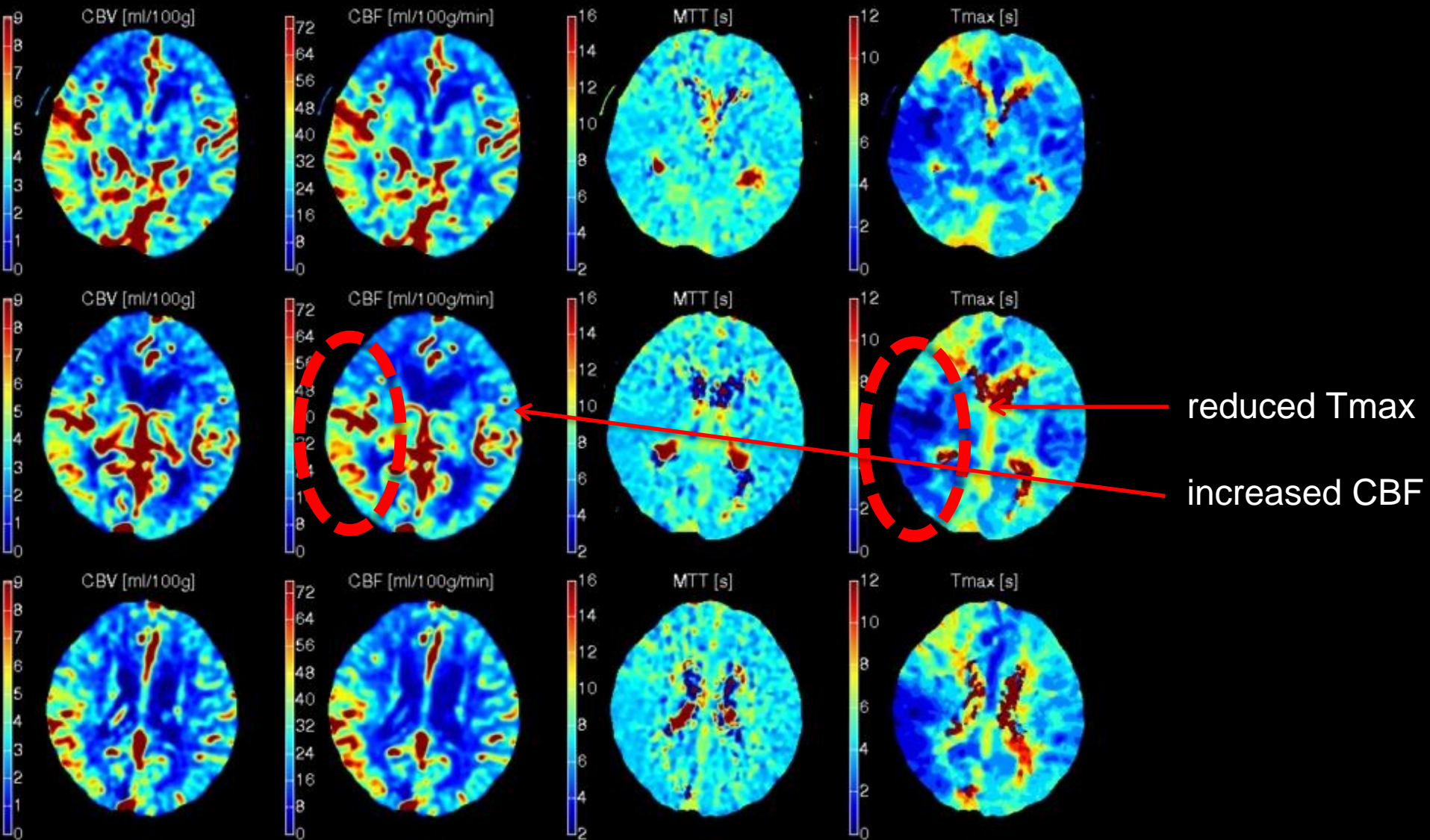


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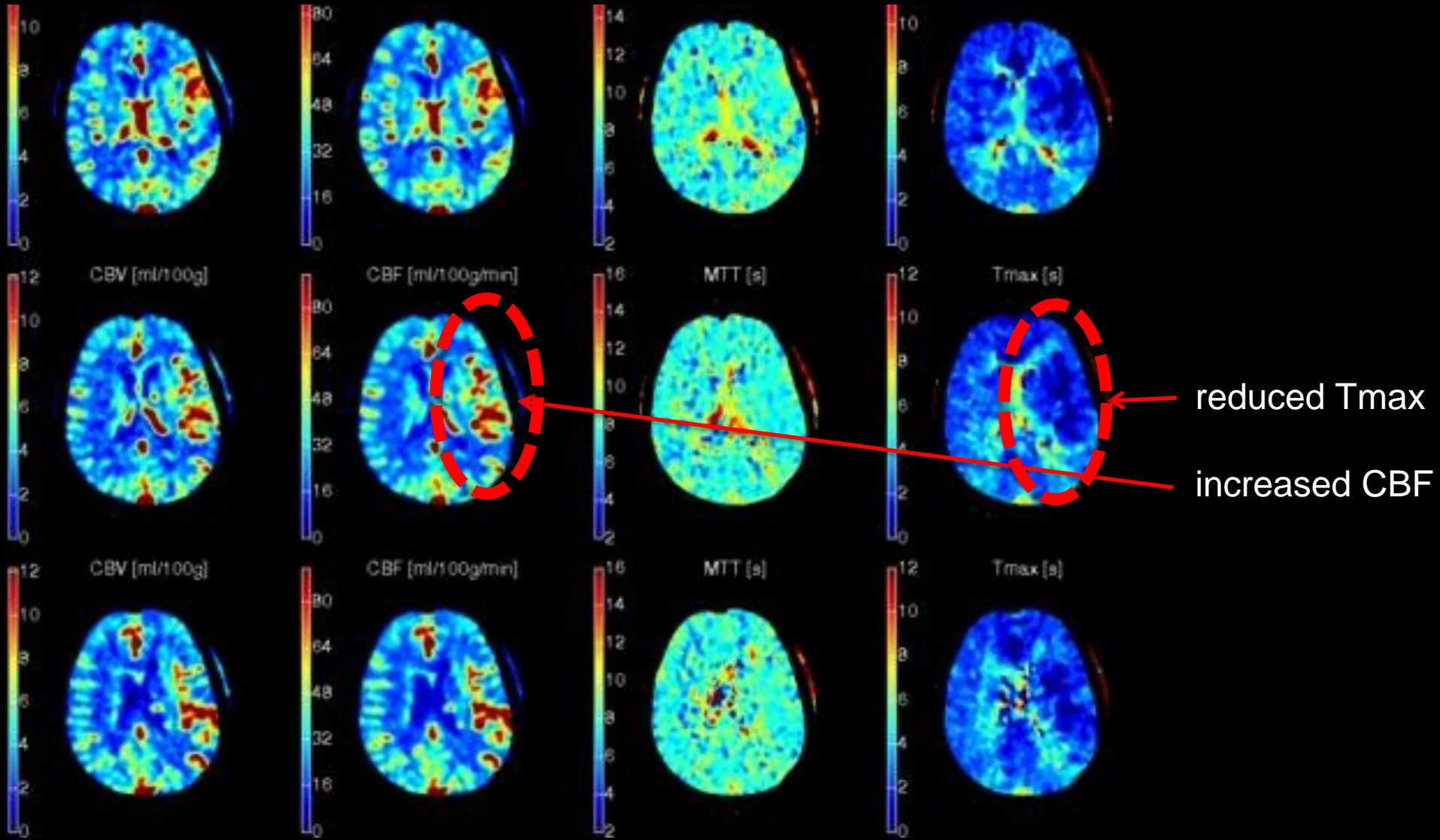
IM:8 SE:607



Post-seizure hyperperfusion



Post-reperfusion hyperperfusion



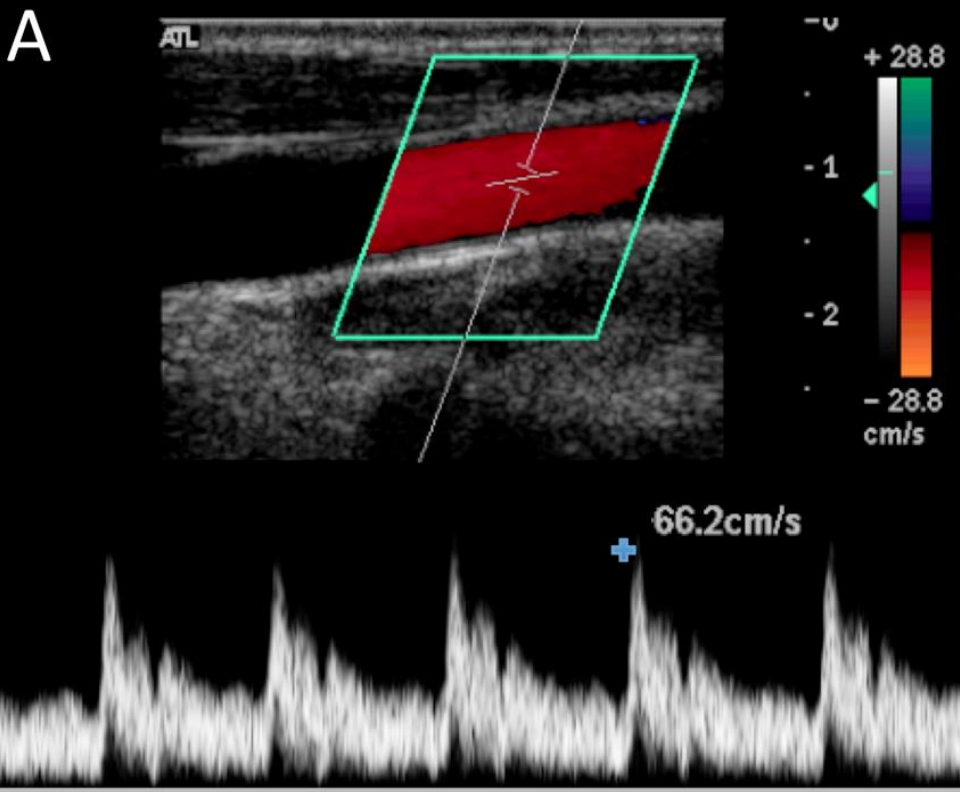
Stroke: mechanism determines prevention

Aetiology:

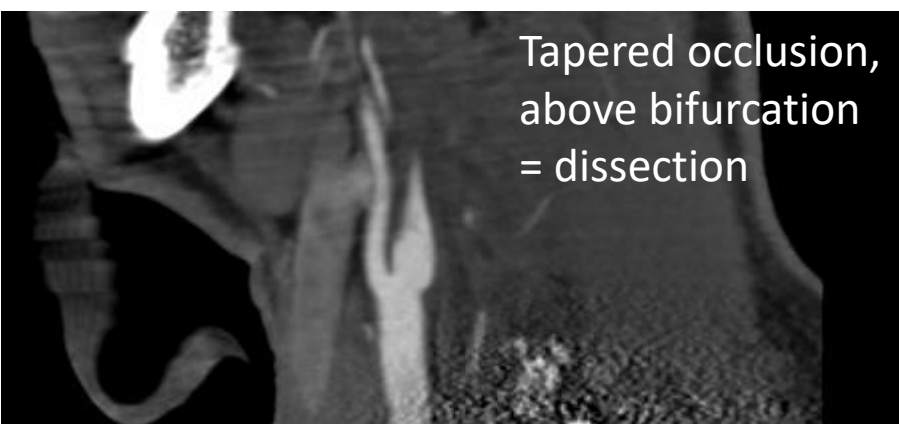
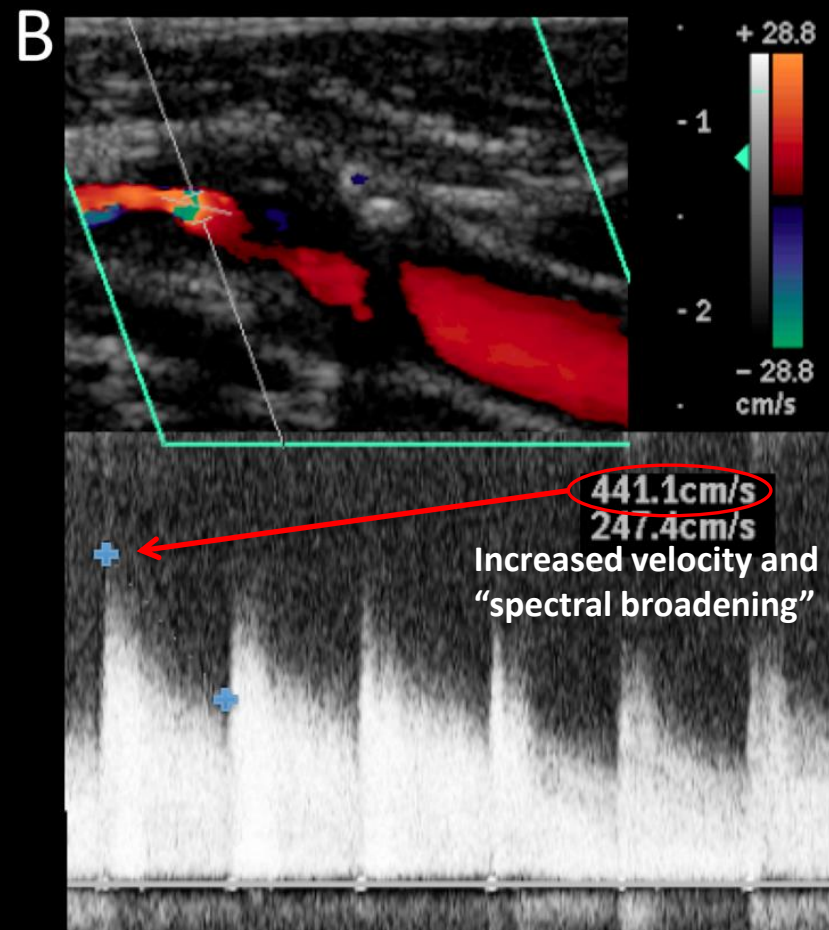
- Carotids – CTA or Doppler US
- US – look for increased velocity/spectral broadening
- >70% **symptomatic stenosis** → endarterectomy
consider for 50-70% stenosis (not if occluded)

- ECG ?AF, evidence for big old infarct (mural thrombus)
- TTE/TOE ?vegetation, mural thrombus, PFO +/- ASA
aortic arch atheroma,

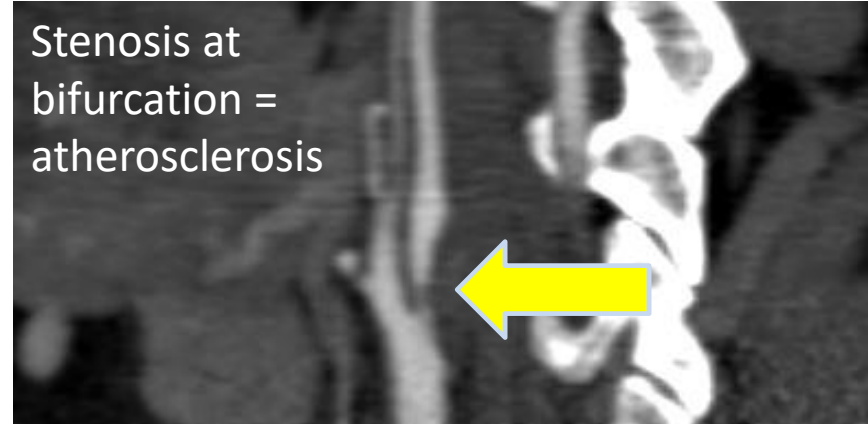
NORMAL



ABNORMAL



CTA

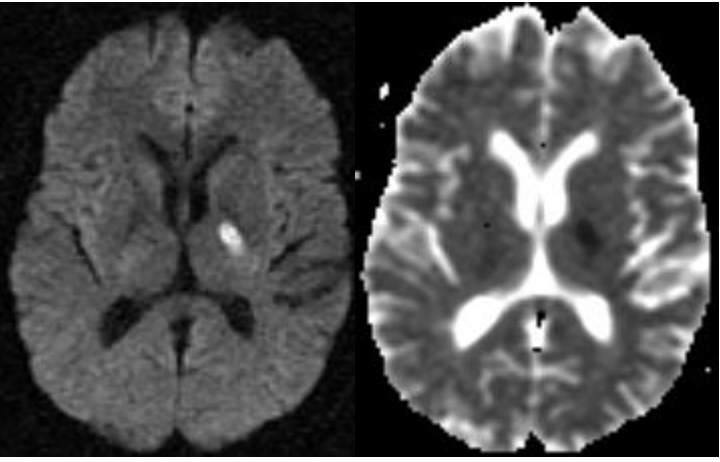


Stroke: mechanism determines prevention

Young stroke aetiology:

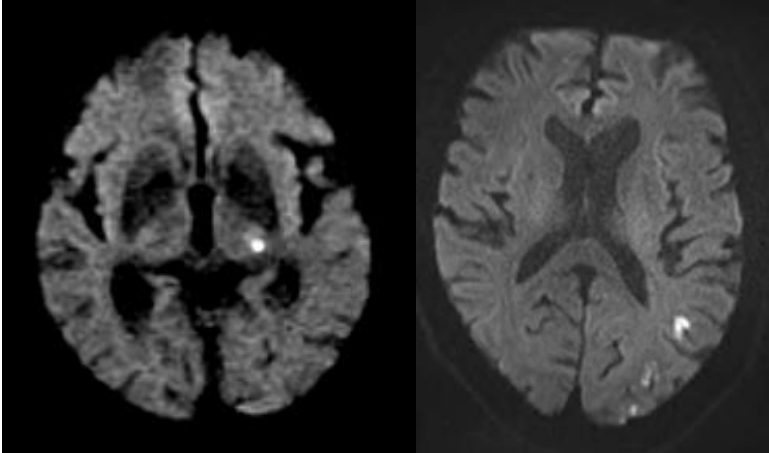
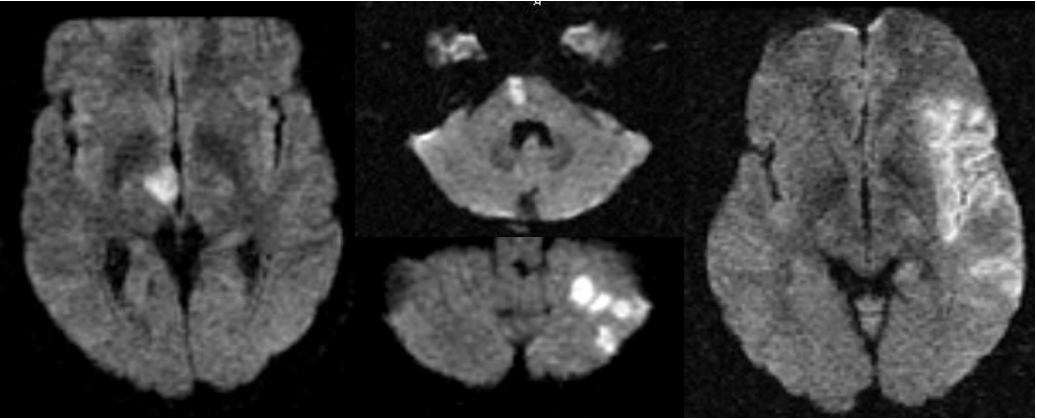
- Carotids – prefer CTA ?dissection
- TTE/TOE ?vegetation, mural thrombus, **PFO +/- ASA**
aortic arch atheroma
TTE with bubbles – better Valsalva to detect shunt, TOE for valves
- Vasculitic & thrombophilic bloods
 - “vasculitic”: ANA, ENA, RF, ANCA, C3/4,
 - “thrombophilic” – FBE (thrombocytosis, polycythemia)
antiphospholipid (anticardiolipin IgG, anti β_2 glycoprotein, lupus inhibitor), protein C, S, antithrombin, factor V Leiden and prothrombin mutations,
?homocysteine
 - ?Fabry’s testing (dried blood spot)

Diffusion MRI



DWI ADC
Diffusion-weighted imaging Apparent diffusion co-efficient

Always check that the bright area on DWI is “true” restriction ie dark on ADC vs “T2 shine-through”



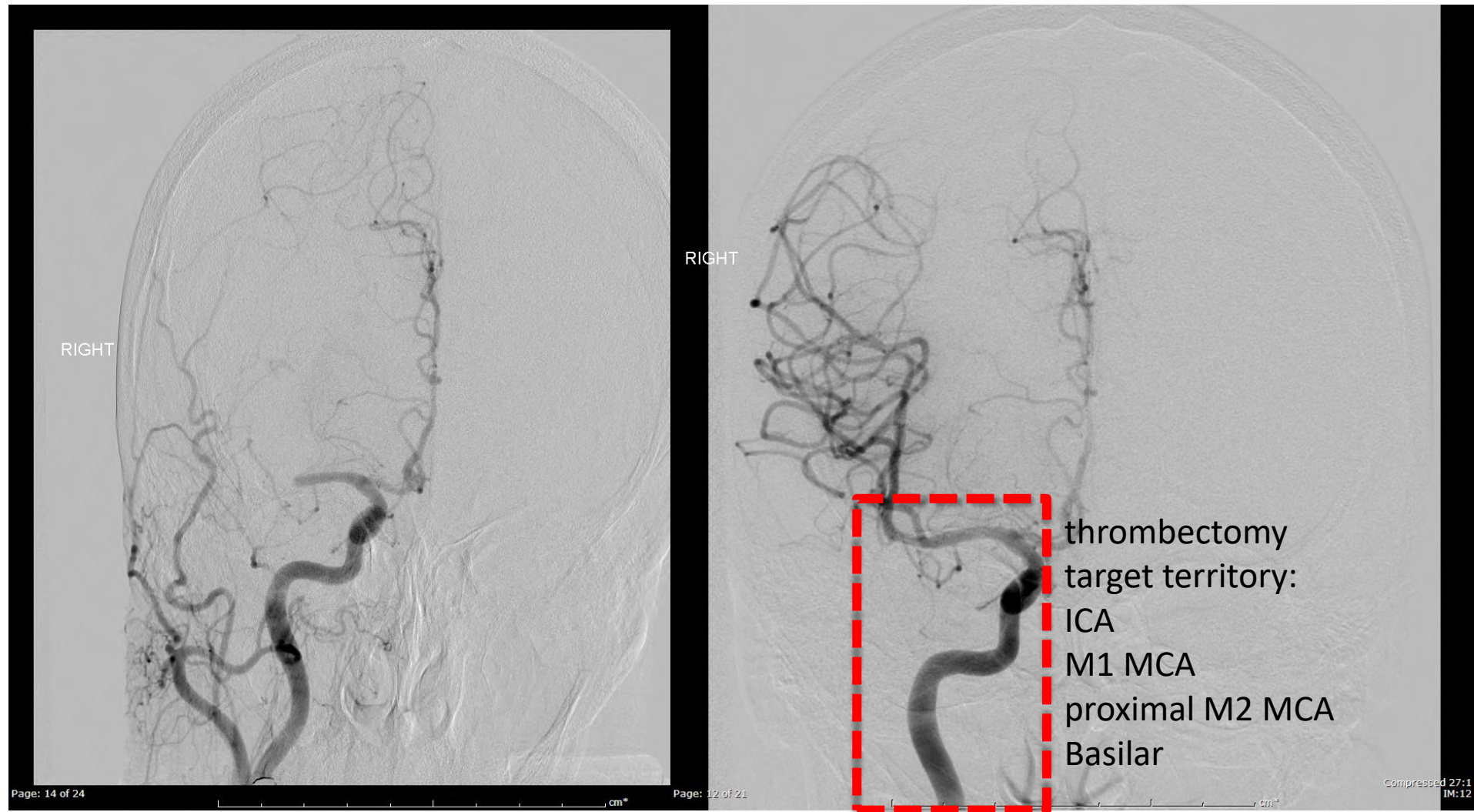
“TIA” but DWI +ve = stroke
High risk recurrence

T1 fat saturated image -



Advanced imaging: Digital subtraction angiogram

mostly for treatment, occasionally if suspect dissection/vascular malformation and CTA equivocal



groin puncture 19.15
Pre (19.21) Post (19.40)

?subarachnoid hemorrhage

- Non-con CT
- If normal → LP for xanthochromia (foil - light protected)
- CTA if SAH confirmed (otherwise you find lots of incidental aneurysms)
- DSA if looks treatable via endovascular or if CTA equivocal

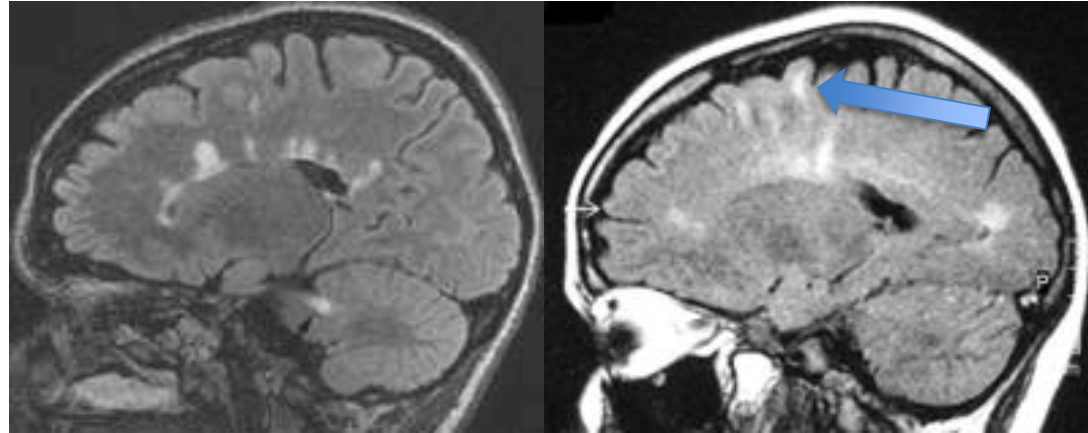
- Thunderclap headache without SAH?
 - Reversible cerebral vasoconstriction
dissection, CVST, colloid cyst?
 - Exertional headache

?MS

2017 revision – McDonald Criteria

“high specificity” white matter lesion locations:

- Periventricular
- Juxtacortical “U-fibre”/cortical
- Infratentorial
- Spinal cord*



Dissemination in space = at least 2 lesions in different “high specificity” regions

Dissemination in time = 2nd scan with a new lesion (at any time)

or a single scan with both enhancing and non-enhancing lesions or OCBs

*the symptomatic lesion is now counted towards “dissemination in space”

NB periventricular lesions less specific – MAGNIMS 2016 criteria required ≥ 3 ...

NB 2 clinical attacks separated in space and time still counts as clinically definite MS

PPMS = 1yr of disease progression & 2/3 of:

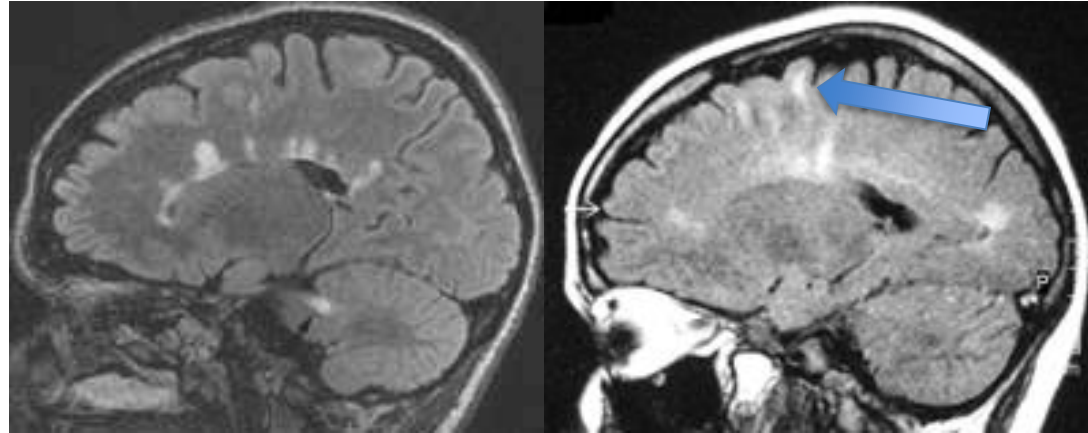
Dissemination in space of cord, brain or oligoclonal bands

?MS

2017 revision – McDonald Criteria

“high specificity” white matter lesion locations:

- Periventricular
- Juxtacortical “U-fibre”/cortical
- Infratentorial
- Spinal cord*



“the McDonald criteria were not developed to differentiate multiple sclerosis from other conditions but to identify multiple sclerosis or a high likelihood of the disease in patients with a typical clinically isolated syndrome once other diagnoses have been deemed unlikely”

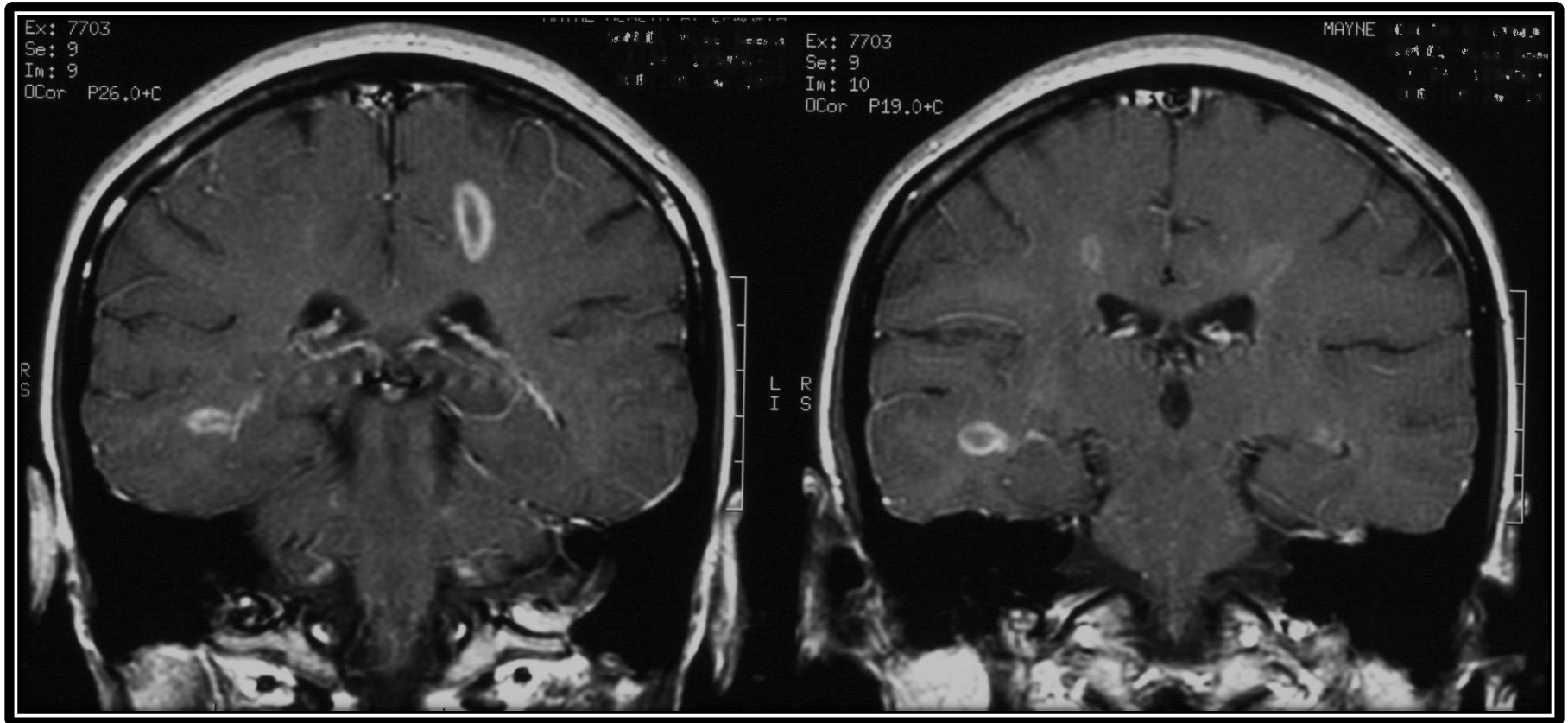
Easier to diagnose MS earlier – starting treatment separate decision
we need to consider the likely disease activity vs burden of therapy

NB 2 clinical attacks separated in space and time still counts as clinically definite MS

PPMS = 1yr of disease progression & 2/3 of:

Dissemination in space of cord, brain or oligoclonal bands

Gadolinium Enhancing lesions



New lesions usually enhance for <1 month. With concern about gadolinium accumulation, diffusion restriction often used as a surrogate for active lesions

?MS

CSF

- a few lymphocytes common (usually <50)
- unmatched oligoclonal bands (paired serum)
- present in >90% clinically definite MS
- differential: vasculitis, CNS infection, paraneoplastic

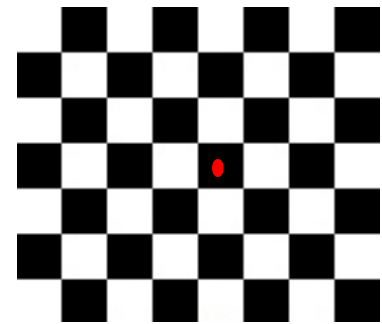
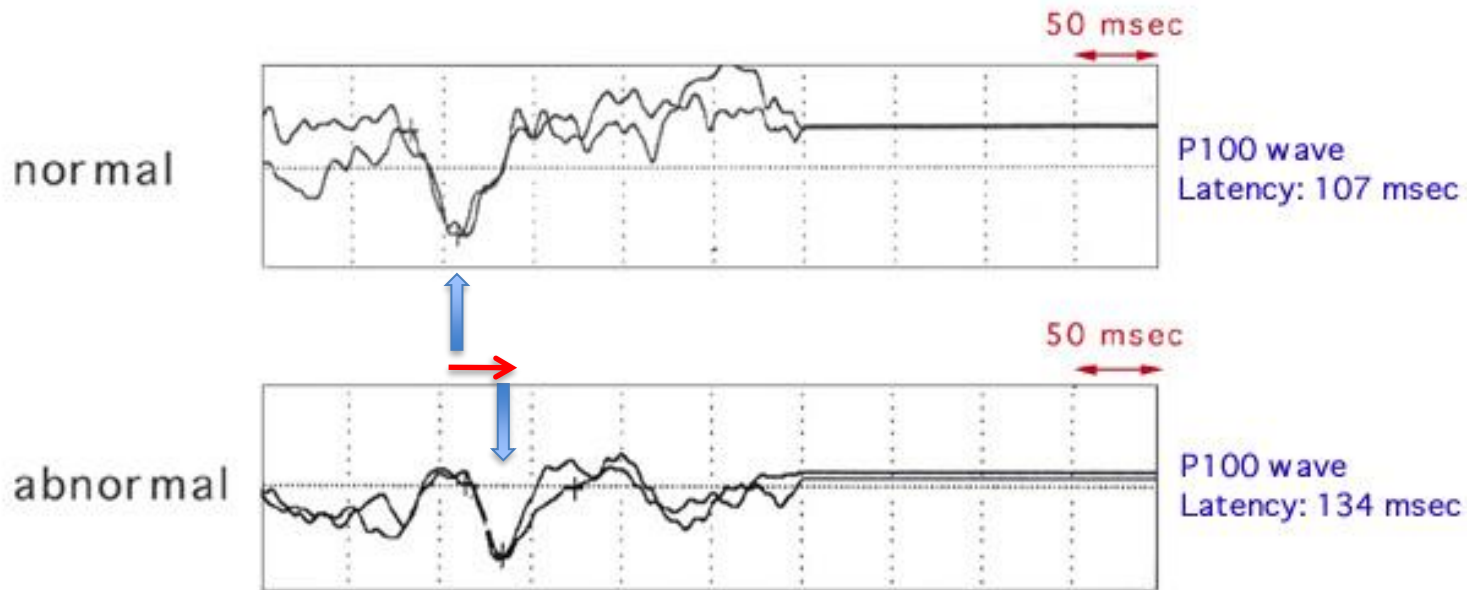
serum



CSF

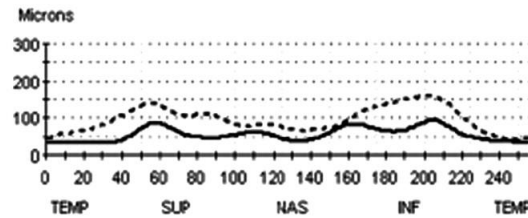
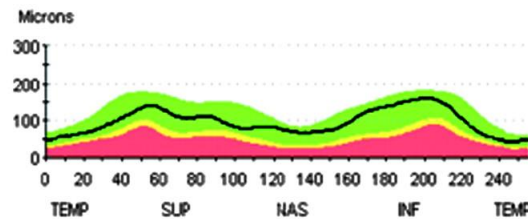
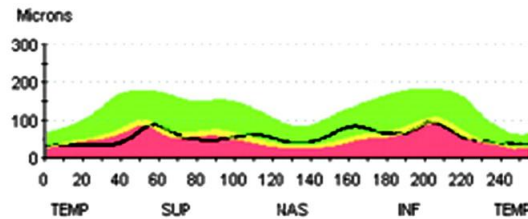
?MS

Visual Evoked Potentials (VEP)

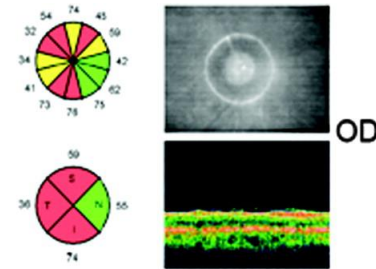
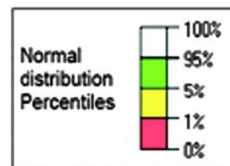


?MS

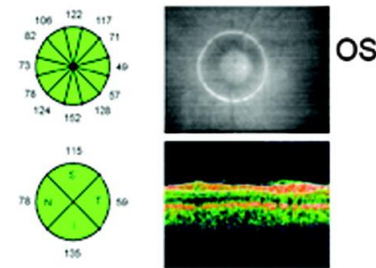
- OCT
- Optical coherence tomography (light)
- Loss of retinal nerve fibre layer after right optic neuritis
- may have initial swelling



OD	Scans used	1, 2, 3
OS	Scans used	1, 2, 3



Signal Strength (Max 10)	9
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Signal Strength (Max 10)	10
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	OD (N=3)	OS (N=3)	OD-OS
lmax/Smax	1.08	1.14	-0.07
Smax/lmax	0.93	0.88	0.05
Smax/Tavg	2.46	2.36	0.10
lmax/Tavg	2.65	2.69	-0.04
Smax/Navg	1.61	1.79	-0.18
Max-Min	63.00	117.00	-54.00
Smax	88.00	139.00	-51.00
lmax	94.00	159.00	-65.00
Savg	59.00	115.00	-56.00
lavg	74.00	135.00	-61.00
Avg.Thick	55.80	96.68	-40.88

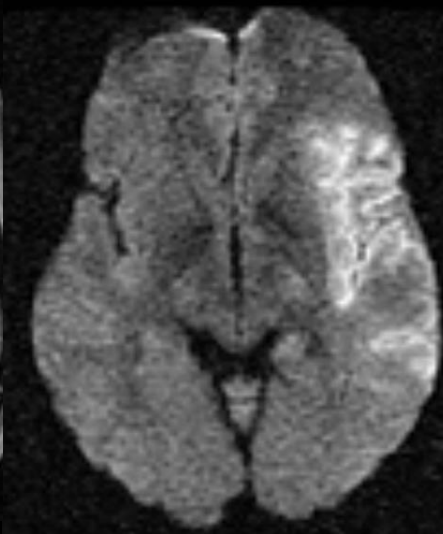
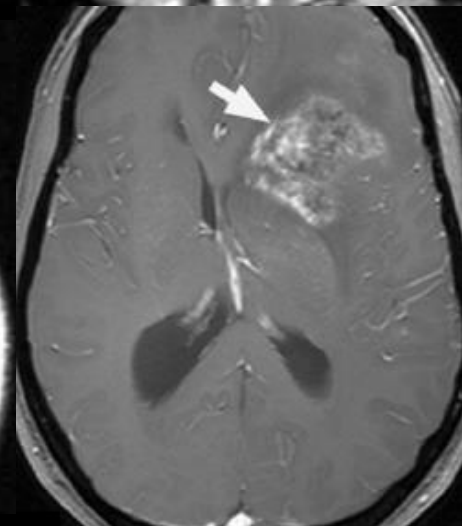
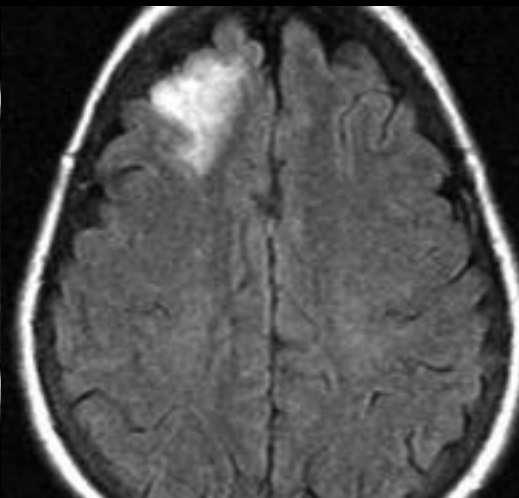
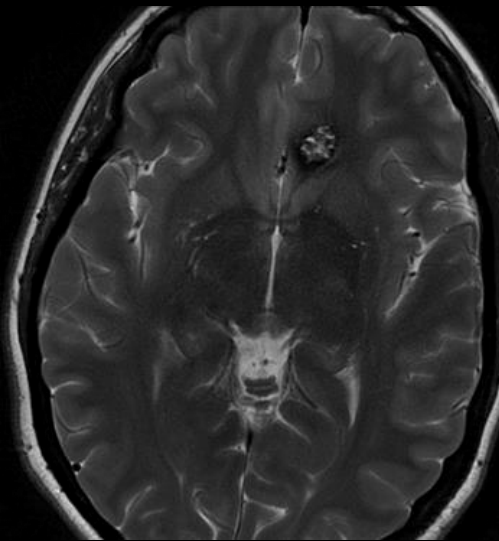
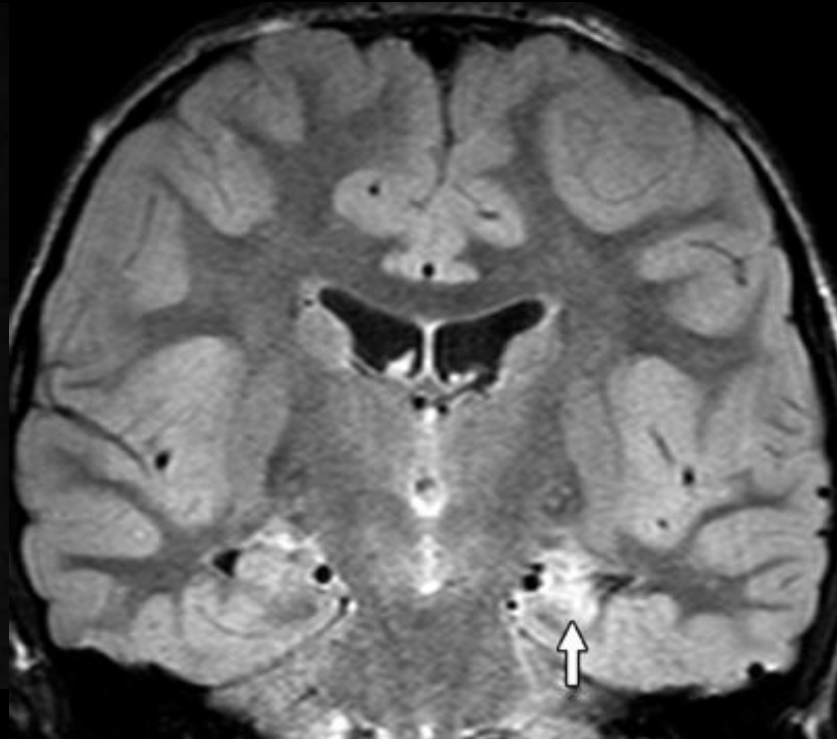
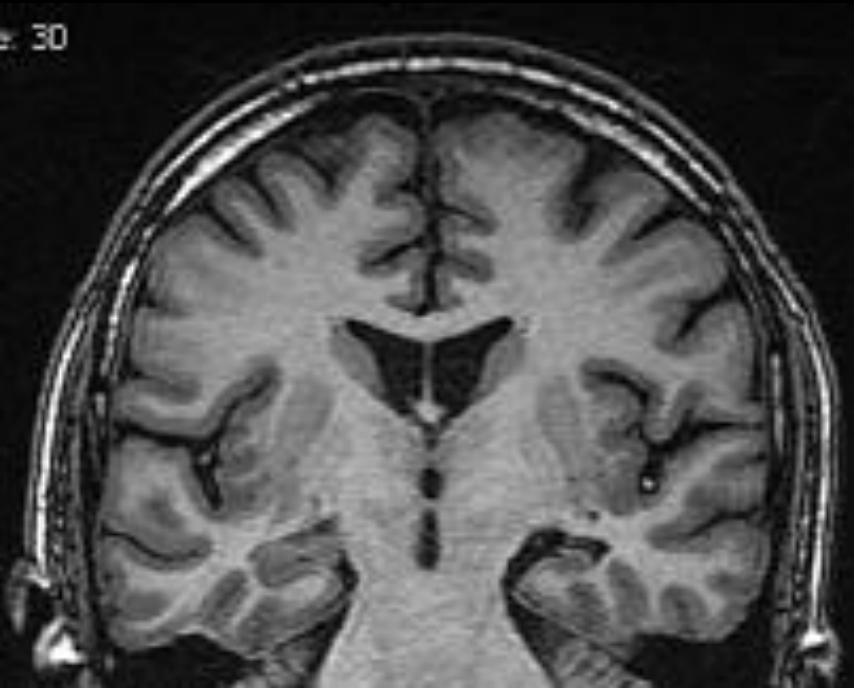
?MS

- Consider other inflammatory diseases:
 - Neuromyelitis optica (anti-aquaporin4 “NMO” Abs)
 - longitudinally extensive transverse myelitis (LETM) ≥ 3 vertebral segments
 - anti-MOG antibody syndrome
 - isolated optic neuritis 55%, half bilateral; TM (often LETM) 18%; ADEM 18%
 - Sarcoid, Behçet’s
- Many newer MS treatments are immunosuppressive
 - Consider immunization status and viral status similar to pre-transplant etc
 - VZV vax
- Serology for JC virus if considering natalizumab (PML risk stratification)

?seizure

- Hx (especially from a witness) is the best test
 - use the telephone if no witness present!
- **EEG**
- **MRI**
- (PET/SPECT – hypometabolism in lesion at rest but hypermetabolic during seizure)
- Pharmacogenomics
 - Carbamazepine, Stevens-Johnson Syndrome, **HLA B1502**

Epilepsy - MRI



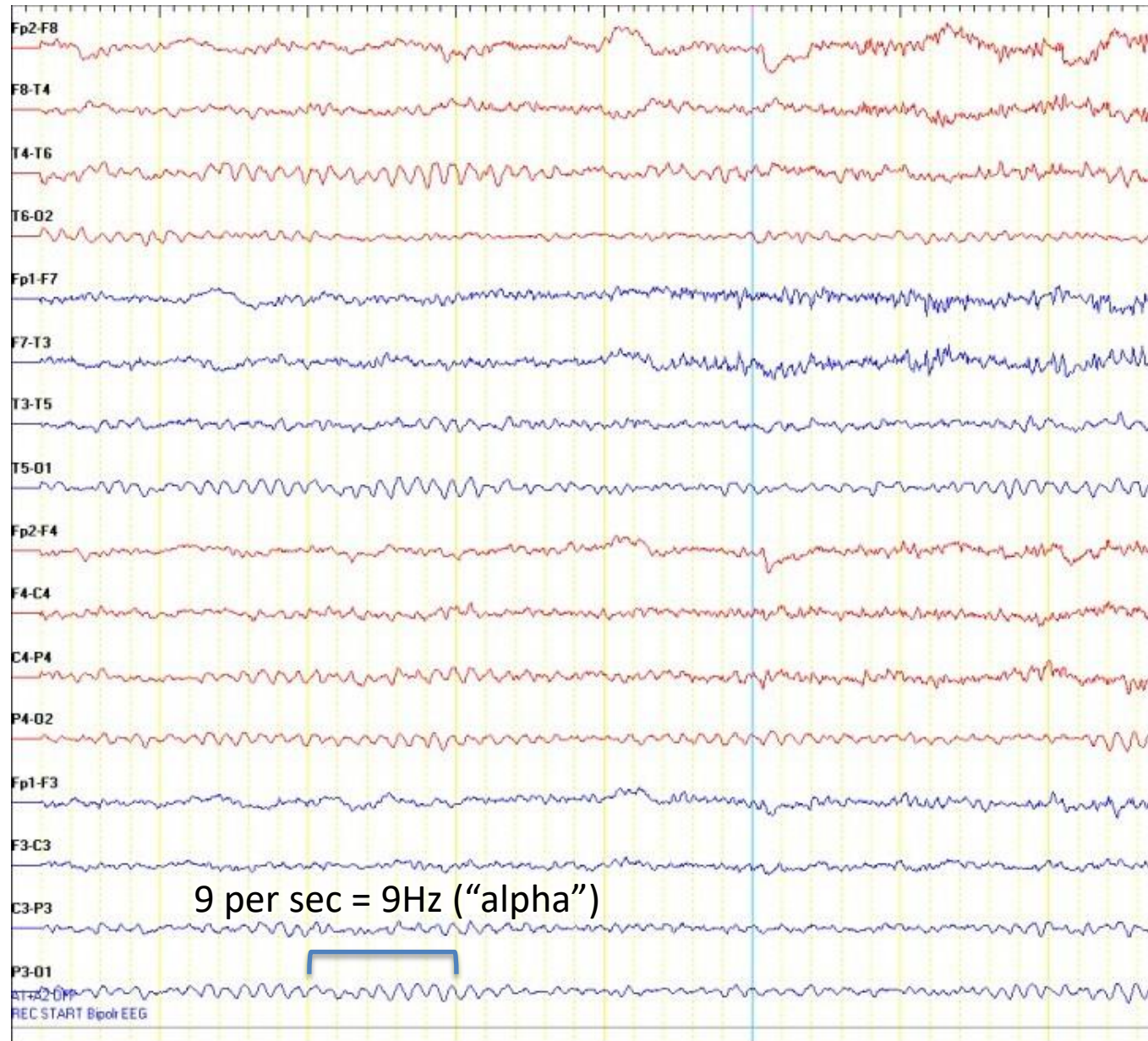
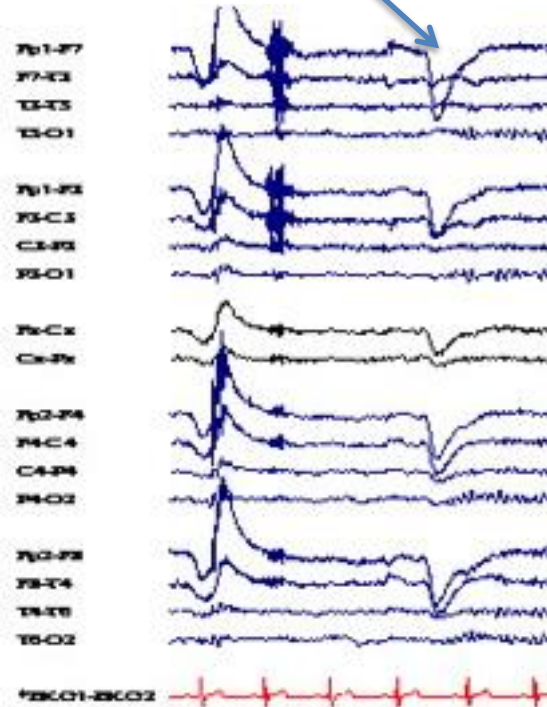
Electroencephalography - EEG

General points:

- Even numbers = right hemisphere, odd = left
- F = frontal, T = temporal, C = central, O = occipital
- Normal = “alpha” 8-12Hz, attenuates with eyes open
- Abnormalities
 - generalized slowing (“encephalopathic”)
 - focal slowing (intermittent or persistent)
 - epileptiform discharges – focal or generalized
 - triphasic waves
 - burst-suppression

Normal EEG

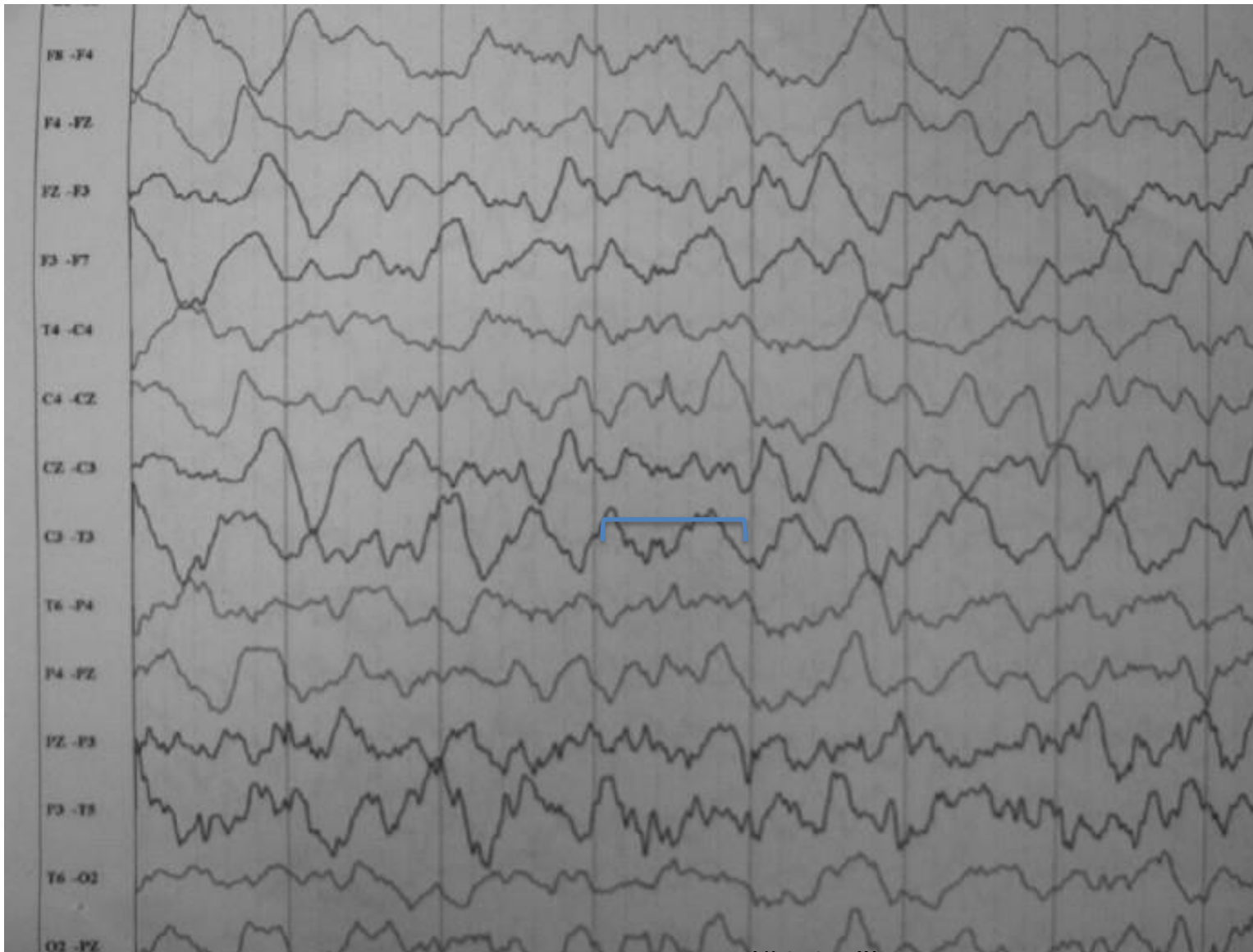
Eye blink
(normal)



9 per sec = 9Hz ("alpha")

REC START Bipolar EEG

Generalized slowing EEG



2-3 per sec = 3Hz ("delta")
either normal "slow wave" sleep
or severe encephalopathy

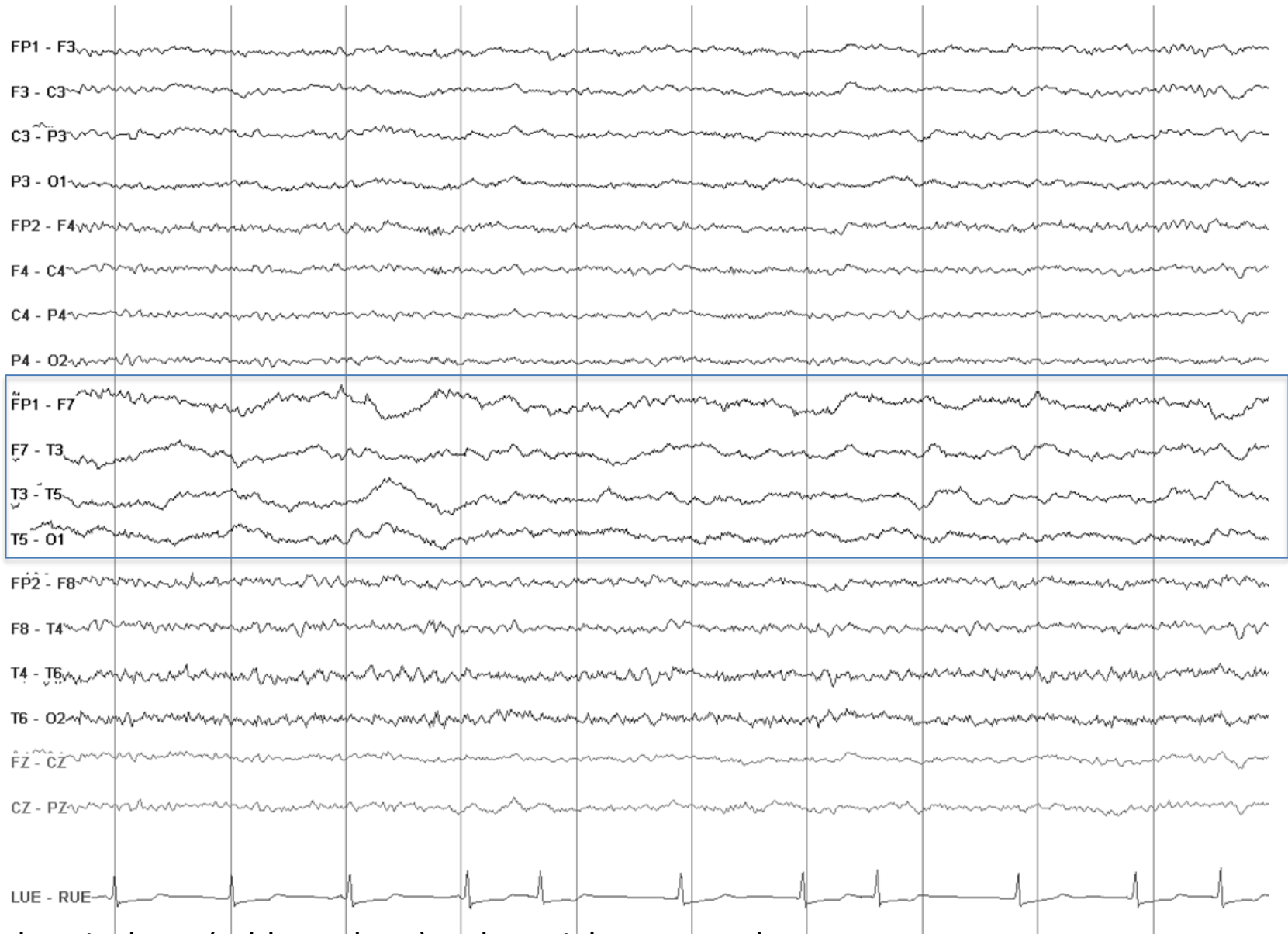
Generalized slowing EEG



Background 5-7Hz (“theta”) – encephalopathic

Plus “triphasic waves” (boxes) seen in metabolic encephalopathy and CJD

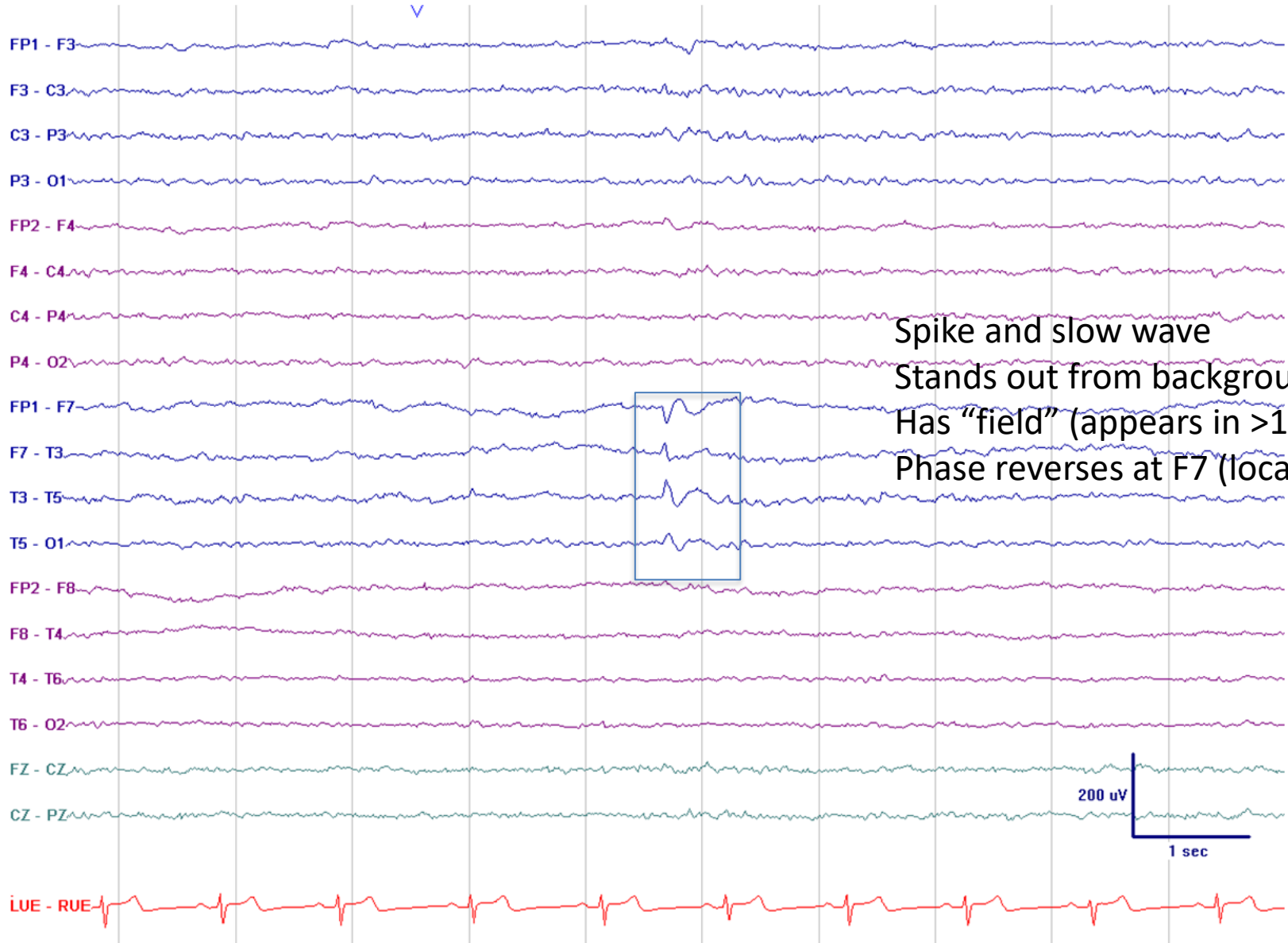
Focal slowing EEG



Left hemisphere (odd numbers) = slow, right = normal

Nonspecific – any structural or functional lesion (in this case stroke – note the AF on rhythm strip)

Focal epileptiform discharge



Spike and slow wave

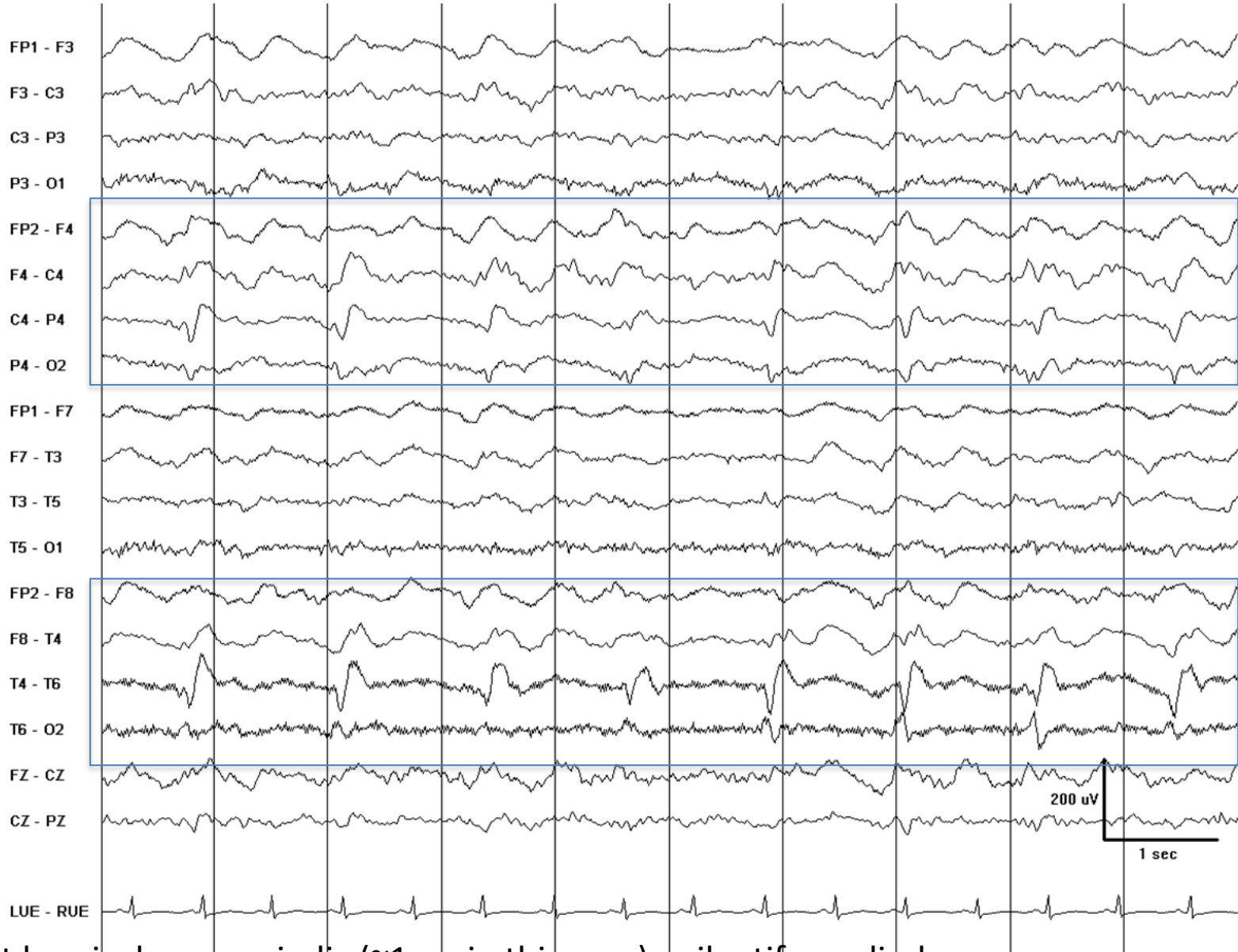
Stands out from background

Has "field" (appears in >1 electrode)

Phase reverses at F7 (localization)

Left frontal epileptiform discharge

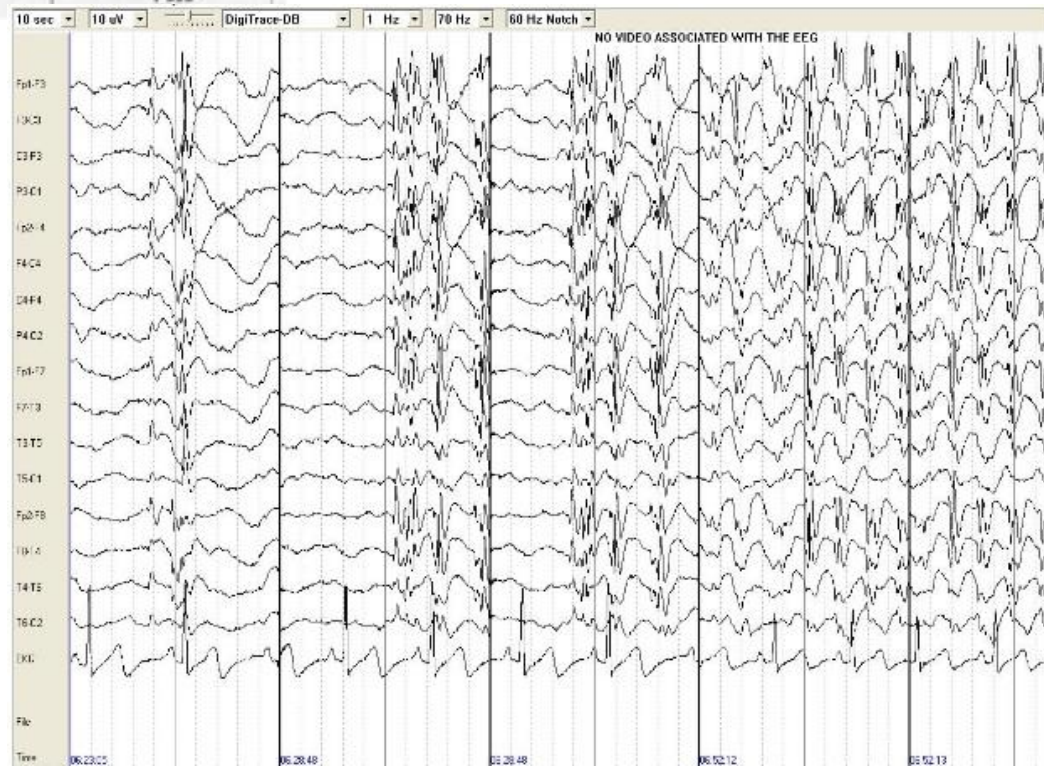
Periodic lateralized epileptiform discharge (PLED)



Right hemisphere, periodic (~1sec in this case) epileptiform discharge

Nonspecific severe injury eg stroke, encephalitis, tumour etc, **no need for anticonvulsant**

Generalized epileptiform discharge



“childhood absence epilepsy”

Normal background then a run of

3Hz “spike and wave”

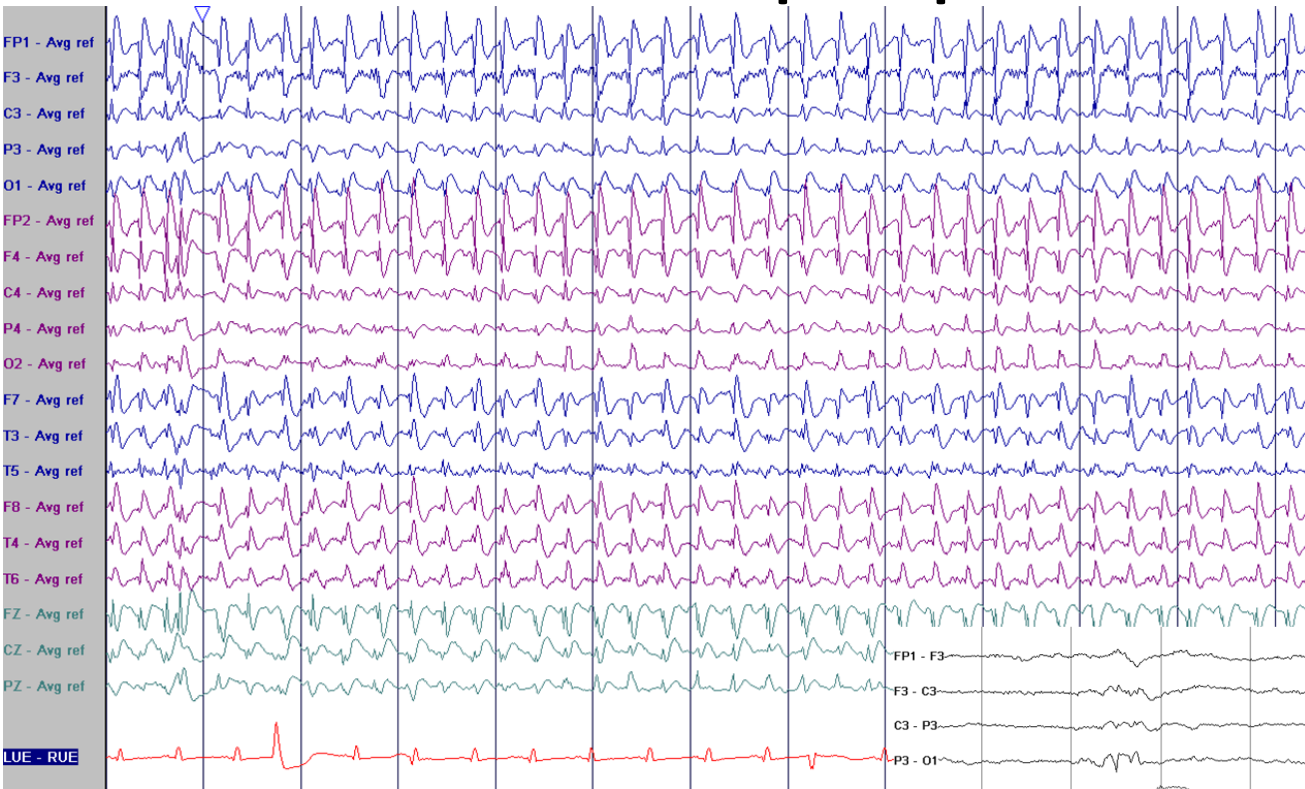
bilateral but doesn’t have to be same in
all leads

clinical correlate = absence seizure

“Juvenile myoclonic epilepsy”

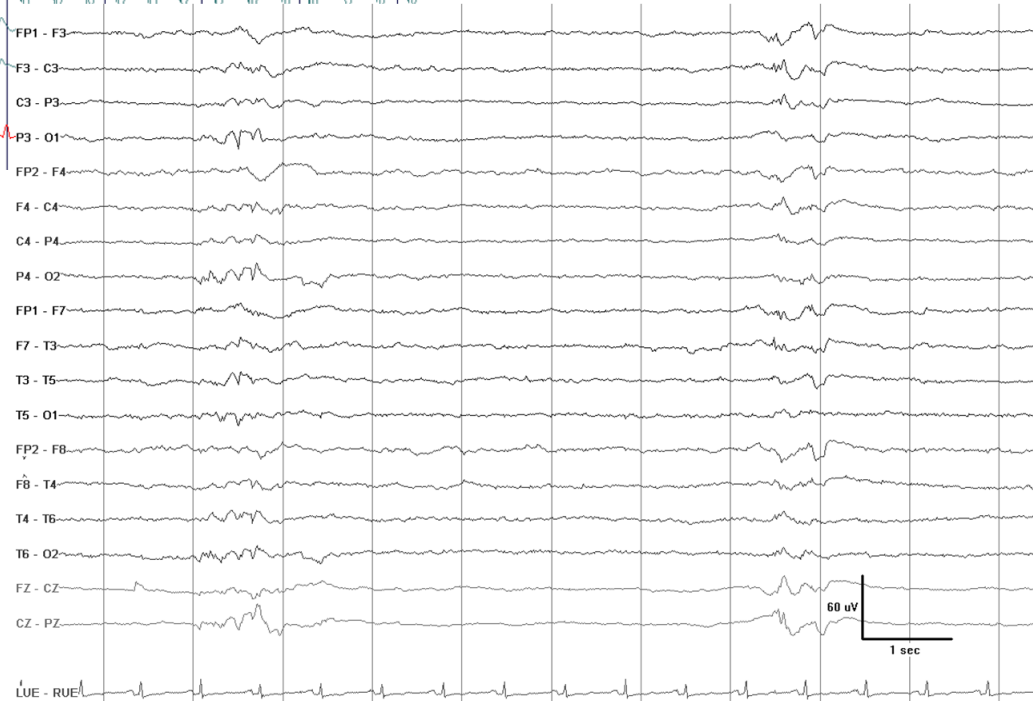
Isolated jerks or 4-6Hz spike and wave

Generalized epileptiform discharge?

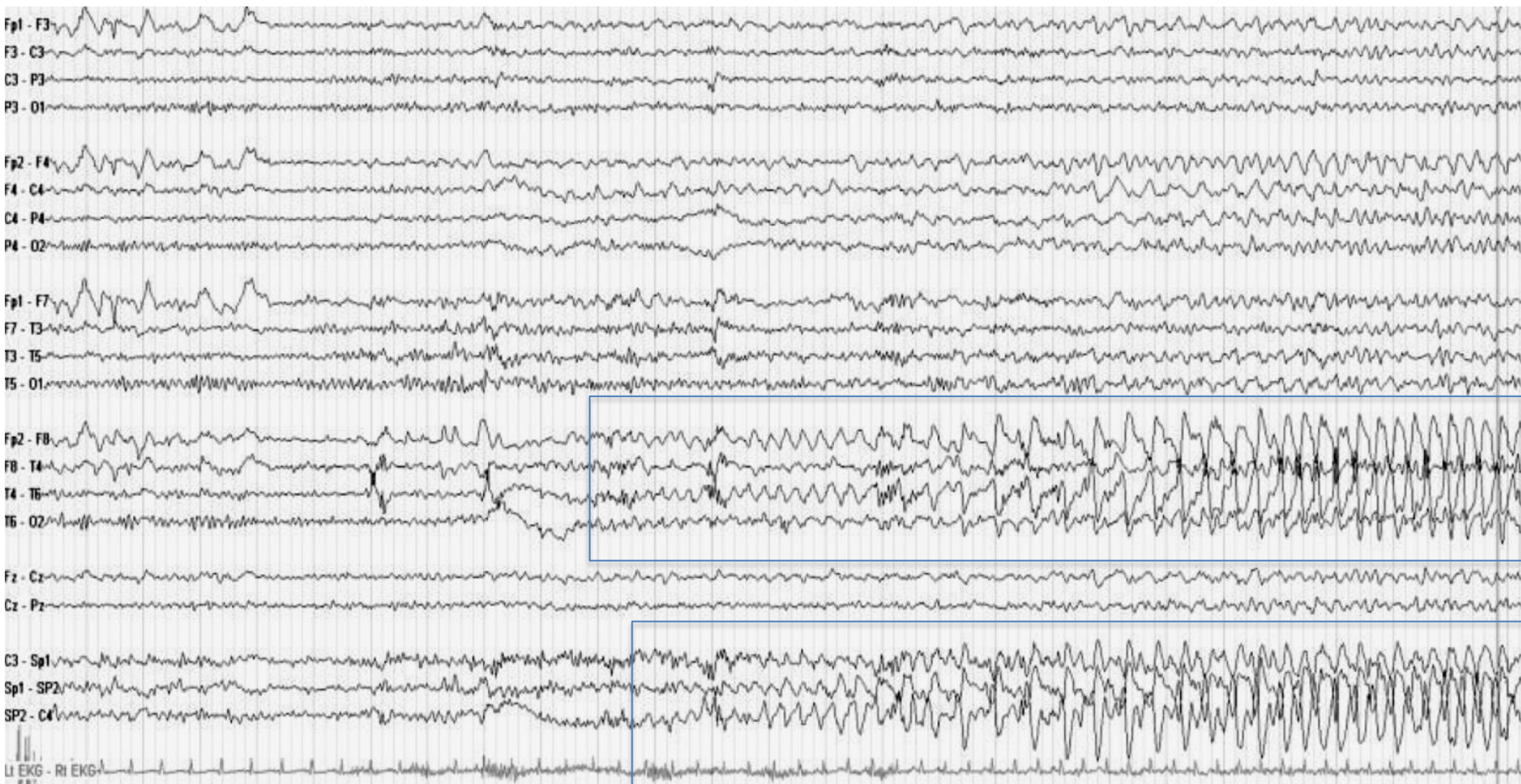


Generalized Periodic Epileptiform Discharges (GPEDs) – often seen post-cardiac arrest
In post-anoxic injury no benefit from anticonvulsants, generally poor prognosis

Burst-suppression with GPEDs—post-cardiac arrest or deep induced coma



Seizure



Right temporal focal seizure

Varying morphologies but the key is **evolution** in frequency and amplitude over time

If generalizes → can only see muscle artefact

?Neuropathy

- **Generalized peripheral neuropathy:**
Common causes: DM, EtOH, vitamins, paraproteins, vasculitic, drugs, hereditary
- **Bloods:** fBSL/OGTT, U&E, Vit B12, T₄/TSH, SPEP, vasculitic
- **Nerve conduction studies:**
reduced velocity, dispersion +/- delayed “F-waves” = demyelinating
reduced amplitude = axonal
but focal “block” (>50% drop in amplitude) = demyelinating
- Sural nerve biopsy – rarely needed.
Consider if suspect amyloid, sarcoid, vasculitis

- **Mononeuropathy:**
usually compressive (occasionally vasculitic – painful):
median/ulnar/peroneal → **nerve conduction studies**
– if several pressure palsies consider HNPP (Hereditary neuropathy with pressure palsies, autosomal dominant – **PMP22 gene test**)

- More complex neuropathies – CIDP, MMN (anti-GM1 in 60-80%),
brachial/lumbosacral plexopathy, radiculopathy
→ nerve conduction studies/EMG, MRI of spine/plexus

Rec: ADM

10 mV/D

3 ms/D

Normal Motor Conduction

dLAT/CV

AMP

AREA

DUR

Dist 60

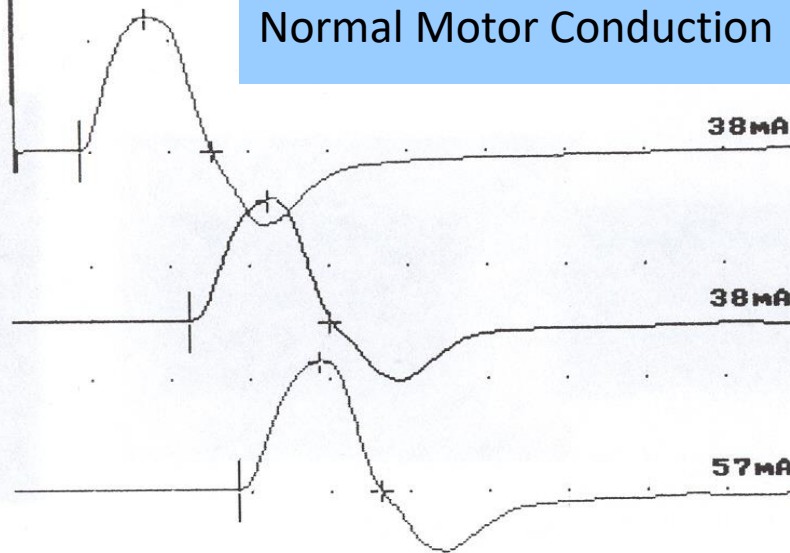
Wrist

Dist 260

B/Elbow

Dist 115

AbElbow



2.6

11.7

36.5

5.0

61.9 m/s

-10 %

-10 %

7 %

6.8

10.5

32.9

5.3

67.6 m/s

8 %

7 %

1 %

8.5

11.3

35.3

5.4

CV Motor

Right Ulnar

Rec: ADM

5 mV/D

3 ms/D

dLAT/CV

AMP

AREA

DUR

Dist 70

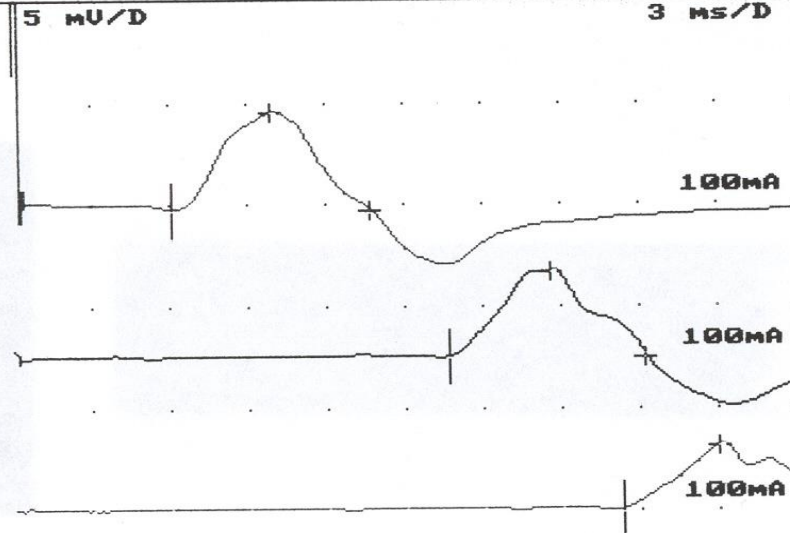
Wrist

Dist 200

B/Elbow

Dist 115

AbElbow



6.2

4.8

18.6

7.6

18.9 m/s

-14 %

-11 %

-1 %

16.8

4.1

16.6

7.5

17.4 m/s

-23 %

-20 %

11 %

23.4

3.2

13.2

8.3

Demyelinating Neuropathy

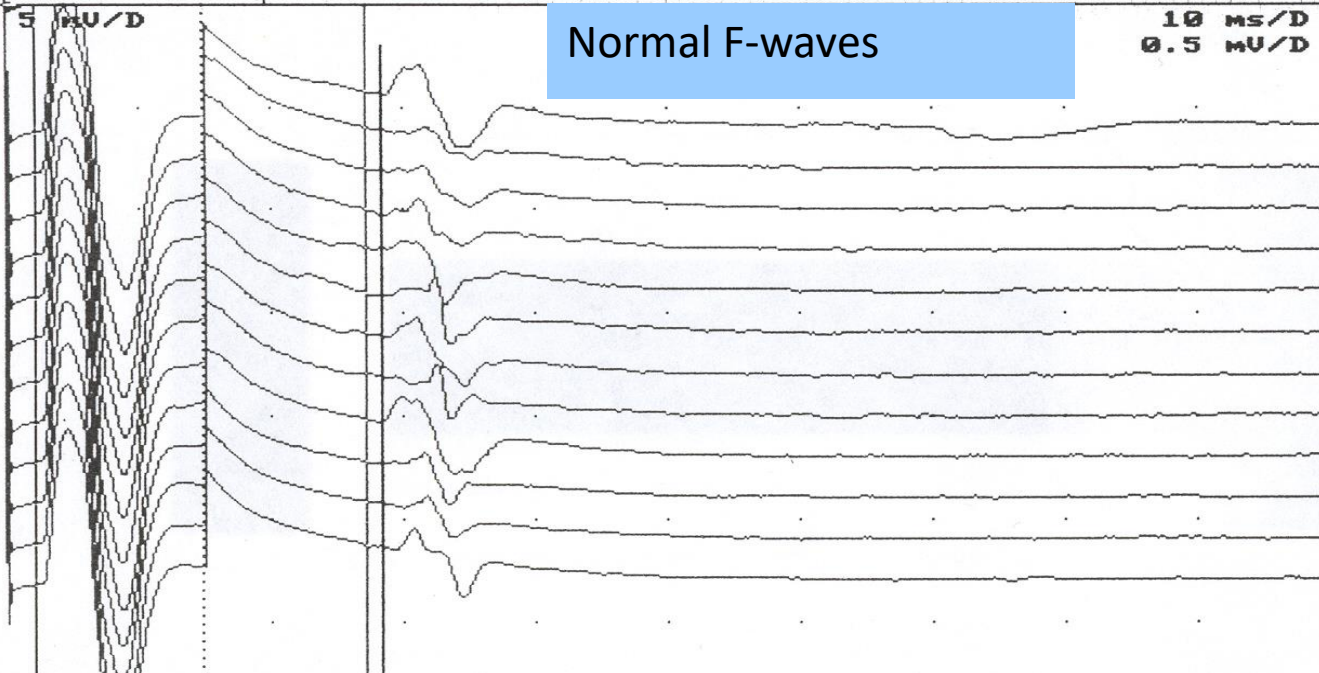
F-responses

Right Ulnar

5 mV/D

Normal F-waves

10 ms/D
0.5 mV/D



Stim pos :
Rec. pos. : ADM
#Stim : 12
F :
M-lat : 2.3
F lat min : 28.6
max:
mean:

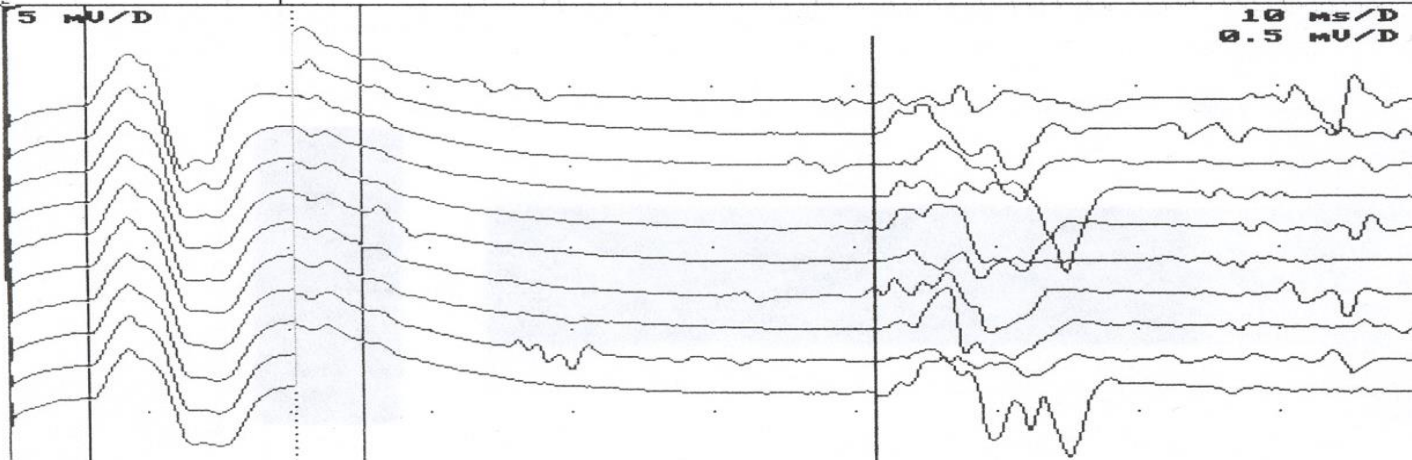
F-responses

Right Ulnar

5 mV/D

Prolonged F-waves

10 ms/D
0.5 mV/D



Stim pos :
Rec. pos. : AD
#Stim : 1
F :
M-lat :
F lat min : 6
max:
mean:

Neo: FDI

10 mV/D

0.0 mA

3 ms/D

0.1 ms

1 Hz

Dist 110



Dist 65

Dist 60

Dist 20

Dist 20

Dist 20

Dist 20

Dist 20

Dist 20

Dist 20

20 [mV]

AMP

Dist [mm]

375

20 [ms]

Lat

Dist [mm]

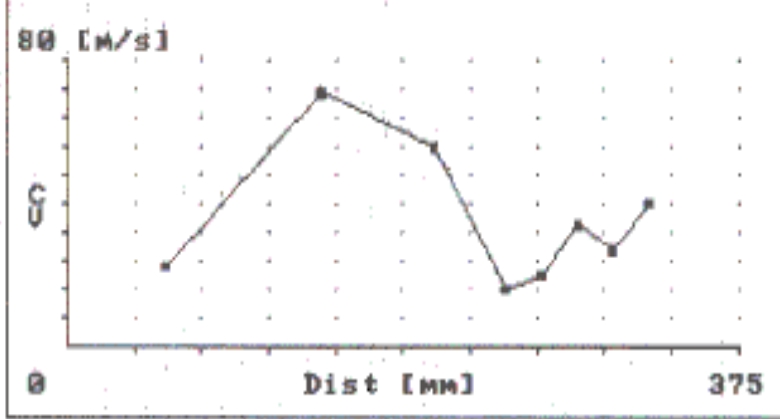
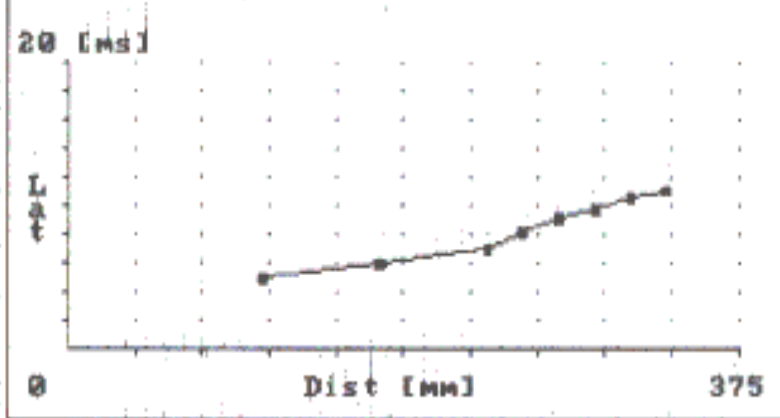
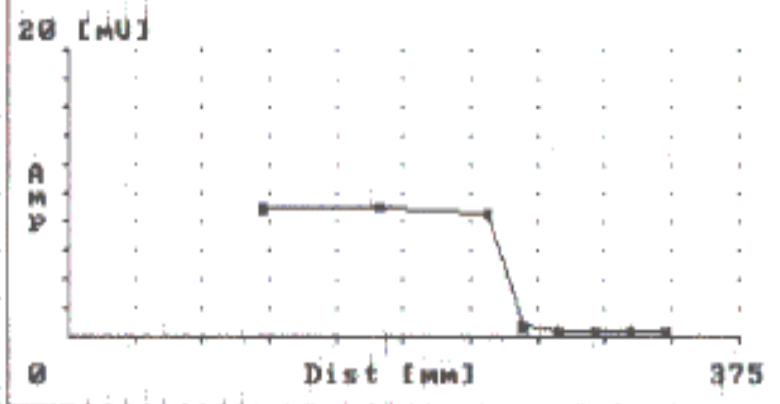
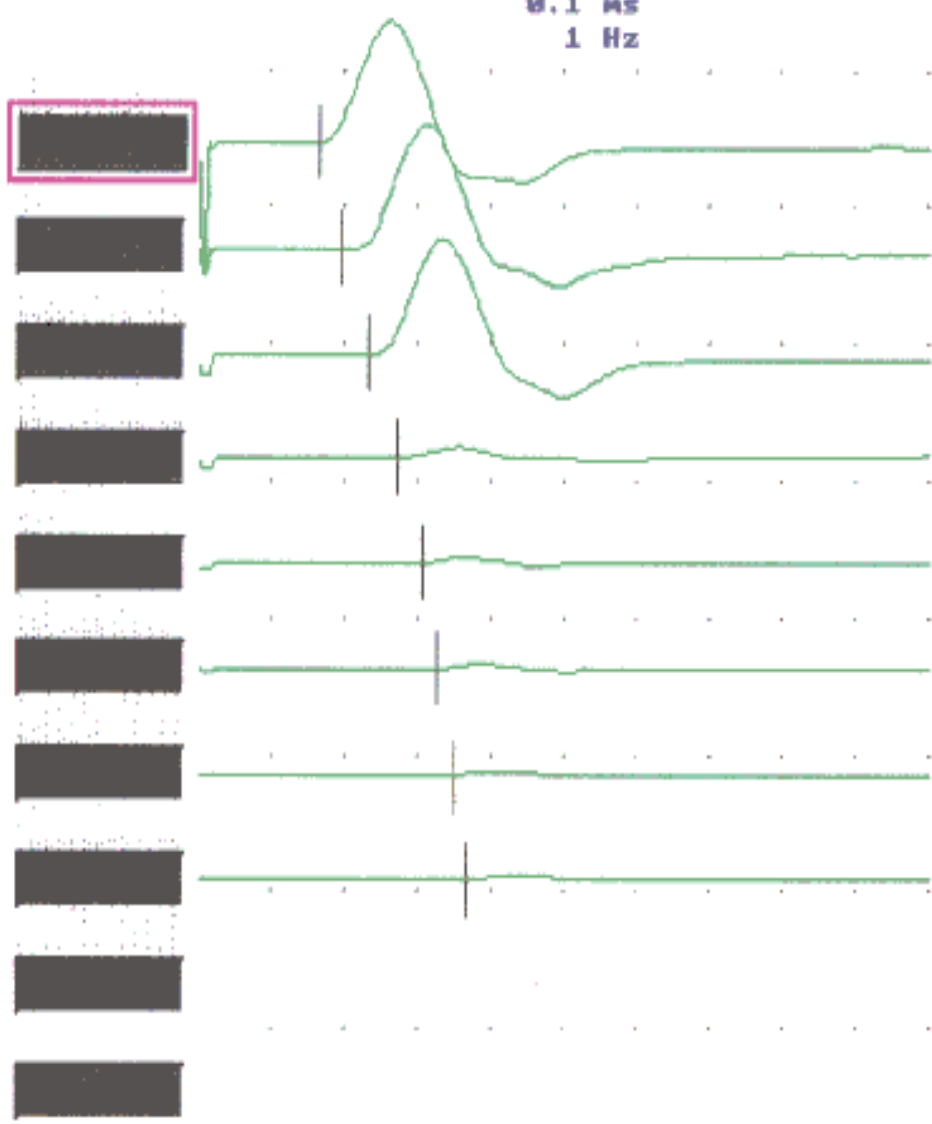
375

80 [m/s]

CG

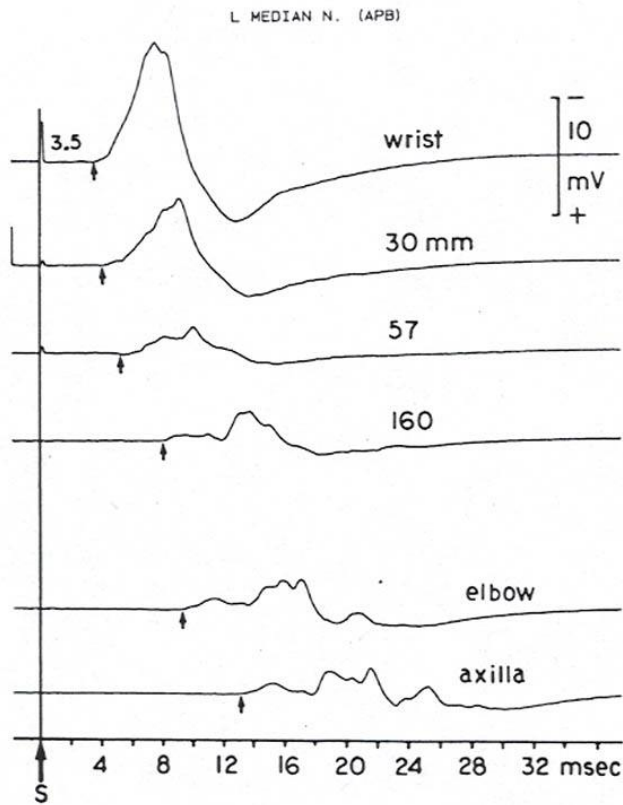
Dist [mm]

375



Multifocal Motor Neuropathy (MMN) – motor conduction block

B



Acute flaccid paralysis

- dDx GBS, cord compression/transverse myelitis, myasthenia, botulism, porphyria
- **MRI spine** if can't exclude cord compression clinically
- **CSF** "albuminocytologic dissociation" in GBS (inflammation/cells **outside** dura in nerve roots, spill-over increased protein)
exception = HIV-related GBS has increased cells
 - elevated protein – non-specific: inflammation, diabetes, blocked spinal CSF flow
- **NCS/EMG** – take time to become abnormal (major early abN suggests actually CIDP)
 - Delayed/loss of F-waves, later slowing
- Bloods - ganglioside Abs: GM1 (GBS, also MMN, MND), GQ1b (Miller-Fisher)
- Don't forget to monitor FVC (respiratory failure risk)

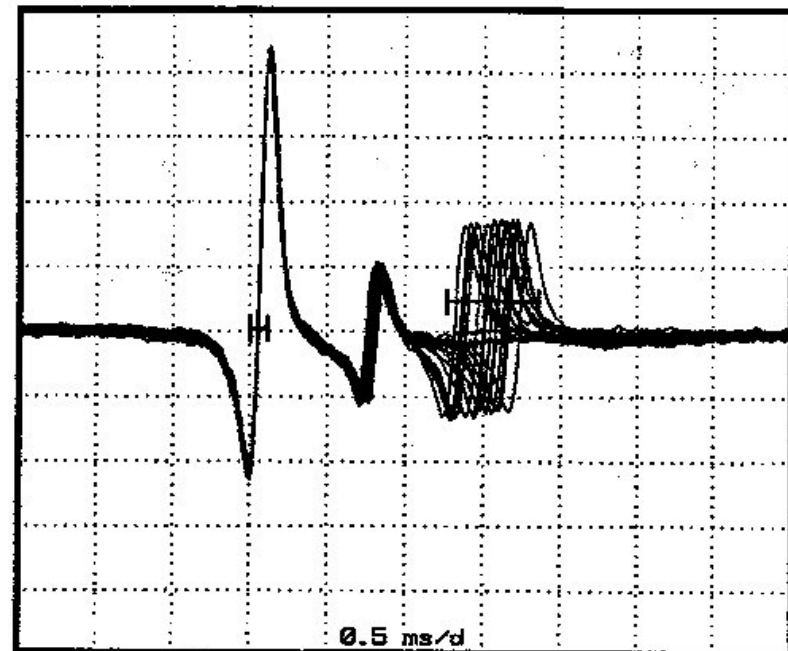
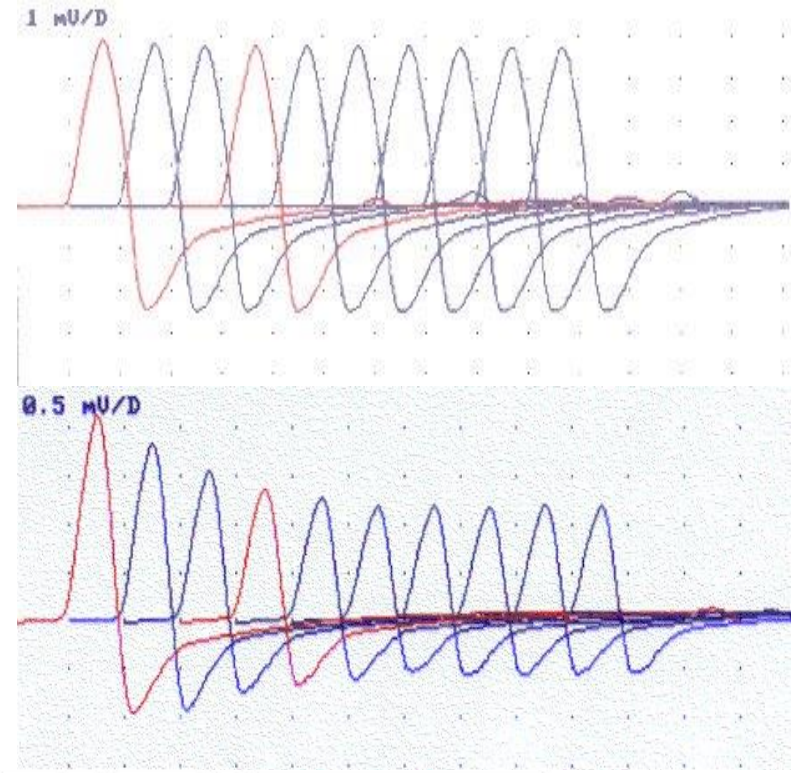
?Myasthenia

- Repetitive stimulation EMG (2-3Hz) - decrement
- **Single Fibre EMG** – “jitter”
 - best sensitivity (provided tested in a weak muscle)
- Tensilon (edrophonium) test
- **ice test** (for ptosis)
- **Acetylcholine receptor antibodies**
- Anti-MuSK Abs (~50% of AChR negative myasthenia)
- **CT Chest**, anti-striated muscle Abs - ?thymoma

Dx of Myasthenia Gravis

- Repetitive Nerve Stimulation
 - Sens 48-76%
 - Hand > Shoulder > Facial mm
 - Proper technique
- Single Fibre EMG
 - Sens. 60-89 %
 - EDC > Facial mm.
 - Weak muscle: Sens. 99%

variation in delay between 2 fibres from same muscle unit = “jitter” (variable NMJ transmission)



?Motor neuron disease

- anterior horn cell degeneration
- **key = mix of upper and lower motor neuron signs** (“ALS”)
(c-spine can also do this but LMN signs would be exclusively “above” the UMN signs)
Some MND presentations can be virtually pure UMN (“PLS”) or LMN (“PMA” 4%)
- usually starts in one limb or bulbar and spreads
- **dDx – always exclude cervical spine disease and MMN**
- sensory, sphincter, autonomic, visual abnormalities are not consistent with MND
- El-Escorial criteria: 4 “regions”: bulbar, cervical, thoracic, lumbosacral
“definite MND” = UMN+LMN in bulbar +1 spinal or 3 spinal
- CK (often mildly elevated – non-specific)
anti-GM1 (can be mildly raised in ~15%, high titre suggests alternative Dx)
- **NCS/EMG**
 - **fibrillations (active denervation)**
 - **large polyphasic motor units** (neuropathic reinnervation)
 - exclude sensory involvement, repeat in 6 months to assess progression/spread
- RFT - FVC, MIP
- if young onset or family history consider genetics (*and overlap with fronto-temporal dementias*)

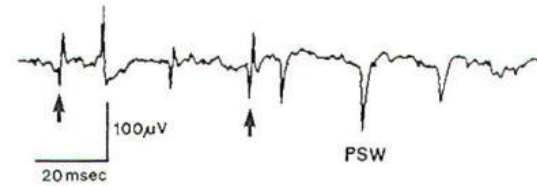
?Myopathy

- Usually proximal-predominant
 - Inflammatory (poly/dermatomyositis, inclusion body myositis): consider underlying malignancy if DM/PM
IBM is more degenerative than truly inflammatory – quads & finger flexors
 - Metabolic (electrolytes, thyroid, parathyroid, Vit D)
 - Hereditary – patterns eg fascio-scapulohumeral or limb-girdle
 - Myotonia, periodic paralysis
- **Bloods:** CK (AST/ALT!), T₄/TSH, Vit D, electrolytes, vasculitic
CK very high in inflammatory myopathy eg 5-50x ULN (also elevated LD)
- **EMG:** next slide
- MRI muscles – can guide site of biopsy
- **Biopsy:** suspected inflammatory myopathy or mitochondrial disease
sample an affected but not end-stage muscle (?use MRI), away from EMG needle sites
 - PM: focal endomysial (ie inside muscle) infiltration by mononuclear cells (mostly CD8+ T lymphocytes and macrophages), capillary obliteration, endothelial cell damage, increased connective tissue
 - DM: mixed B- and T-cell **perivascular** inflammatory infiltrate, perifascicular muscle fiber atrophy
 - IBM: inflammatory cells + inclusion bodies
 - Mitochondrial: COX negative fibres, "Ragged Red Fibers" – clumps of diseased mitochondria accumulate in the subsarcolemmal region of the muscle fiber (modified Gömöri trichrome stain) also raised lactate

COX = cytochrome oxidase

Electromyography - EMG

- Spontaneous activity – fibrillations, positive sharp waves
 - Denervation
 - Inflammatory myopathy



- Neurogenic (Re-innervation – high amplitude and duration, polyphasic)
- Myopathic (low amplitude and duration)
- Myotonia “dive-bomber” sound

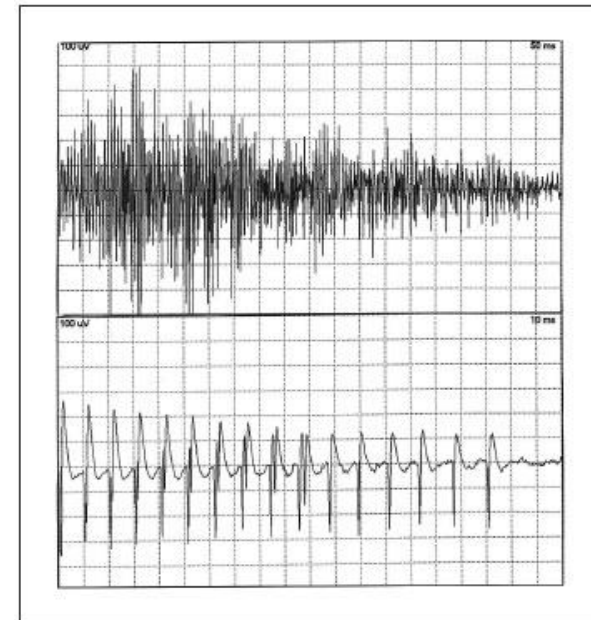
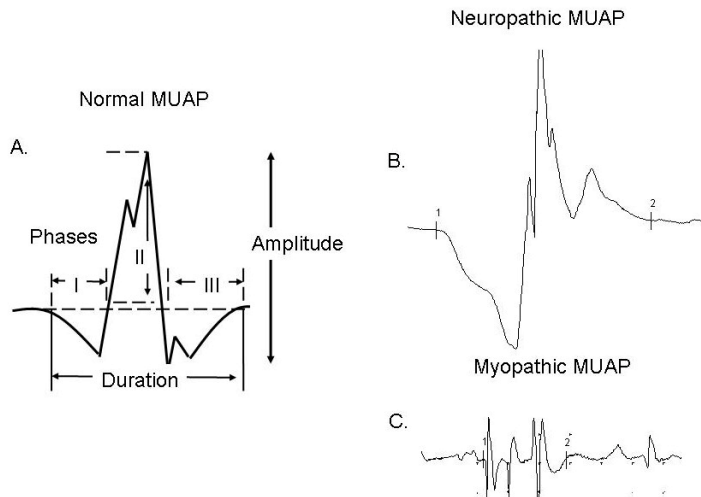
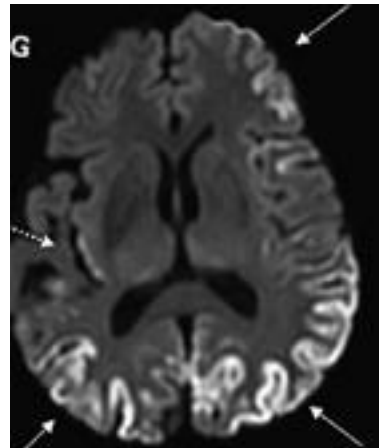
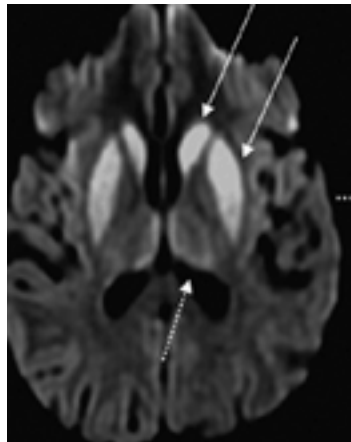


Figure. Myotonic potentials in the right deltoid muscle.

Miscellaneous

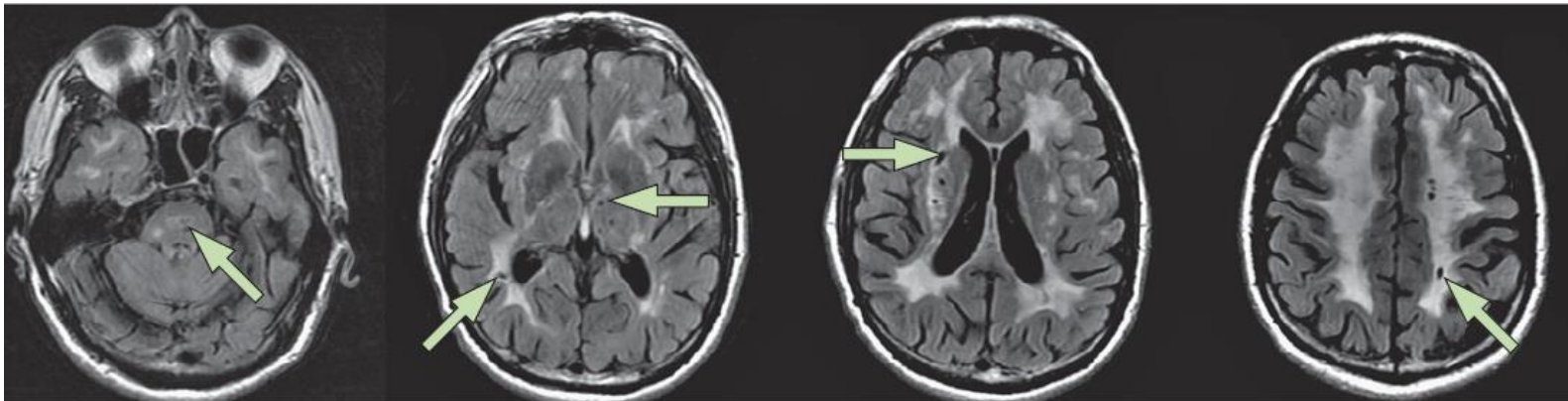
- Rapidly progressive cognitive issues
 - ?CJD – Diffusion MRI, CSF 14-3-3 (non-specific)
direct PrP detection “RT-QUIC” assay, EEG



- +/- seizure, psychosis, sleep-wake disturbance, movement disorder:
 - ?NMDA Abs, Ix for teratoma
 - ?limbic encephalitis – paraneoplastic, VGKC Abs – now subclassified:
Abs to extracellular domains of leucine-rich glioma-inactivated 1 (LGI1)
and contactin-associated protein-like 2 (CASPR2)

Miscellaneous

- Migraine, strokes, dementia with this MRI:



Extensive white matter disease with **anterior temporal involvement**

- **CADASIL**
Cerebral Autosomal Dominant Arteriopathy
Subcortical Infarcts & Leucoencephalopathy
 - NOTCH3 gene mutation
 - Skin biopsy for electron microscopy (osmophilic granules)

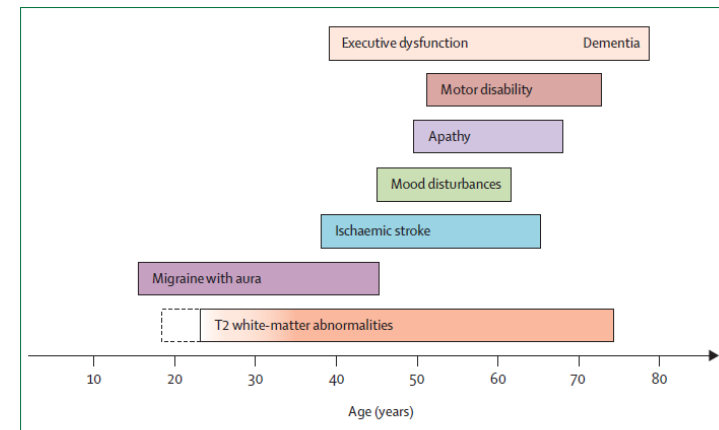


Figure 1: Natural history of the main clinical manifestations of CADASIL.

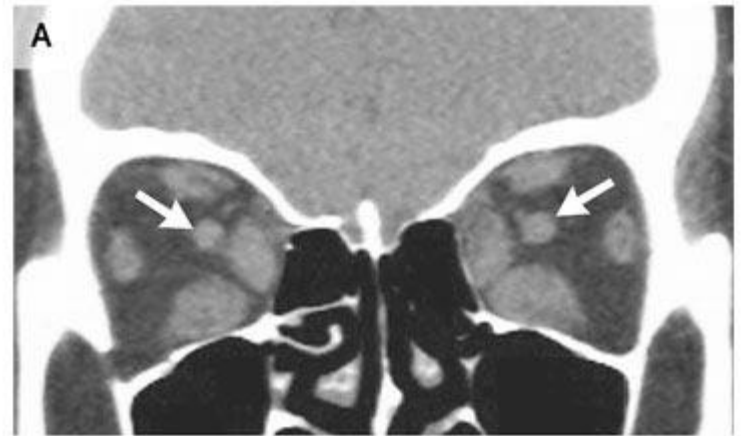
The exact age at earliest onset or of first MRI abnormalities is uncertain (dotted line). The frequency of T2 white-matter abnormalities increases progressively and becomes constant by around 35 years in all patients. CADASIL=cerebral autosomal dominant arteriopathy with subcortical infarcts and leucoencephalopathy.

Miscellaneous neuro investigations

- Temporal artery biopsy
- Anti-GAD – Stiff person syndrome (spasms and rigidity)
- Cu/caeruloplasmin – Wilson's (dystonia/parkinsonism, cognitive impairment)
- Blood film – acanthocytes: neuroacanthocytosis (chorea, parkinsonism, cognitive impairment, seizures)

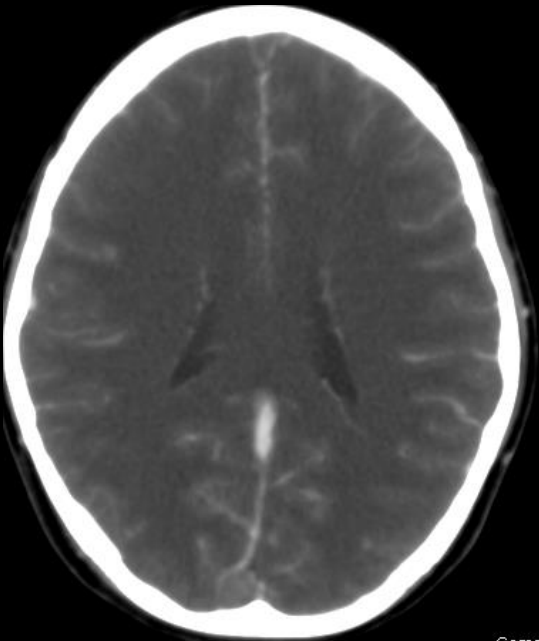
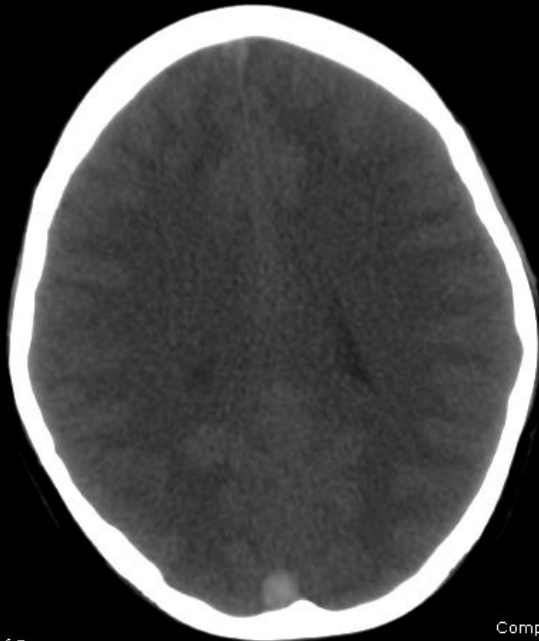
Spot Quiz

Grave's ophthalmopathy -
Inferior/medial rectus often
worst affected

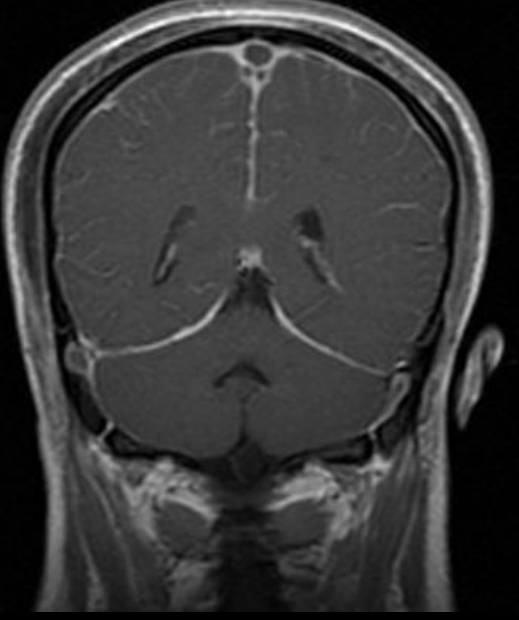
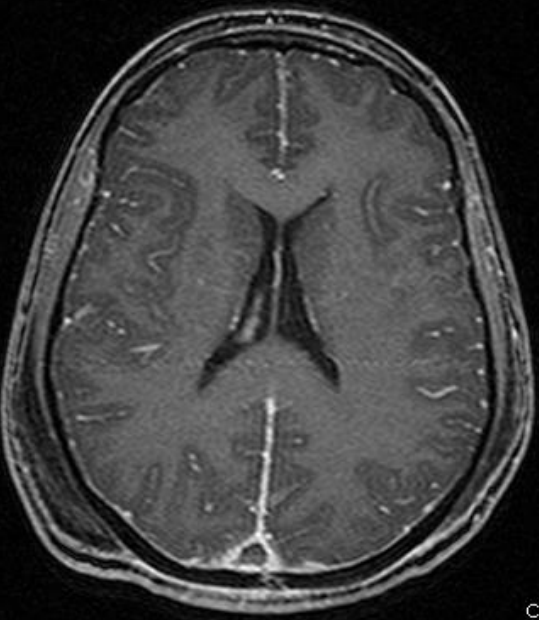




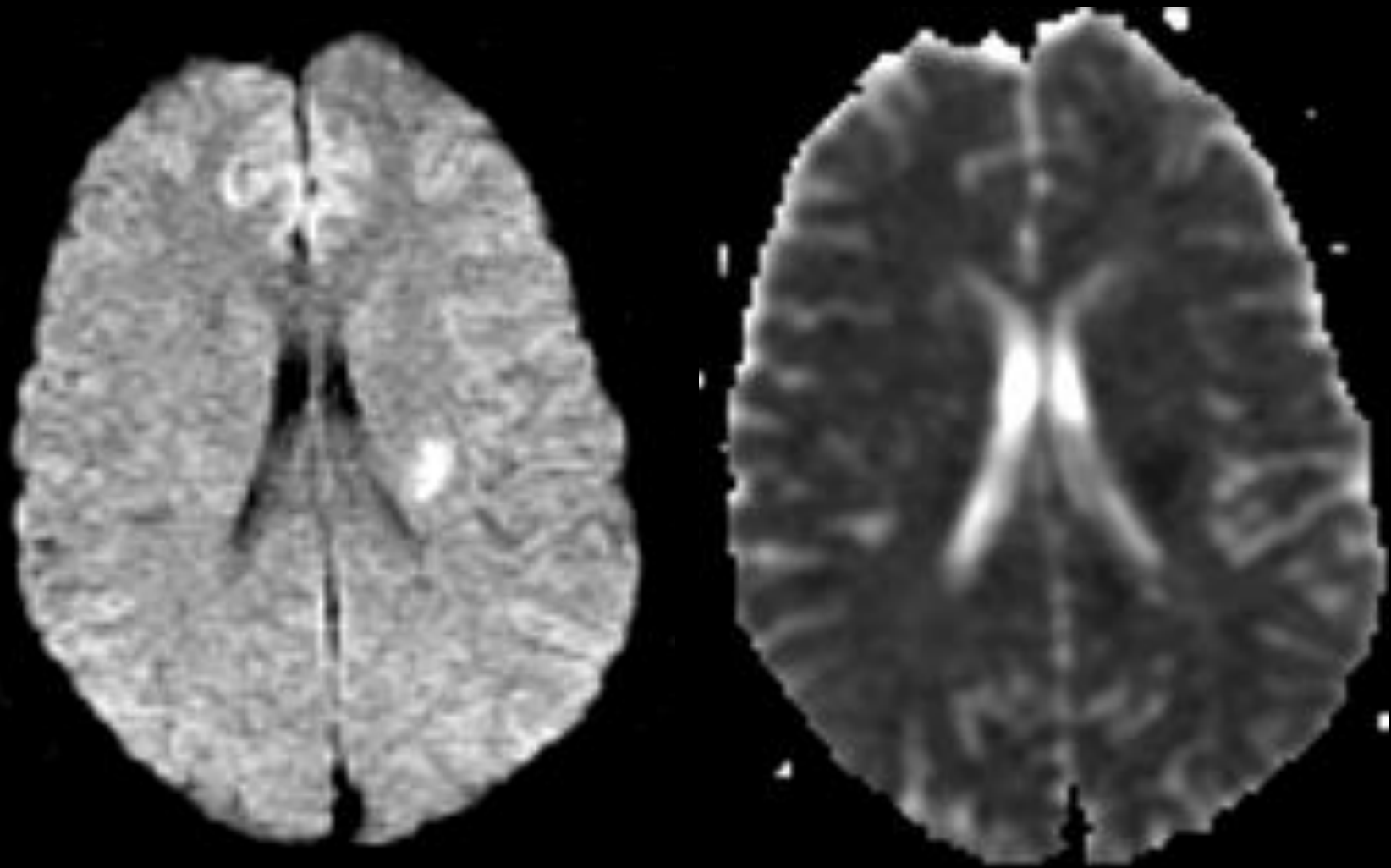
top left – subtle left basal ganglia loss of grey-white differentiation, top right established infarct 24h later, bottom = left MCA hyperdense thrombus



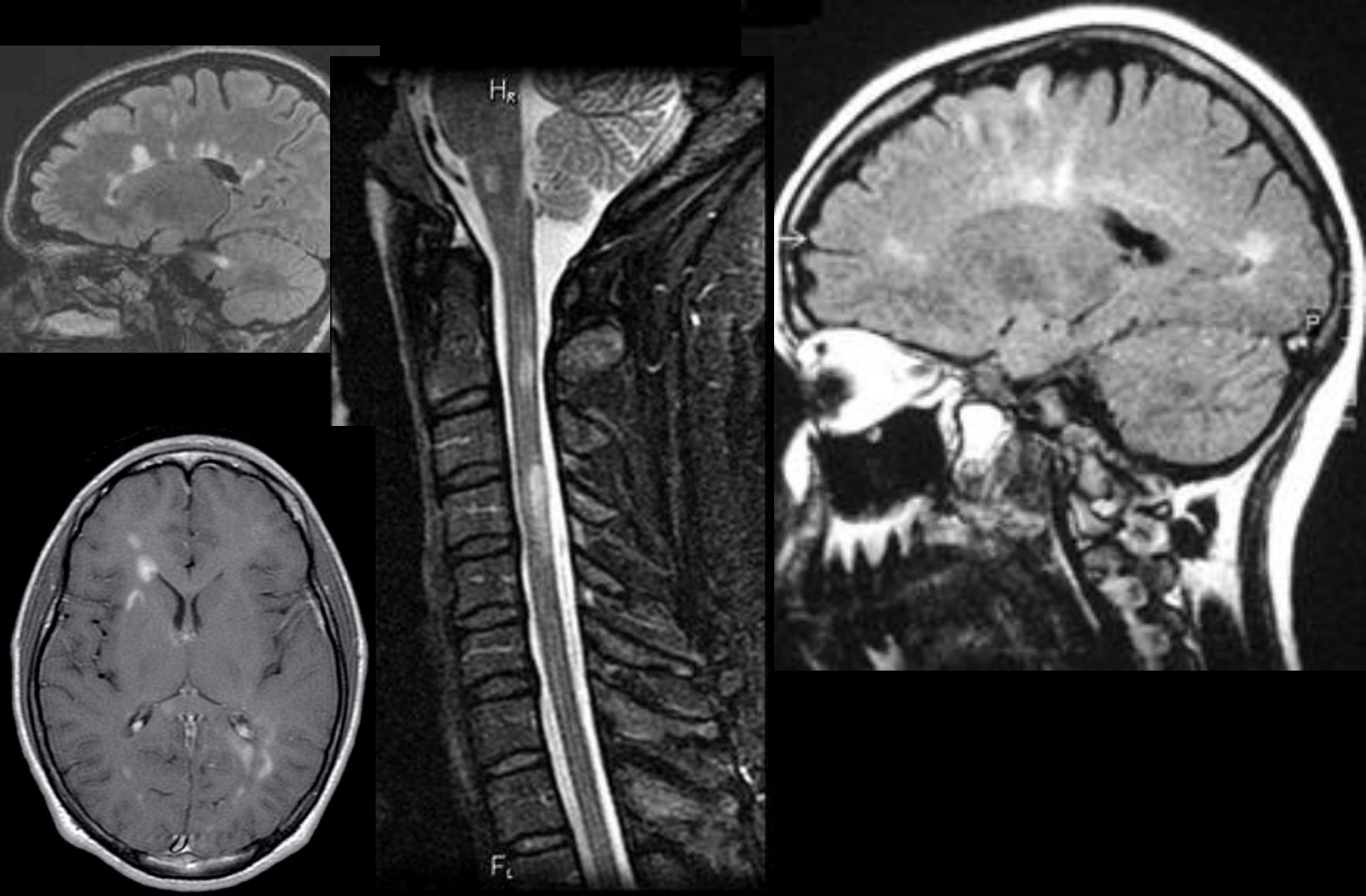
top left – non-contrast CT
hyperdense sagittal sinus, top
right CT Venogram “empty delta”
lack of filling in sagittal sinus,



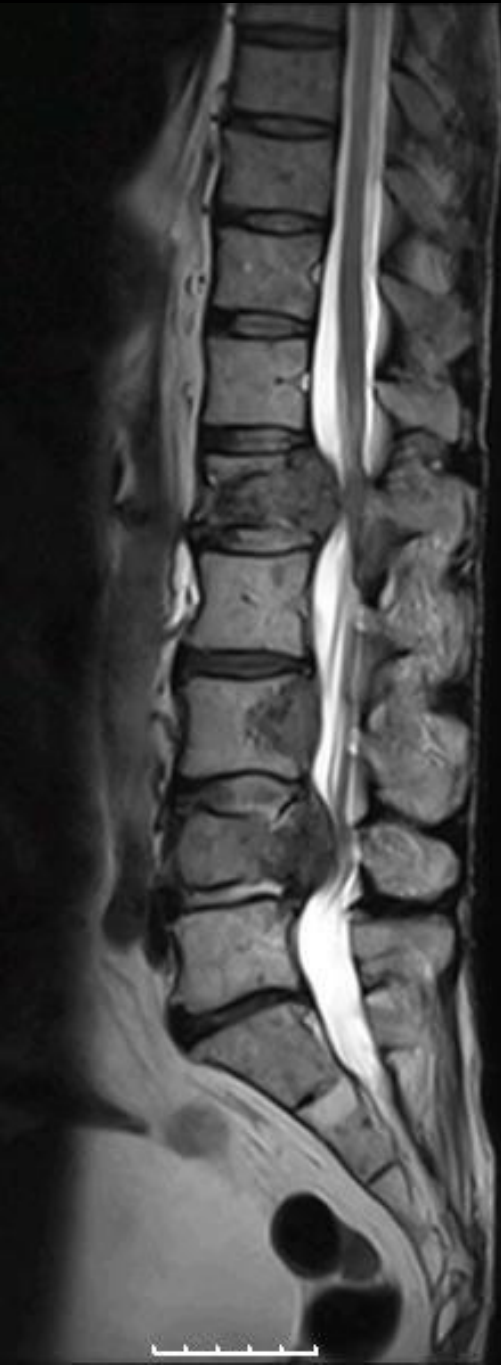
lower panel = gadolinium-
enhanced MRI, lack of filling in
sagittal and transverse sinuses



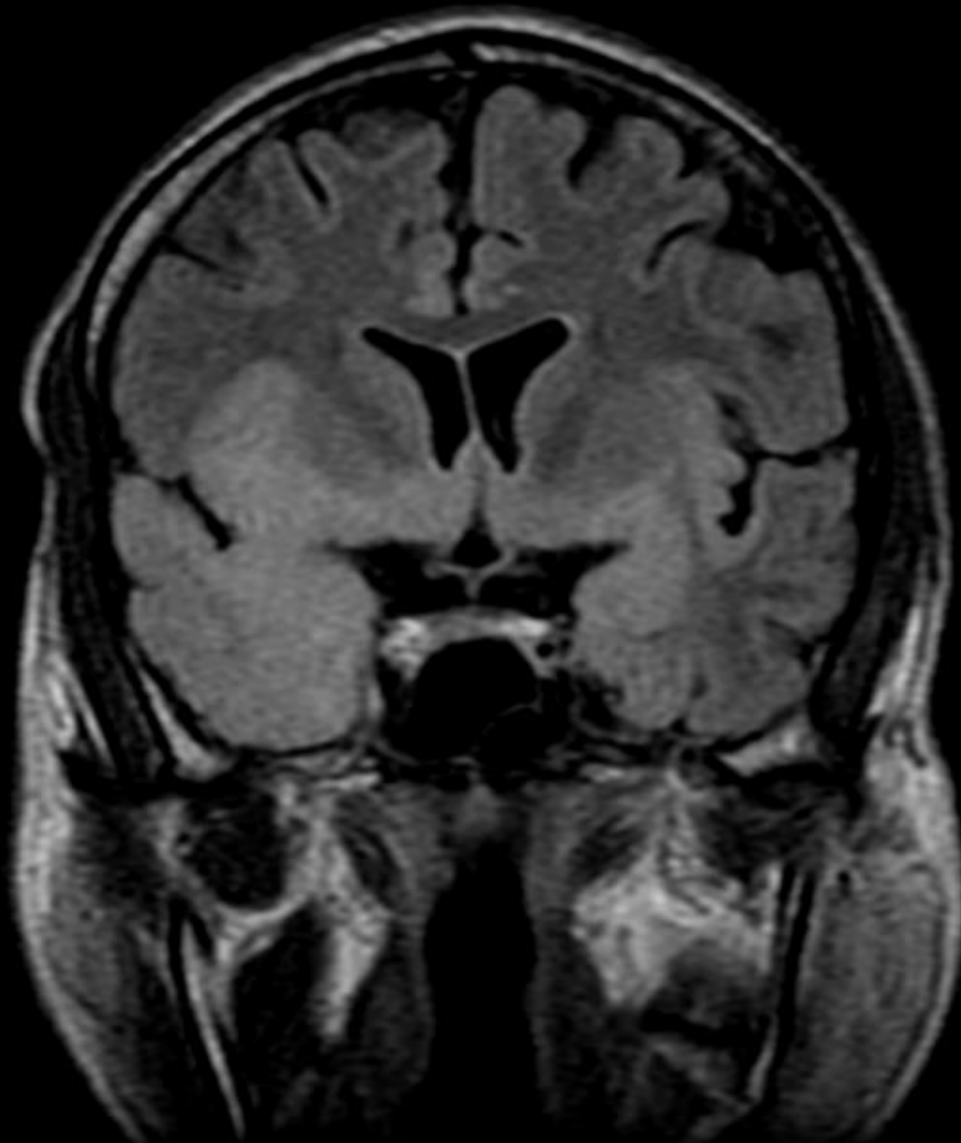
left lacunar infarct with low ADC



MS: top left - Dawson's fingers, bottom left - open C enhancement, middle - c-spine and medulla lesions (not longitudinally extensive), right - juxtacortical u-fibre lesion + periventricular



left – malignant cord compression; right disc herniation causing cord compression



HSV encephalitis

Questions?

Blood tests

- Neuropathy: fBSL/OGTT, U&E, Vit B12, T₄/TSH, SPEP, vasculitic
 - Anti GM1 – 60-80% of MMN and sometimes (~15%) MND
- Myopathy: CK (AST/ALT!), T₄/TSH, Vit D, electrolytes, vasculitic
 - CK – mild elevation in MND, major elevation in inflammatory myopathy
- Vasculitic: ANA, ENA, dsDNA, Rf, ANCA, c3/4
- Thrombophilia: FBE, Factor V Leiden & Prothrombin gene mutations, protein C, S antithrombin deficiencies, Anti-cardiolipin IgG, lupus inhibitor, homocysteine(?)
- Pre-immunosuppression: HIV, HBV, HCV, VZV, TB, JC virus etc

Antibodies

- Anti-neuronal – Hu, Yo, Ri,
- VGKC - (LGI1 and CASPR2)
- NMDA
- GAD (stiff person syndrome)
- Ganglioside
 - GM1 – GBS, MND...
 - GQ1b – Miller Fisher (ataxia, areflexia, ophthalmoplegia)
- NMO (anti-aquaporin4 antibodies) - ~70% sensitive for neuromyelitis optica
- anti-MOG (myelin)
- JC virus serology ~50% of patients exposed
 - risk stratification for natalizumab PML risk

CSF

- generally image before LP
 - safety, leptomeningeal enhancement after LP can confuse interpretation
- opening pressure: N<20cm H₂O, abN>25cm H₂O
(careful in obese/compressed abdomen)
- biochem
 - “albuminocytologic dissociation” – GBS (inflammation outside dura in nerve roots, spill-over increased protein)
 - elevated protein – non-specific: inflammation, diabetes, blocked spinal CSF flow
- Cells – lymphocytes, PMNs
- Cytology (spun down) - ?malignancy (larger volume 3x)

CSF - special tests

- xanthochromia – spectrophotometry for bilirubin etc – extra, light protected tube, not sent in vacuum tube system
- *unmatched* oligoclonal bands (= found in CSF but not serum ie CNS-restricted immune process)
- 14-3-3 – non-specific marker of neuronal death (CJD but many other conditions too)
- JC virus PCR on CSF for Dx of PML
- VZV IgG for post-zoster CNS vasculitis etc (better than PCR)

Nerve/Muscle biopsy

- Sural nerve biopsy rarely required
- Perhaps if suspect:
 - Vasculitis
 - Amyloidosis
 - Sarcoidosis
 - HNPP (tomaculous neuropathy) but use PMP22 gene test...
 - Leprosy
 - Tumour infiltration
 - Inherited (some)
- Muscle biopsy – suspected inflammatory myopathy or mitochondrial disease