MRI & CT Use in Emergent CNS Illness & Injury: Beyond the Non-contrast CT

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Clinical Overview

- Neurological emergency patients are commonly seen in the ED
- Advanced neuroimaging available
- Practice standard: non-contrast CT
- Neuroimaging plan per consultants

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Clinical Imperative

- Consultants often determine need
- More requests for immediate testing
- Illness severity, patient stability key
- ED time, patient outcome influenced
- Test availability, interpretation varies
- Location, test duration problematic

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CNS MRI, CT: The Questions

- What tests are available?
- What clinical settings drive need?
- What tests should be performed?
- How do these tests alter acute Rx?
- Is outcome improved with testing?

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CNS CT, MRI : The Tests

- CT with contrast
- CT angiography (CTA)
- MRI, without or with contrast
- MR angiography (MRA)

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Other Tests to Consider

- Traditional cerebral angiography
- Digital subtraction angiography (DSA)
- CT myelography
- Carotid Doppler ultrasonography
- Transcranial ultrasonography
- Echocardiography

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CNS MRI, CT: Organ Systems

- Spinal cord
  - Cord
  - Supporting spine structures
- Brain and Vessels
  - Brain and brain stem
  - CNS vessels, arterial and venous

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Clinical Settings: Spinal Cord

- Spinal cord compression
  - Infection, abscess
  - Traumatic myelopathy, disc herniation
  - Tumor, metastatic lesions
- Spinal cord inflammation

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Clinical Settings: Spinal Cord

- Spinal cord compression
- CT, plain x-rays for spine fractures
- CT will detect significant lesions
- MRI will better detect smaller lesions
- MRI with contrast is the optimal study

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Leg Weakness: Working Dx

- 28 yo back pain, aggressive stretching
- Radiculopathy, weakness, parasthesias
- Rule out herniated disc low thoracic spine
- History MVC with anterior cervical fusion
- Low extremity clonus with dorsiflexion

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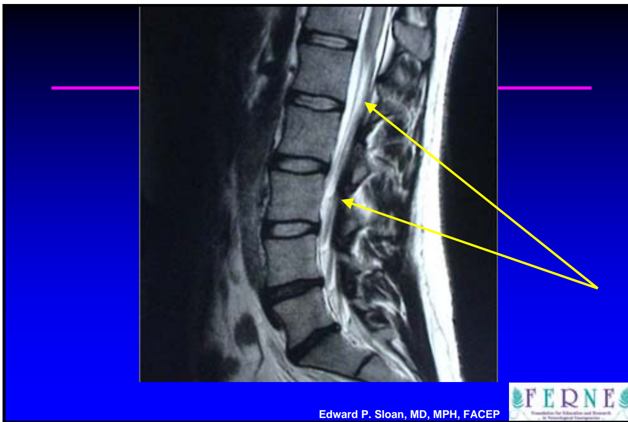

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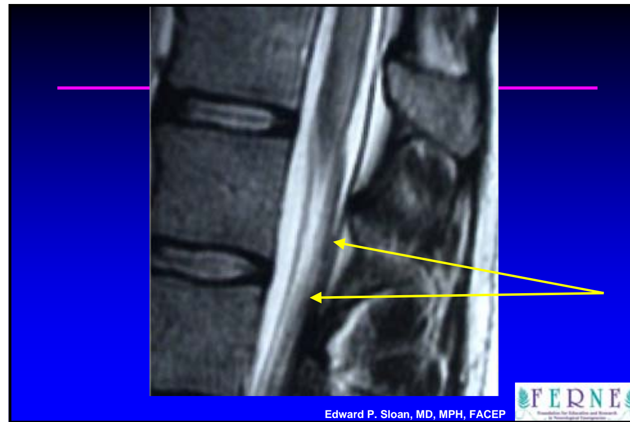

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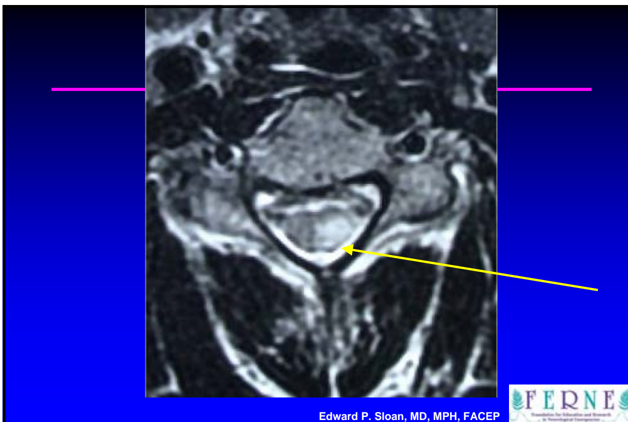

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Clinical Settings: Brain, Vessels

- Inflammation, infection, vasculitis
- Carotid or vertebral artery dissection
- Dural venous sinus thrombosis
- Acute hemorrhage (SAH, ICH & IVH)
- TIA and small CVA
- Large, severe CVA

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Inflammation, Infection & Vasculitis

- CT contrast if mass lesion possible
- MRI more sensitive: lesion detection
- Examples:
  - Multiple lesions noted in MS
  - Lesions of herpes or WNV encephalitis
- MRI usually NOT indicated acutely

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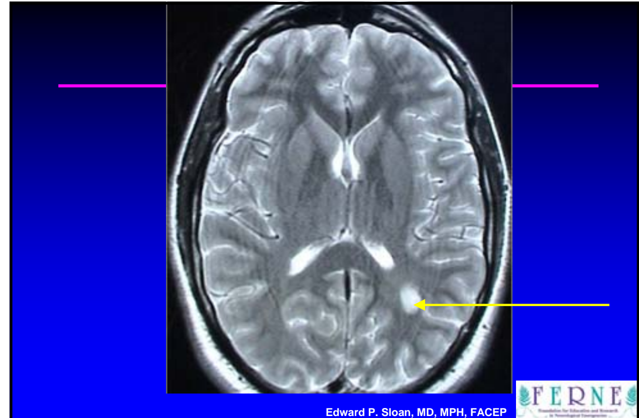

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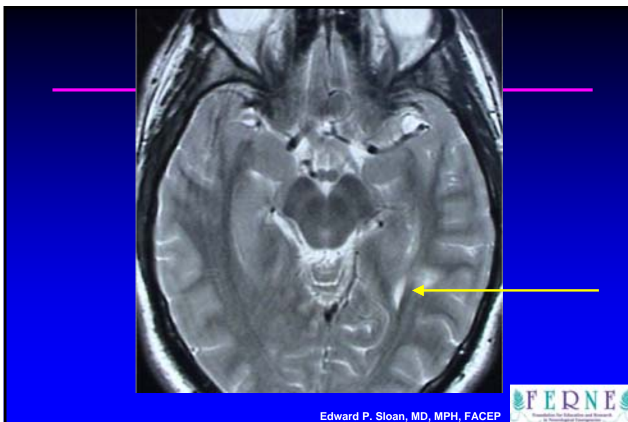

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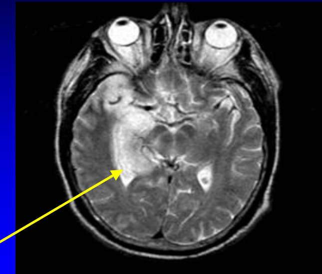
WNV Encephalitis MR Findings

- Inflamed portion of the temporal lobe, involving the uncus and adjacent parahippocampal gyrus, in brightest white on MR.



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Carotid or Vertebral Artery Dissection

- Local hematoma, mass & occlusion
- Thromboemboli distally
- Angiography is the gold standard
- MRI will detect intramural hematomas
- MRA will detect lumen compromise
- CTA ?????

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Severe Headache: Working Dx

- 38 yo wrestling coach, trauma, cephalgia
- Rule out basilar migraine and CVA
- Rule out vascular etiology
- CTA: suspected high grade stenosis R common carotid and subclavian origin
- Vertebral artery plaques, L vessel small

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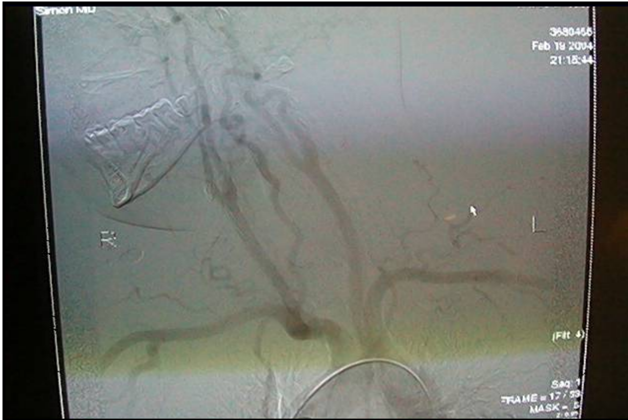

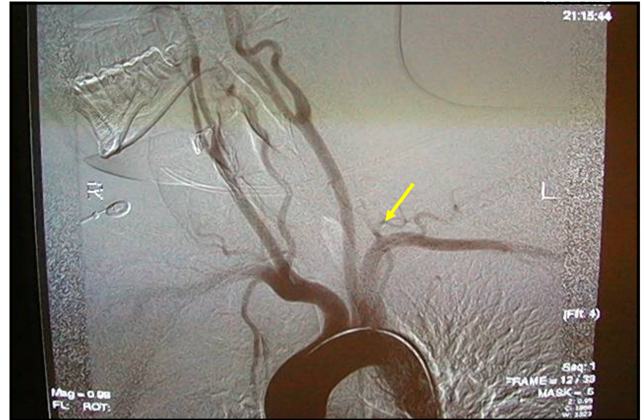

Dural Venous Sinus Thrombosis

- Major brain dural venous sinuses
- Lost cortical, deep venous drainage
- Multiple infarctions, hemorrhagic
- Dehydration, sepsis, pregnancy, coag
- Headache, vision changes, CVA, sz
- High mortality disease process

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Dural Venous Sinus Thrombosis

- MRI, MR venography acutely
- MRI will show acute thrombus
- Contrast MRI will highlight vessel
- MR venography will exclude false +
- Anticoagulant therapy
- Repeat assessments non-invasive

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Subarachnoid Hemorrhage

- Detection of aneurysm or AVM
- Decisions need to be made regarding:
  - Interventional radiology, coil placement
  - Neurosurgery, operative intervention
- Cerebral angiography optimal test
- CTA duplicates contrast
- MRA may not detect small aneurysms

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Subarachnoid Hemorrhage

- No cerebral angiogram acutely, unless:
- Interventional radiology is able to perform the angiogram and coil placement ASAP
- Neurosurgical operative intervention is to be performed immediately
- Other tests (MRA, CTA) may not obviate the need for cerebral angiography

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Acute Intracerebral Hemorrhage

- CT will detect hemorrhage, effects
- Contrast CT not indicated
- MRI also detects acute hemorrhage
- MRI detects chronic microbleeds
  - Small punctate hemosiderin lesions
  - Clinically silent, unknown significance
  - Increased ICH risk with tPA use?

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Stroke, Microbleeds, and ICH

- Didn't plenty of patients in the NINDS trials likely have undiagnosed microbleeds?
- If undetected, do they exist clinically?
- Do microbleeds actually impart risk?
- Are these predictive of symptomatic ICH?
- No need to perform MRI in order to manage risk prior to tPA use in ischemic stroke

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TIAs and Small CVAs

- Minimal or resolving symptoms
- Need to evaluate for future CVA risk
- Six questions:
  - Ischemic? Location?
  - Etiology? Probability of each etiology?
  - What tests? What treatments?
- Large and small vessel disease
- Cardioembolic source

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TIAs, Small CVAs: Large Vessel Dx

- Large vessel 15-20% of all strokes
- Extracranial (Likely large vessel cause)
  - 75%+ of large vessel disease location
  - Carotids, vertebrals, aorta
- Intracranial
  - 5-8% of strokes
  - CVD, dissection, vasculitis, spasm
  - Moya Moya Dx

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Large Vessel Dx: Extracranial

- CT angiography
  - Will detect carotid artery occlusion
  - Sensitivity, specificity for stenosis OK
- MR angiography
  - Also good study to detect carotid occlusion
  - Comparable sensitivity and specificity
- Cerebral arteriography
  - Not needed given CTA, MRA use

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Large Vessel Dx: Intracranial

- CTA and MRA both may be used
- Cerebral angiography may be optimal
- Suspect intracranial lesion when:
  - Young patients, no extracranial source
  - Failed antiplatelet therapy, recurrent TIAs or cortical strokes in a single vascular territory
  - Posterior stroke, negative cardiac evaluation
  - In pre-op eval for carotid endarterectomy

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TIAs, Small CVAs: Small Vessel Dx

- Lacunar infarcts
- 20% of all cerebral ischemic events
- DM, HTN, smoking
- Sub-cortical infarct, < 1.5 cm in size
- Occlusion of a penetrating end artery
- Basal ganglia, thalamus, internal capsule, brainstem locations

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TIAs, Small CVAs: Small Vessel Dx

- Evaluate as with large vessel disease
- Consider MRI, MRA, CTA when:
  - No risk factors
  - Atypical lacunar infarct syndrome
  - Lacune is in an atypical territory
  - Lacunar syndrome, no infarct on CT
- Testing NOT indicated acutely

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TIAs and Small CVAs

- Need to evaluate for future CVA risk
- Large and small vessel disease
- Cardioembolic source
- There is no indication for ED evaluation that includes MRI, MRA, or CTA
- These tests may be used electively in an ED observation protocol
- Not current ED standard of care

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Sudden Weakness: Diagnoses

- 22 yo with mild L weakness and resolving speech and mental status problems
- L low density “mass” cerebral peduncle
- Arachnoid cyst, cistercercosis, tumor??
- Later with hemorrhage R basal ganglia

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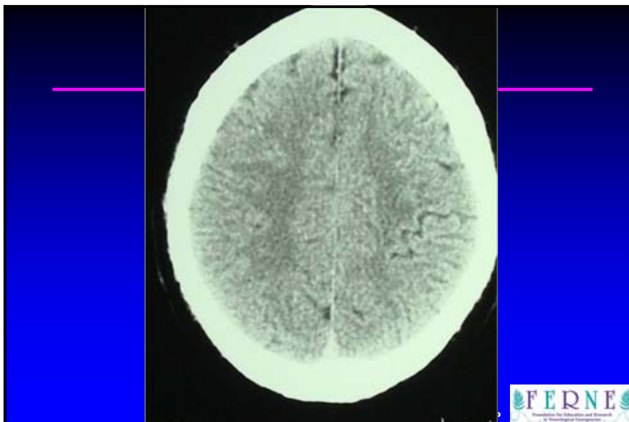

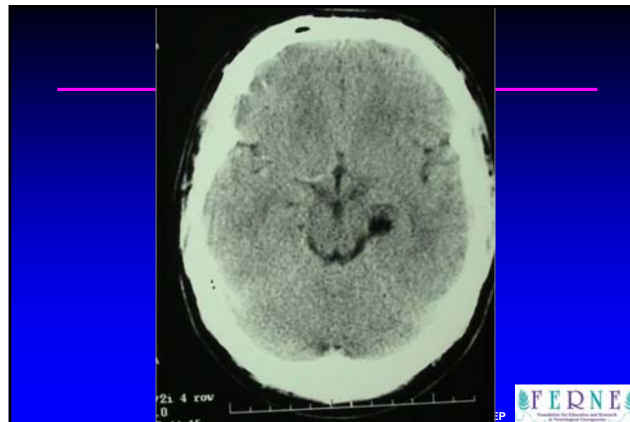

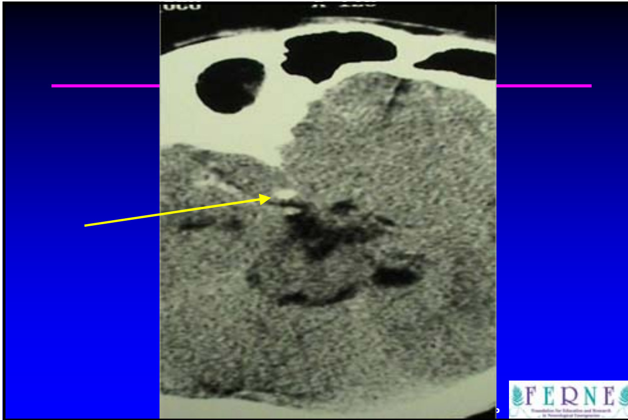

Sudden Weakness: Diagnoses

- 22 yo with mild L weakness and resolving speech and mental status problems
- 6 hours later, patient noted to have a deteriorating mental status
- R basal ganglia hemorrhage noted
- Were there microbleeds?
- Would their detection have management?

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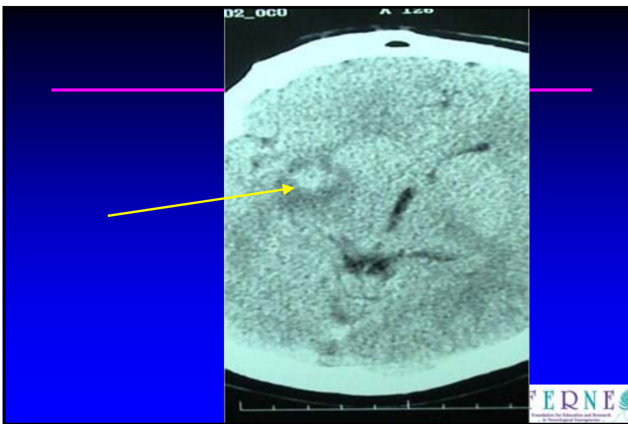

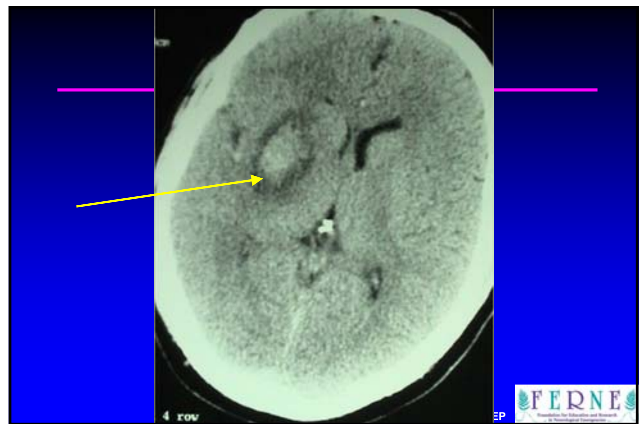

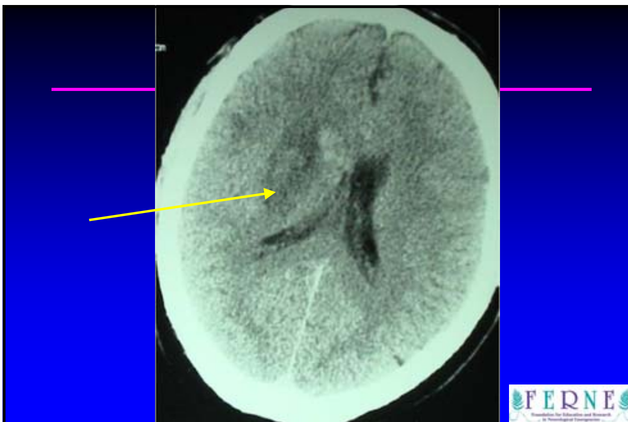

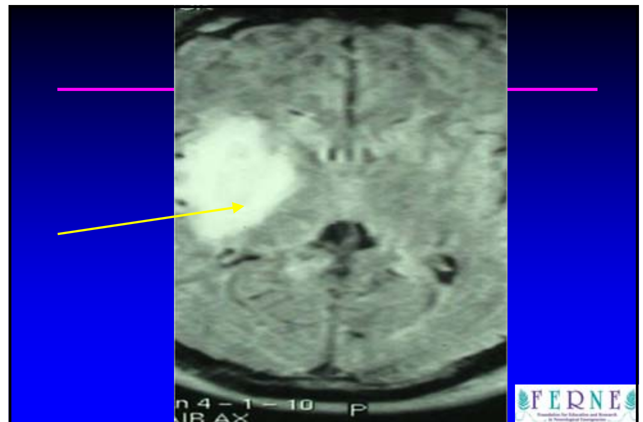

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Large, Severe CVAs

- Patients with acute stroke
- Moderate severity
- NIHSS ranges from 10-20?
- Acute hemorrhage must be excluded
- Thrombolytic therapy a consideration
- Can pt selection be optimized?

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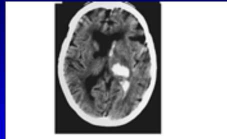
Non-Contrast Cranial CT

- Primary use is to rule out acute hemorrhage
  - Contraindication to the use of thrombolytic therapy
  - Identification of potential surgical candidates
- Limited sensitivity for acute cerebral ischemia (31-75%)



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Acute Ischemic Stroke CT

- Decreased gray-white differentiation
  - Especially in the basal ganglia
- Loss of insular ribbon
- Effacement of sulci
- Edema and mass effect *
- Large area of hypodensity* (>1/3 MCA)

*May signify increased risk of hemorrhage with thrombolytic therapy

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Magnetic Resonance Imaging (MRI)

- Multimodal MRI
- Demonstrates hyperacute ischemia
- Considered less reliable in identifying early parenchymal hemorrhage
- What role does MRI play in diagnosis and management of the acute stroke pt?

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MRI: Stroke Center Approaches

- CT acutely with follow-up MRI
  - Late delineation of stroke findings
- Both CT and MRI acutely
  - More expensive, time-consuming
  - Possible enhancements in therapy?
- MRI acutely
  - Is it a reasonable alternative?

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What is Multimodal MRI?

- T1, T2 Imaging: Conventional weighted pulse sequences
- DWI: Diffusion-Weighted Imaging
- PWI: Perfusion-Weighted Imaging
- GRE: Gradient Recalled Echo pulse sequence (T2*-sensitive)
- FLAIR: Fluid-Attenuated Inversion Recovery images

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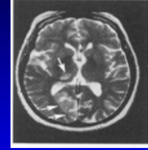
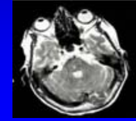
T1 & T2 Weighted Pulse Sequences

- Sensitive for subacute and chronic blood
- Less sensitive for hyperacute parenchymal hemorrhage





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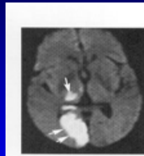
Diffusion-Weighted Imaging

- Ischemia decreases the diffusion of water into neurons
- Extracellular water accumulates
- On DWI, a hyperintense signal
- Present within minutes
- Irreversible damage delineated
- Non-salvageable tissue?



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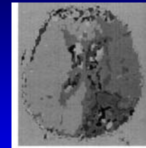
Perfusion-Weighted Imaging

- Tracks a gadolinium bolus into brain parenchyma
- PWI detects areas of hypoperfusion
  - infarct core (DWI area)
  - Ischemic penumbra



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DWI/PWI Mismatch

- Subtract DWI signal (infarct core) from the PWI signal (infarct core and ischemic penumbra)
- DWI/PWI mismatch is the hypoperfused area that may still be viable (ischemic penumbra)

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DWI/PWI Mismatch

- Important clinical implications
- May identify the ischemic penumbra
- If there is a large mismatch, then reperfusion may be of benefit, even beyond the three hour tPA window
- If there is no mismatch, there may be little benefit to thrombolytic therapy, even within the three hour window

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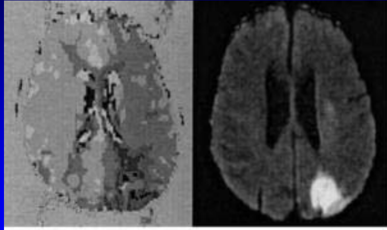
DWI/PWI Mismatch



- PWI hypoperfused area
- DWI signal

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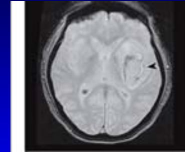
Gradient Recalled Echo (GRE) Pulse Sequence

- May be sensitive for hyperacute parenchymal blood
- Detects paramagnetic effects of deoxyhemoglobin & methemoglobin as well as diamagnetic effects of oxyhgb



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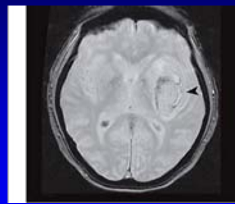
Gradient Recalled Echo (GRE) Pulse Sequence

- Core of heterogeneous signal intensity reflecting recently extravasated blood with significant amounts of oxyhgb
- Hypodense rim reflecting blood that is fully deoxygenated



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So what is the role of MRI in the ED evaluation of the stroke patient?

- Secondary?
  - Initial CT to rule out hemorrhage
  - Subsequent MRI to fully delineate ischemia, infarct and to follow treatment
- Primary?
  - Initial and possibly only imaging modality

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MRI in Large, Severe CVAs

- Primary MRI not current EM standard
- Logistical, timing issues exist
- MRI likely able to diagnose hemorrhage
- DWI/PWI mismatch a promising exam
- Tailored thrombolytic therapy??
- Improved patient outcome??

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Neurological Illness in Pregnancy

- Early pregnancy
- CT: ionizing radiation
- CT with abdominal shielding is OK

- MRI: technically poses less risk
- May be the preferred study acutely

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New Onset Seizure in Pregnancy

- 32 year old Hispanic female
- 23 weeks pregnant, new onset seizure
- Generalized tonic-clonic seizure

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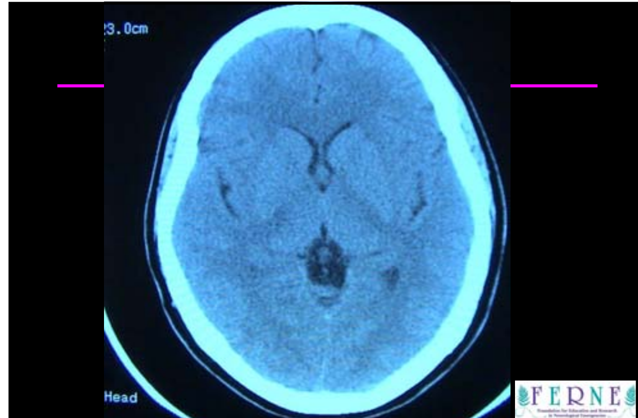

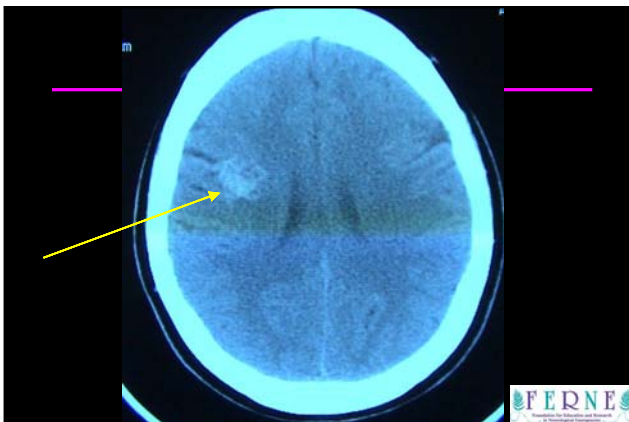

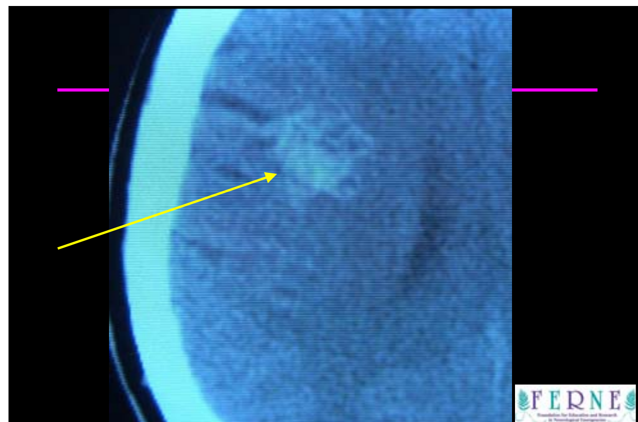

CNS MRI & More in 2006

- MRI mostly used in spinal cord dx
- CTA may be quick and efficient
- MRA may be used as is CTA
- Location, test duration problematic
- Cerebral angiography gold standard
- Know the indications & the process

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Thank you!!

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