Imaging in Subarachnoid Hemorrhage

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SAH Causes

- Traumatic
- Non-Traumatic

Post-trauma SAH

Convexity Post-trauma SAH

Post-trauma SAH
Non-traumatic causes of SAH

- ruptured intracranial aneurysms (80-85%)
- non-aneurysmal perimesencephalic sah (10%)
- avm’s
- dissection
- venous thrombosis, sickle cell dz, vasculitis, coag disorders, RCVS, pituitary apoplexy, other, unknown.

Unruptured Intracranial Aneurysm Risk (ISUIA Studies)

- Patients without prior SAH and anterior circ aneurysms 5 year cum rupture rate and (post circ rupture rates incl pcom)
  - <7mm - 0% (2.5%)
  - 7-12mm - 2.6% (14.5%)
  - 13-24mm: 14.5% (18.4%)
  - >25mm: 40% (50%)

SAH Grading

- **Hunt & Hess Grade**
  - 1: asympt. or mild h/a, sl. Nuchal rigidity
  - 2: Cr N palsy, mod-sev. h/a, nuchal rigid
  - 3: mild focal deficit, letharg or confusion
  - 4: stupor, mod-sev. hemipar., early decereb rigid
  - 5: deep coma, decerebrate rigidity, moribund
  - Add 1 grade for serious systemic dz (e.g. htn, dm, severe atheros, copd, severe vasospasm)

SAH Outcomes

- SAH from ruptured aneurysms affect ~22,000 pts per year in U.S.
- 10% die before reaching hospital
- 46% 30 day mortality
- Related to presentation grade: 15-20% mortality for grades 1-2

Pitfalls in the Diagnosis of SAH

- Pts with H/A: 1-2% visits to E.R.
  - Most have primary h/a disorders e.g. migraine, muscle tension
  - ~1% will have SAH; 12% if only worst h/a of life considered
  - Edlow et al, NEJM, vol 342 (1) Jan 6, 2000

Pitfalls in the Diagnosis of SAH

- Clinical (classic):
  - Sudden onset severe h/a (worst of life)
  - Transient LOC or buckling of legs at h/a onset
  - Vomiting
  - Nuchal rigidity
  - Dec. level of consciousness
  - Focal neuro deficits
  - Retinal hemorrhages (subhyaloid or vitreous due to inc. icp & dec venous outflow from eye)

Pitfalls in the Diagnosis of SAH

- 25-35% SAH pts initially receive misdiagnosis
  - Avg delay ~ 5 days
  - These pts tend to be in better clinical condition at presentation but worsened as a result of misdx
  - These are also the pts more likely to benefit from early intervention
  - Edlow et al, NEJM, vol 342 (1) Jan 6, 2000

Pitfalls in the Diagnosis of SAH

- Specific misdiagnoses:
  - idiopathic h/a, migraine, muscle tension
  - meningitis
  - systemic inf’ n (flu etc)
  - stroke
  - htn crisis
  - cardiac dz (arrhythmia, syncope, mi) 90% will have ekg abilities
  - sinus dz
  - c-spine dz
  - psychiatric
  - trauma related (secondary head trauma)
  - back pain
  - Edlow et al, NEJM, vol 342 (1) Jan 6, 2000
Misdiagnosis in SAH

- Diagnostic Error
  - **No CT performed**: 71%
  - CT or LP results misinterpreted: 16%
  - CT done, but no LP: 7%
  - Other: 4%

  - Kowalski et al, JAMA, Vol 291, No 7, Feb 18, 2004

Pitfalls in the Diagnosis of SAH

- Lumbar Puncture: “Gold Standard”
  - Should be done in pts with clinically suspected SAH, and, negative, equivocal or technically inadequate CT.

Complications

- Re-bleeding: risk is 4% on day 1, 15-20% within 14 days
- Hydrocephalus: may be seen acutely (15%), subacutely or chronically
- Hyponatremia

Pitfalls in the Diagnosis of SAH

- Lumbar Puncture: “Gold Standard”
  - Traumatic tap vs. SAH (need to distinguish b/c 1-5% gen pop harbor intracranial aneurysms)
    - 3 tube method (decreasing rbc’s): unreliable
    - Crenated erythrocytes: unreliable
    - Erythrophages: days to develop: inconsistent
    - Xanthochromia: Released hgb metabolized to oxyhgb (reddish pink) + bilirubin (yellow) → Xanthochromia (12 hrs after SAH)
      - Centrifuge immed to avoid in vitro lysis (false +)
      - Spectrophotometry much more sens than visual inspection but rarely used!

  - Edlow et al, NEJM, vol 342 (1), Jan 6, 2000

Complications

- Vasospasm:
  - Most significant cause of morbidity and mortality in pts with SAH reaching medical care
  - Related to amt blood on CT and H&H grade
  - Time course: almost never before day 3; max freq day 6-8; usu resolves by 2 weeks
  - Seen on angio in 30-70% of pts around day 7
    - Symptomatic vasospasm occurs in 20-30%

Work-up for Potential SAH

- Non-contrast Brain CT
- Lumbar Puncture: Gold Standard for SAH
- Conventional Arteriography: Gold Standard for aneurysm search
- CTA
- MRA
Diagnosis of SAH
CT Scanning

- On 3rd gen CT ~95% sens in 1st 24 hrs and decreases each day thereafter
  - Within 6 hrs 100%¹
  - After 6 hours 87%¹
- Our technique: NCCT, MDCT, 2.5mm post fossa, 5mm supratentorial

¹ Sensitivity of computed tomography performed within six hours of onset of headache for diagnosis of subarachnoid haemorrhage: prospective cohort study
- BMJ 2011; 343 doi: http://dx.doi.org/10.1136/bmj.d4277 (Published 18 July 2011)
Headache and Rt 3rd Nerve

Isodense SAH

Isodense SAH
Isodense SAH

**MRI in SAH**
- FLAIR
- GRE
- T1, T2 less sensitive
- Does NOT supplant CT in evaluation for SAH but may be complimentary especially if a few days old

**FLAIR**
- Nulls SI of free fluid (i.e. CSF)
- Increased protein or cellularity (e.g. blood) causes incomplete/ absent nulling and increased signal
- Fairly sensitive but not specific for SAH and also has considerable pitfalls

**FLAIR Pitfalls**
- CSF Pulsation and turbulence artifacts- may produce false + and obscure true +
- Acute blood may infrequently be dark
- Patients on FIO2 > 60% will have increase SI in extravent CSF
- False + from vasc abnities with leptomeningeal enhancement e.g. venous congestion from sinus thrombosis or dural fistulae, stroke
- Mj Ddx SAH, meningitis
S/P RT to Dural Based Met

Gradient Echo
- Relies on T2* effect of blood to produce susceptibility and signal loss (dark)
- Pitfalls include false + from Ca++, surrounding vessels, venous engorgement
- Also limited due to susceptibility artifact from skull base and sinuses

FLAIR CSF Flow Artifact

Peri-ischemic SAH: ICA Stenosis

FLAIR HI O2

Peri-ischemic SAH: ICA Stenosis
Peri-ischemic SAH: ICA Stenosis

Subtle SAH on GRE

MRA

Aneurysm Protocol
- 3D TOF
- Cover from foramen magnum to genu corpus callosum (PICA to Pericallosal)
- Thin section T1 FS circle of willis
- Look at source images first & last!

Subtle SAH on GRE

MRA Aneurysm-Pitfalls
- Thrombosed/partially thrombosed aneurysms
- Slow flow aneurysms
- Fatty clinoids
- Small size
Aneurysms- Size Matters!
Huston III et al, AJNR 15:1607-14, Oct 1994

- Aneurysm size
  - > 2mm
  - > 3mm
  - > 4mm
  - > 5mm
  - > 6mm
  - 100% > 3mm aneurysms Id’d retrospectively

- Sensitivity
  - 55%
  - 60%
  - 68%
  - 87.5%
  - 100%

Contrast-free MRA at 3.0T for the detection of intracranial aneurysms. Li MH et al Neurology 2011

- Sensitivity 99%
- Specificity 97%
Vasospasm: MRA

- MRA (Grandin et al. AJNR Oct 2000). 5T
  - 92% sens, 98% spec but poor for ICA, MCA
    (25%, 56%)