Stroke Imaging

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Disclosures: None

Lecture Outline:

- Provide a clinical overview of stroke:
  - Risk
  - Prevention
  - Diagnosis
  - Intervention
- Illustrate how MRI is used in the diagnosis and management of stroke.
- Illustrate how competing modalities are used in the diagnosis and management of stroke.

Stroke
Cerebrovascular Accident (CVA)

Sudden diminution or loss of consciousness, sensation, and voluntary motion caused by rupture or obstruction of a blood vessel of the brain.

Stroke Risk

Controllable Risk Factors

High BP, A. Fib, High Cholesterol, DM, Smoking, ETOH, Physical Inactivity, Obesity

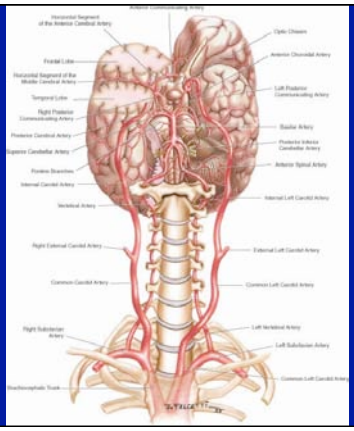
Uncontrollable Risk Factors

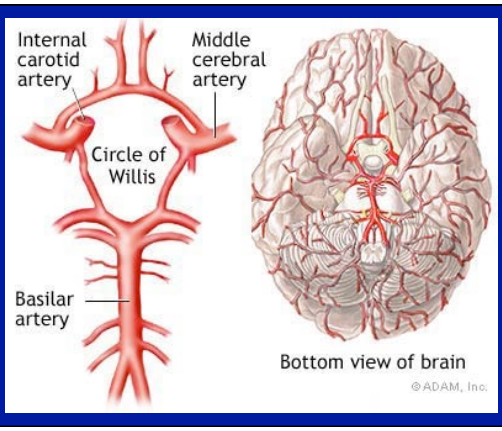
Age, Gender, Race, Family Hx, TIA's or Prior Stroke, FMD, R to L shunt

Stroke Prevention

- Imaging work-up of vascular stenosis
  - Clinical Signs & Symptoms
  - Vascular Screening (advancing age + risk factors)
- Pharmacologic and Surgical Prevention
  - BP, Statins, Anti-platelets
  - Endovascular (Angioplasty vs. Stent)
  - Surgical (Endarterectomy vs. Bypass)

Proc. Intl. Soc. Mag. Reson. Med. 22 (2014)





Pathophysiology of Stroke

Artery rupture- hypertensive hemorrhage

Arterial stenosis/Systemic hypoperfusion

Arterial occlusion
- Embolic
  - Cardiac
    - Atrial fibrillation
    - Right to left shunt- patent foramen ovale
  - Carotid
- Thrombotic (large vs. small vessel)

Venous occlusion- hemorrhagic

Hypertensive Hemorrhage

10-20% of Stroke

>50,000/yr in U.S.

GM nuclei, Pons

Hypoperfusion Stroke

Vascular territory- proximal large vessel stenosis results in the inability for the brain to autoregulate flow in the setting of hypotension.

Global (severe systemic hypotension)

Artery Occlusion- Thrombotic

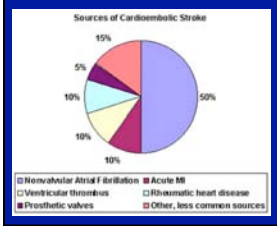
60% of Stroke

300,000/yr in U.S.

Vascular territory

Artery Occlusion- Embolic

25% of Stroke
125,000/yr in U.S.
Vascular territory



Venous Occlusion Stroke

50-100x less common than arterial stroke

- Edema typically involving the underlying WM
- Enhancement / Hemorrhage
  BBB breakdown secondary to elevated venous pressure

Imaging for Stroke Prevention

% Stenosis = $(1 - (\frac{\text{Minimal lumen diameter}}{\text{Distal lumen diameter}})) \times 100\%$

North American Symptomatic Carotid Endarterectomy Trial (NASCET)

Barnett HJ, Taylor DW, Eliasziw M et al. *NEJM* **339** (20): 1415–1425, 1998.

European Asymptomatic Carotid Surgery Trial (EACST)

≥70% carotid stenosis if the surgery can be performed with ≤3% risk of perioperative complications

Consensus statement by the American Academy of Neurology & the American Board of Internal Medicine February 2013

Surgery vs. Stent

The Carotid Revascularization Endarterectomy versus Stenting Trial (CREST)

Mantese VA, Timaran CH, Chiu D, Begg RJ, Brott TG, & CREST Investigators. Stroke, 2010 Oct;41(10 Suppl):S31-4.

↑'d risk of stroke with CAS & ↑'d risk of MI with CEA

The Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy (SAPPHIRE) Trial

Gurm HS, Yadav JS, Fayad P, & SAPPHIRE Investigators. N Engl J Med 2008; 358:1572-1579.

No long term outcome difference for high risk patients

Vascular Assessment

- Conventional Angiography
- CT Angiography (CTA)
- MR Angiography (PC, TOF, Bolus)
- Doppler/US

Anatomic Vascular Assessment

- **Conventional Angiography**
- **CT Angiography (CTA)**
- **MR Angiography** (PC, TOF, **Bolus**)
- Doppler/US

Physiologic Vascular Assessment

- **Conventional Angiography**
- CT Angiography (CTA)
- **MR Angiography** (**PC**, **TOF**, Bolus)
- **Doppler/US**

Vascular Assessment- DSA

Anatomic & Physiologic Test

Advantages
- Superior spatial resolution
- Superior temporal resolution
- Anatomic and Physiologic

Disadvantages
- Stroke risk
- Cost
- Requires contrast
- Ionizing radiation

Vascular Assessment- CTA

Anatomic Test

Advantages
- Intermediate spatial resolution
- Fast and readily available

Disadvantages
- Purely anatomic
- Ionizing radiation
- Requires contrast
- Temporal resolution
- Obscured by calcium

Vascular Assessment- MRA

Physiologic & Anatomic Test

Advantages
- Physiologic test
- No ionizing radiation
- Not obscured by calcium

Disadvantages
- Poor temporal resolution
- Turbulent flow
- Less available
- Requires contrast

2D vs. 3D TOF MRA Tradeoffs

	2D	3D	MOTSA
Flow related enhacement	+++	--	++
Intravoxel Dephasing	--	++	++
Resolution	---	+++	+++

Acetazolamide Imaging of the Brain

Acetazolamide (DIAMOX)- carbonic anhydrase inhibitor

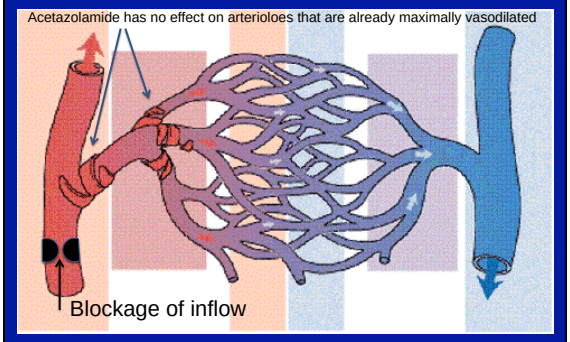
Kidneys excrete bicarbonate, decreasing blood pH

The brain equates blood acidity with CO_2 concentration

The perceived excess of CO_2 results in:
- Deeper and increased rate of breathing
- Vasodilation of the arterioles feeding the brain

Effect of Acetazolamide on Cerebral Blood Flow and Cerebral Metabolic Rate for Oxygen
Vorstrup S, Henriksen L, Paulson OB. J. Clin. Invest. Vol. 74, Nov. 1984, 1634-1639

Cerebral Vascular Reserve- Blood flow to brain is tightly regulated

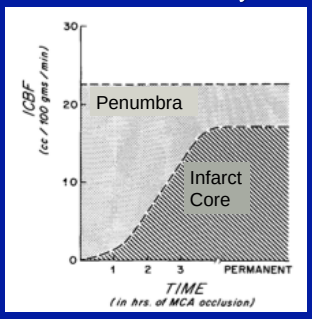


Imaging Recommendations for Acute Stroke and Transient Ischemic Attack Patients

A Joint Statement by the ASNR, ACR, SNIS

Wintermark M, et. al. AJNR 43:E117-E127, Nov. 2013

Thresholds of Focal Cerebral Ischemia in Awake Monkeys



Jones, TH, et. al. J. Neurosurg 54:773-782, 1981

CT vs. MRI

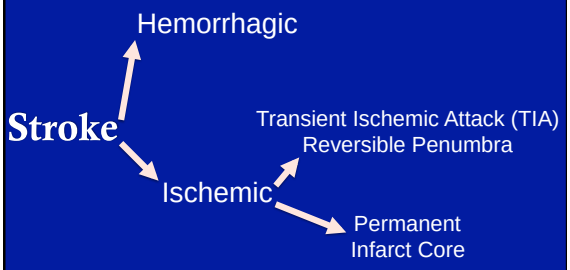
Dx of ischemic stroke in the emergency setting:	Dx of hemorrhagic stroke in ED setting:
CT scan (*non*-contrast)	CT scan (*non*-contrast)
sensitivity= 16%	sensitivity= 89%
specificity= 96%	specificity= 100%
MRI scan	MRI scan
sensitivity= 83%	sensitivity= 81%
specificity= 98%	specificity= 100%

The Lancet, Vol.369, Issue 9558, Pages 293 - 298, 27 January 2007

Acute Stroke Imaging

CT	vs.	MRI
+ Accessible		- Less accessable
+ Fast		- Less fast
+ Identify acute blood		+/- Identify acute blood
- Infarct Core		++ Infarct Core
- Perfusion: +contrast		Perfusion: +/- contrast

Acute Stroke Assessment



Step 1:
Is Intracranial hemorrhage present?

Yes- Supportive care No- Step 2

CT- tPA package insert MRI- Equivalent/Superior

Schellinger PD, et. al.*Stroke. 1999; 30: 765-768*
Kidwell CS, et. al. JAMA. 2004 Oct 20;292(15):1823-30.

Step 2: Candidate for IV tPA?

< 4.5 hours since onset of symptoms

Yes- IV tPA No- Step 3

Step 3: Is endovascular Rx Considered?

< 8 hours since onset of symptoms

Yes- Stat imaging	No- Supportive care
NCCT + DSA	MRI + MRA
NCCT + CTA + CTP	NCCT + CTA
MRI + MRA + PWI/ASL	NCCT + DUS

Stroke: Risk, Prevention, Dx, & Intervention

Use of MRI in the diagnosis and management of stroke.

Non-MRI modalities in the diagnosis and management of stroke.

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