Imaging evaluation of the patient with a CSF leak

GSO 2013

Kristen Lloyd Baugnon, M.D.

Department of Radiology and Imaging Sciences
Division of Neuroradiology

EMORY
UNIVERSITY
SCHOOL OF
MEDICINE

Disclosures

No relevant disclosures.

Acknowledgements

Thanks to Drs. Chen and Wise!

Thanks to the Emory Head and Neck group:

Patricia A. Hudgins, M.D.

Ashley Aiken, M.D.

Amanda Corey, M.D.

Amit Saindane, M.D.

Learning Objectives

- **Classification of CSF leaks**
  - Traumatic, nontraumatic, spontaneous
- **Clinical presentation & diagnosis**
- **Possible imaging modalities**
  - CT, MRI, cisternography (CT&MR)
- **Imaging algorithim**

Skull base CSF Leak

- **CSF from subarachnoid space → nasal or ME cavity**
  - Rhinorrhea or otorrhea
  - Implies osseous & dural defect
- **Up to 50% of pts develop meningitis**
  - Must be worked up & treated

Types of CSF Leak

- **Ommaya 1960 – classification (etiology)**
  - Traumatic
    - Accidental trauma
    - Surgical trauma (iatrogenic)
  - Nontraumatic
    - Known etiology (tumor, congenital lesion, etc)
  - Spontaneous
    - No known etiology
    - New group recently described
    - IIH

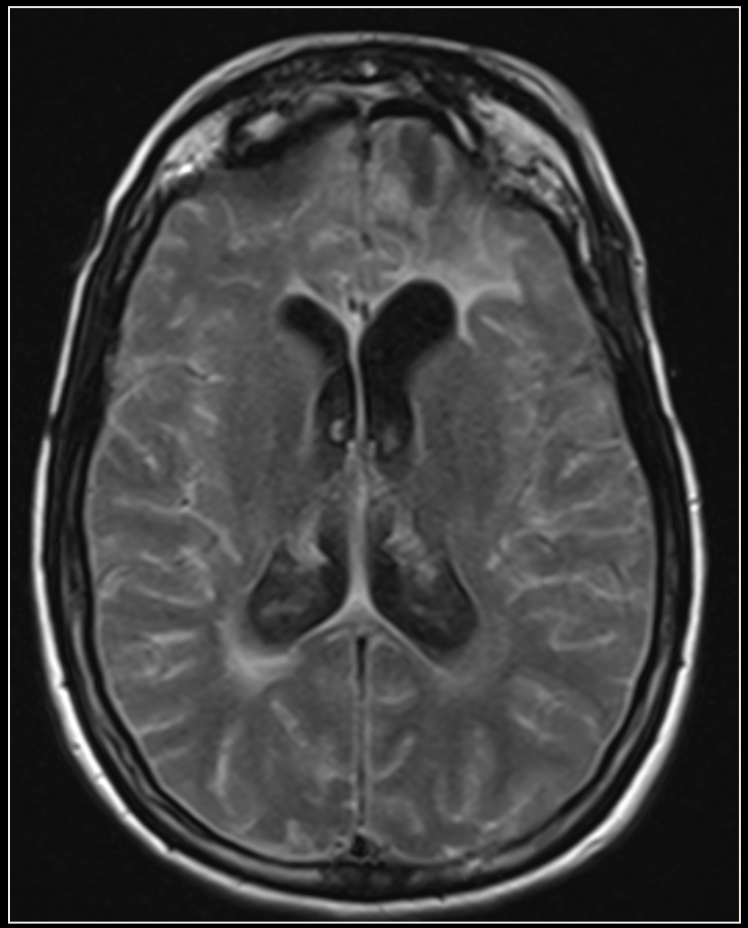
Traumatic CSF Leak

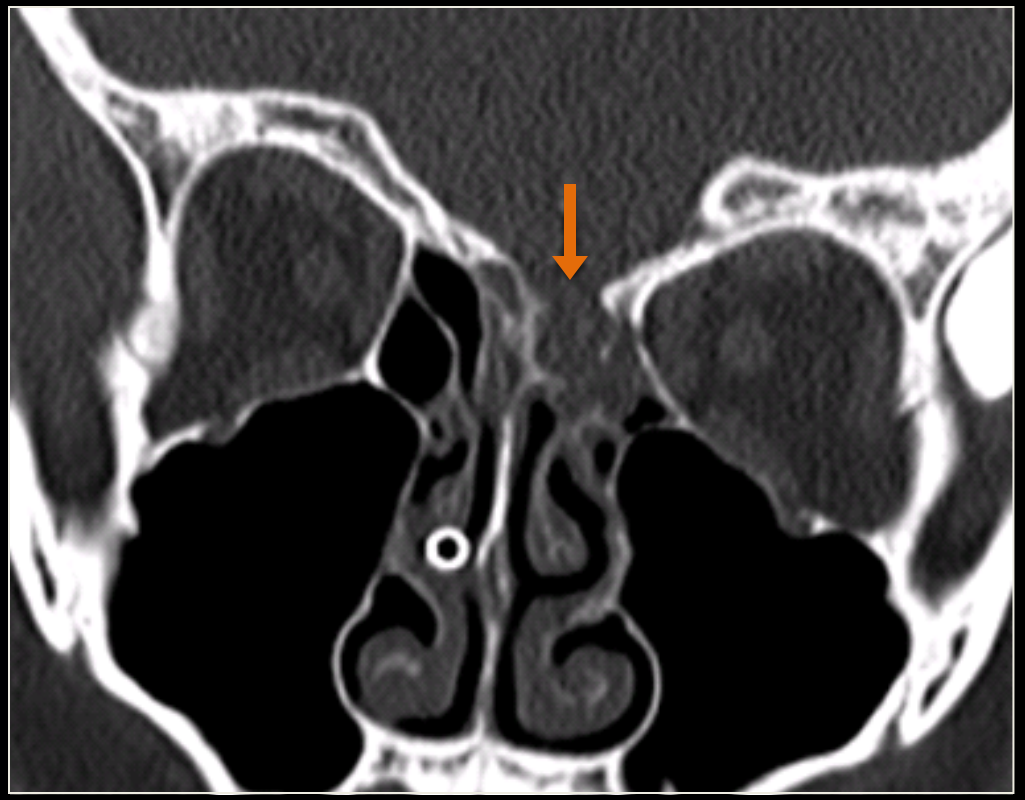
- **Most common etiology – up to 90% of cases**
  - 80% rhinorrhea, 20% otorrhea
- **Extensive skull base fractures**
  - (ie. crib plates, ethmoid roof, frontal/sphenoid sinus, t-bone)

Traumatic CSF leaks

- **80% pts present in first 48 hrs**
  - 95% present in first 3 months
  - 5% delayed presentation
    - Months to years (even decades!) after trauma
- **Most (up to 2/3) heal spontaneously with conservative management (esp otorrhea!)**
  - Bedrest, stool softeners, acetazolamide, lumbar drain
  - Persistent leaks need to be fixed!

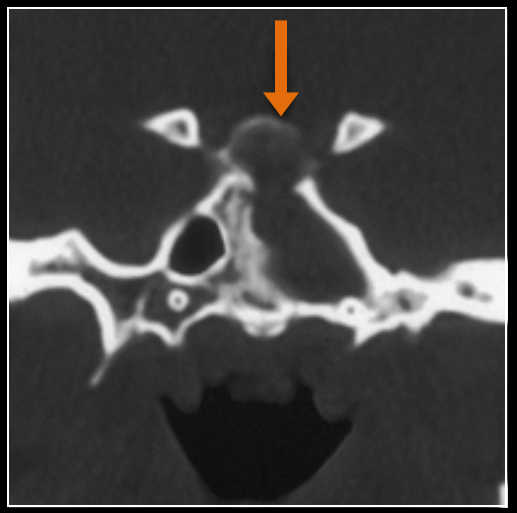
26 yo F w remote hx of trauma and AMS

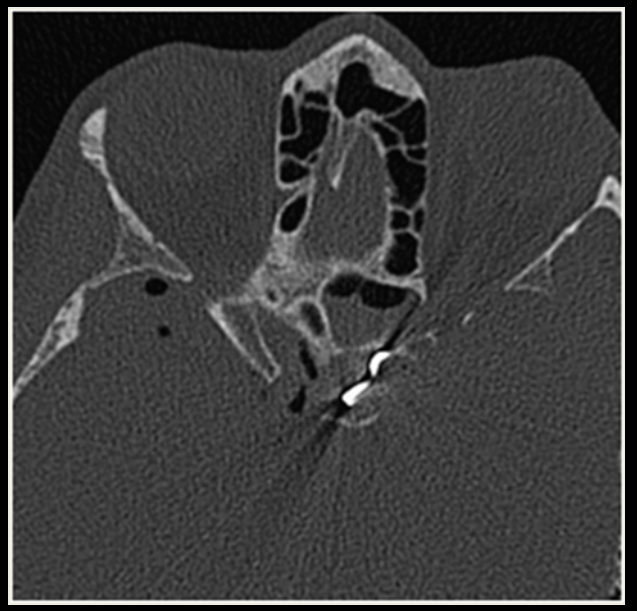




Iatrogenic leaks

- **Most common:**
  - Transphenoidal hypophysectomy
  - Crani with clinoidectomy
  - Endoscopic sinus surgery
- **Often site of defect is obvious**
- **Only HRCT needed for dx & surgical planning**
- **Postop findings make CT Cg challenging**

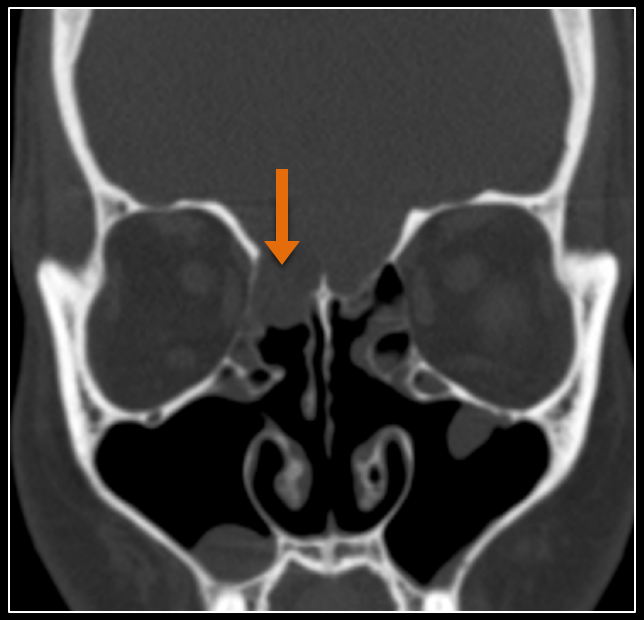


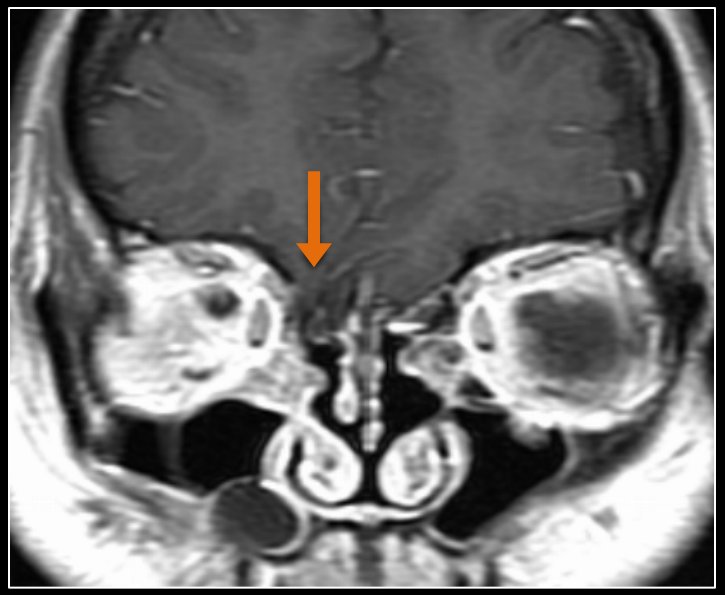


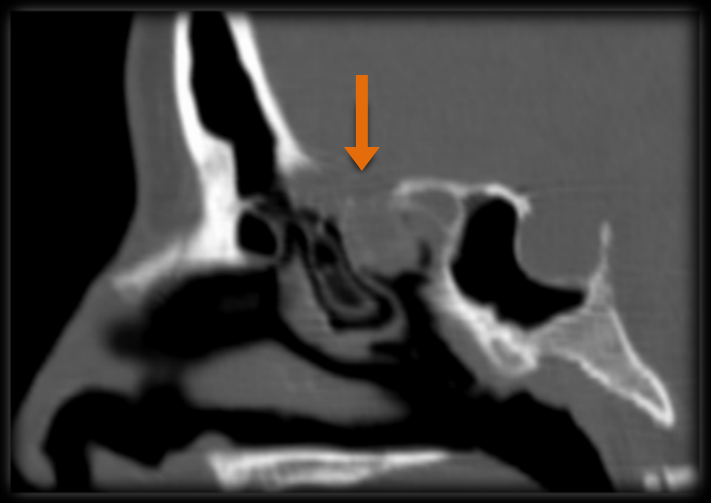
CSF leak post FESS

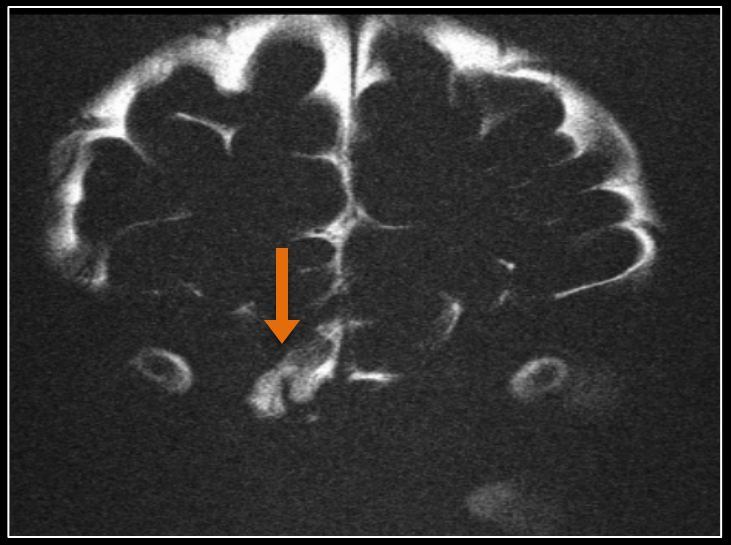
- **Known risk of ESS**
  - Inc risk with revision surgery, polyposis
- **Often recognized and fixed intraop**
- **Sites:**
  - Lateral lamella
  - Cribriform plate
  - Ethmoid roof
    - Anterior ethmoid roof
    - Junction of ant and post ethmoids

39 yo F w rhinorrhea post FESS









Lloyd K, et al
Radiology
2008

Non-traumatic CSF leaks

- **Pathologic cause identified**
  - Tumor involving skull base
    - Before, but usually after chemo/XRT, surgery
    - ORN of the temporal bone occas assoc with CSF leak
  - Increased ICP (i.e. untreated hydrocephalus, congenital or acquired)
  - Congenital lesions:
    - meningoencephalcoeles,
    - Arachnoid cysts
    - Gorhams
    - Inner ear anomalies

Spontaneous CSF leak

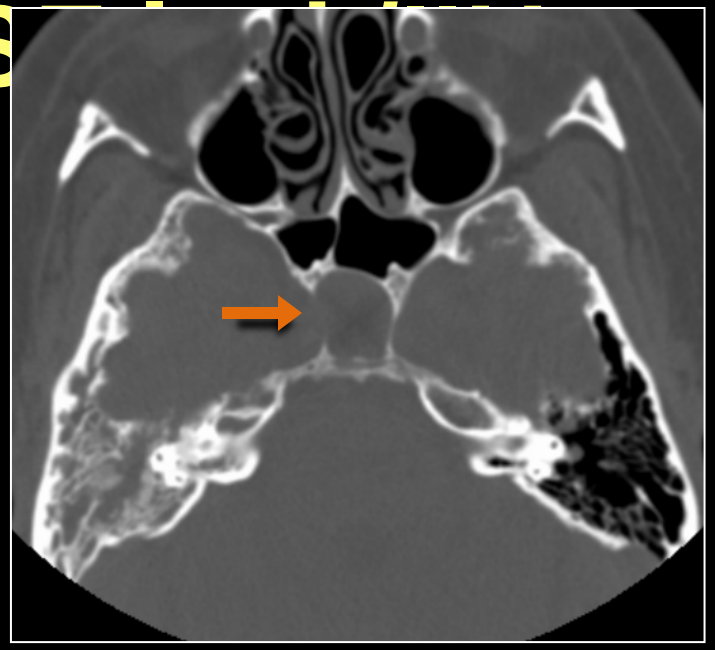
- **No definable cause**
- **Obese middle aged females (BMI > 30)**
- **Radiologic signs of long standing ↑ ICP (IIH)**
  - Mechanism: ↑ IA pressure, ↑ ICP
  - ↑ ICP – arachnoid granulations erode inner table/sinus wall
  - Assoc w encephaloceles (50-100%) (MRI)
- **↑ incidence with ↑ BMI in US (up to 73%)**
- **Identifying pts imp – worse prognosis after repair – may alter mgmt**

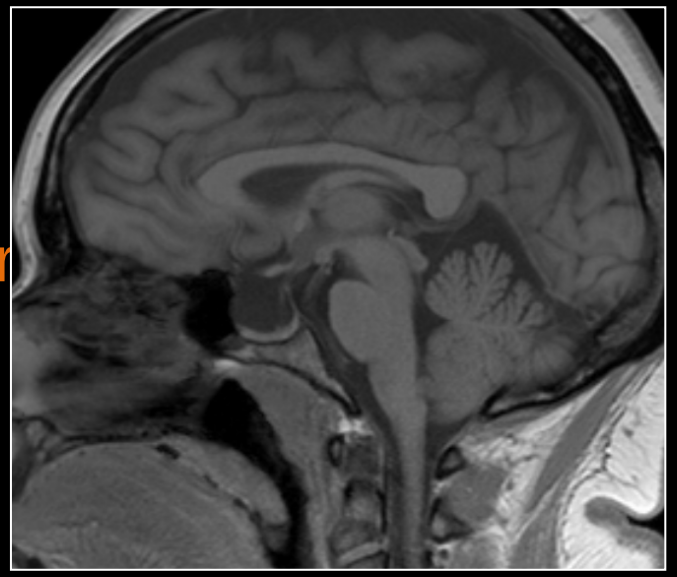
Spontaneous CSF leak/IIH

- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/prominent ON sheath

Spontaneous CS

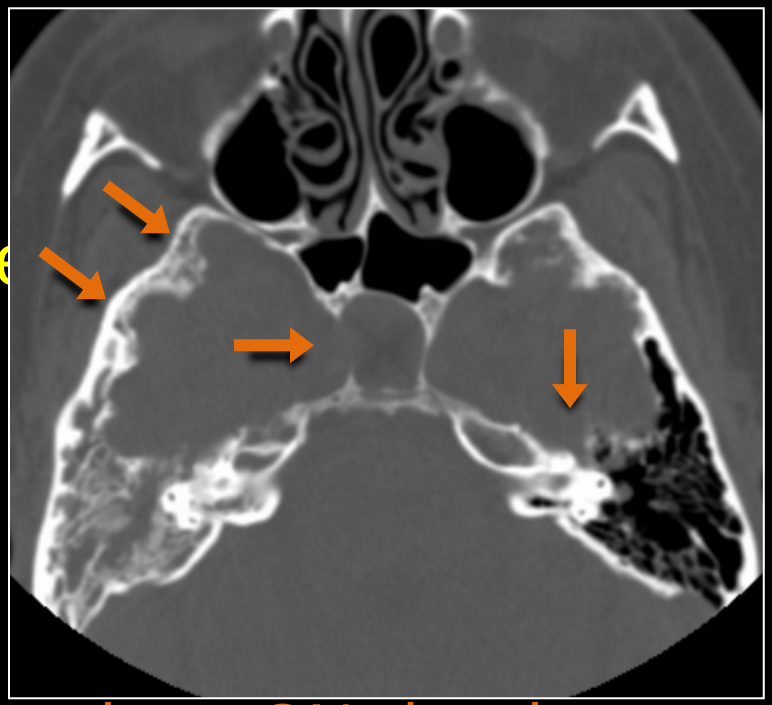
- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/pr





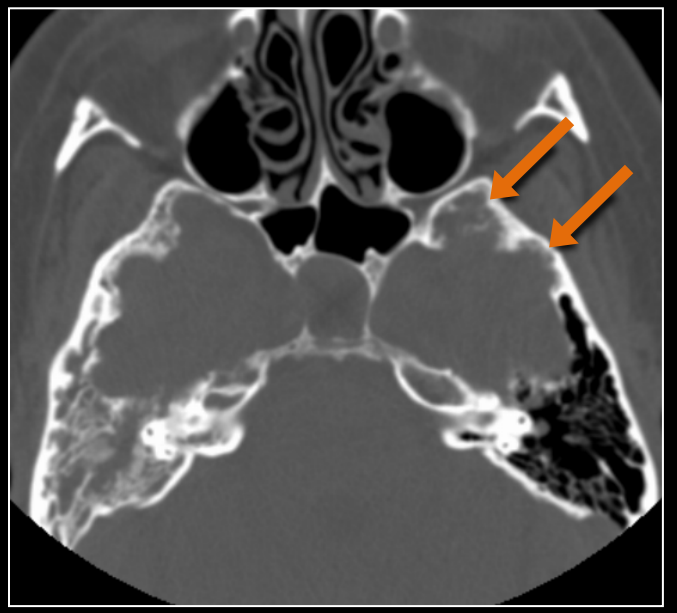
Spontaneous CSF leak/IIH

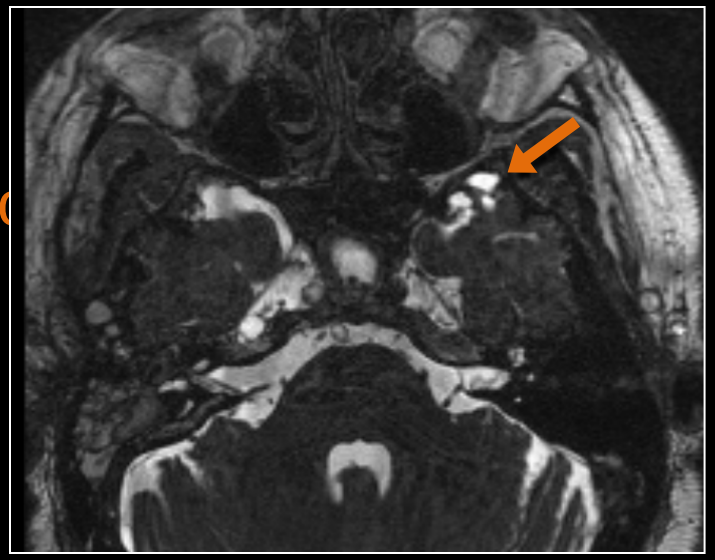
- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/prominent ON sheath



Spontaneous CSF leak/IIH

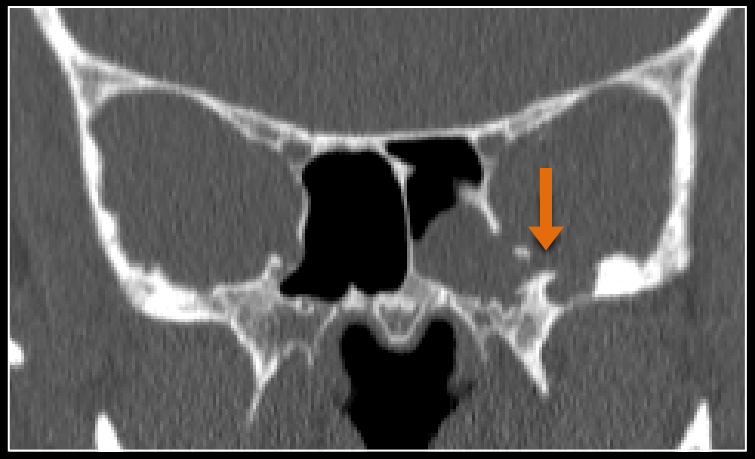
- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/pr

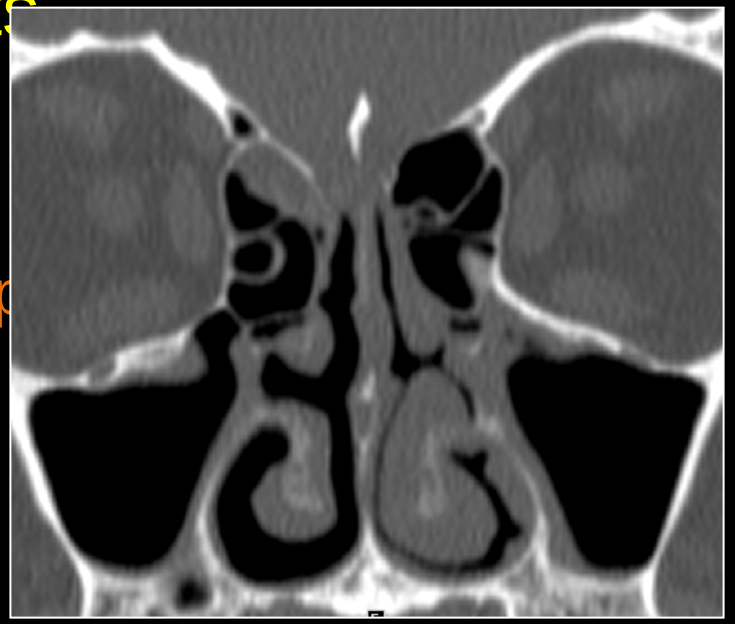




Spontaneous CSF leak/IIH

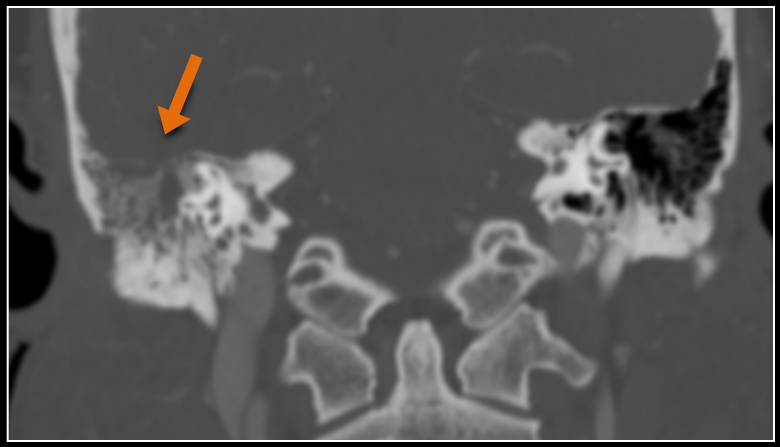
- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/p

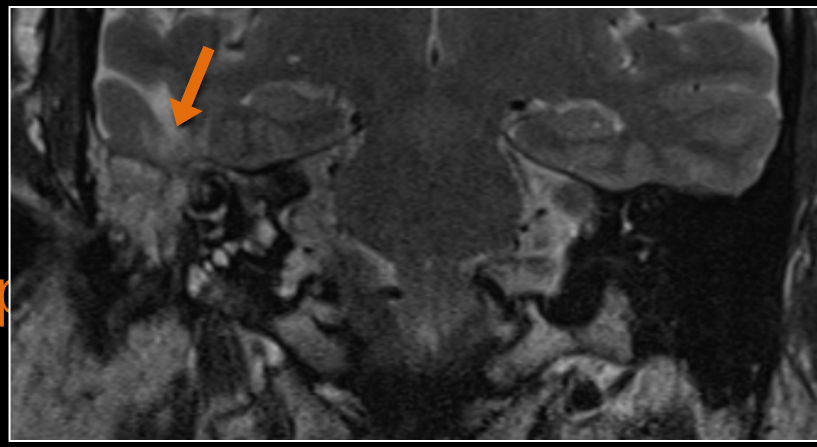




Spontaneous CSF leak/IIH

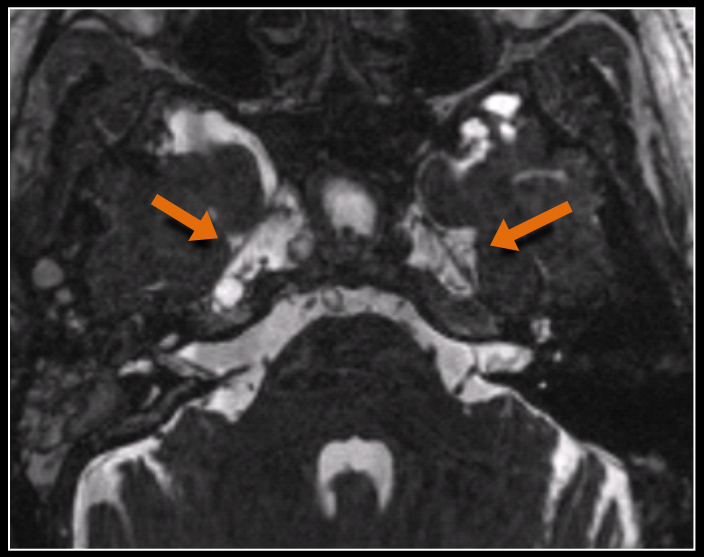
- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/p

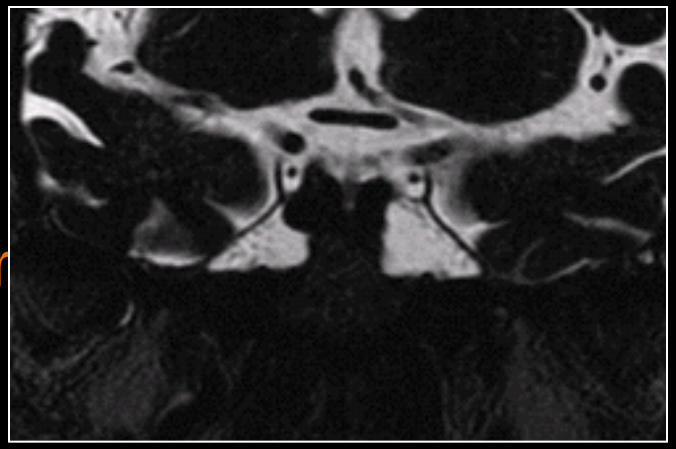




Spontaneous CSF leak/IIH

- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
    - Petrous apex cephaloceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/pr



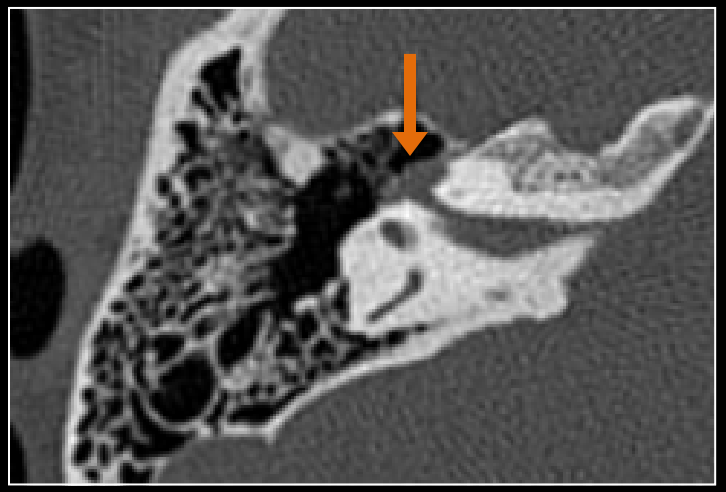


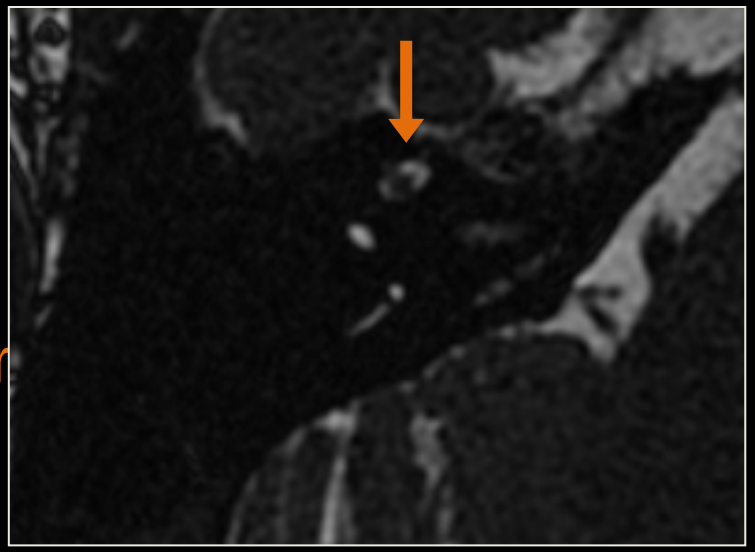
Spontaneous CSF leak/IIH

- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull
  - Prominent arachnoid p
  - Multiple skull base defects
  - Meningoencephaloceles
    - Facial nerve meningoceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/prominent ON sheath

Spontaneous CSF leak/IIH

- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
    - Facial nerve meningoceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/pr

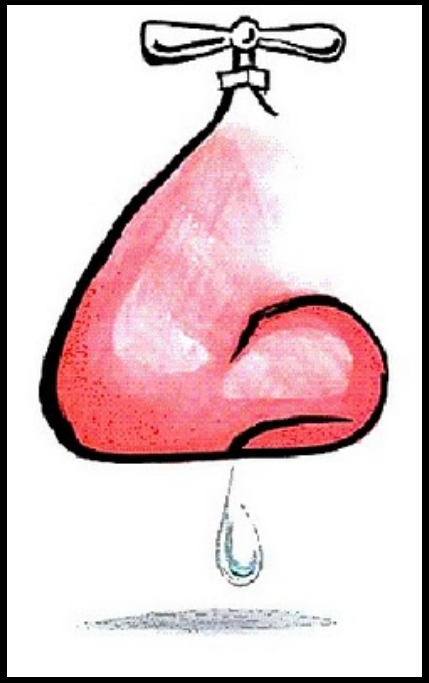




Spontaneous CSF leak/IIH

- **Imaging findings:**
  - Empty sella
  - Scalloping of the skull base
  - Prominent arachnoid pits
  - Multiple skull base defects
  - Meningoencephaloceles
    - Posterior temporal meningoceles
  - Transverse sinus stenosis
  - Flattening of posterior sclera/promi

CSF leak: Clinical Presentation



- **CSF rhinorrhea:**
  - Clear, watery rhinorrhea
  - Worsens with valsalva, head down
- **CSF otorrhea**
  - Serous otitis media
- **Meningitis**
- **Pneumocephalus**
- **Low pressure HA's (intracranial hypotension)**
- **High risk patient: Prior trauma, skull base/ESS, tumor, obese**

Clinical Diagnosis

- **Beta 2 transferrin (beta trace protein) assay**
  - First screening test “gold standard”
  - Protein specific to CSF
  - Unequivocal evidence to support use
    - High sensitivity and specificity
  - Patient collects in testtube
    - stores room temp or fridge
  - Requires only a few drops (0.5 -1 cc)
  - Limitations:
    - Intermittent or no leak (unable to collect)
    - False postive (rare!) Liver failure

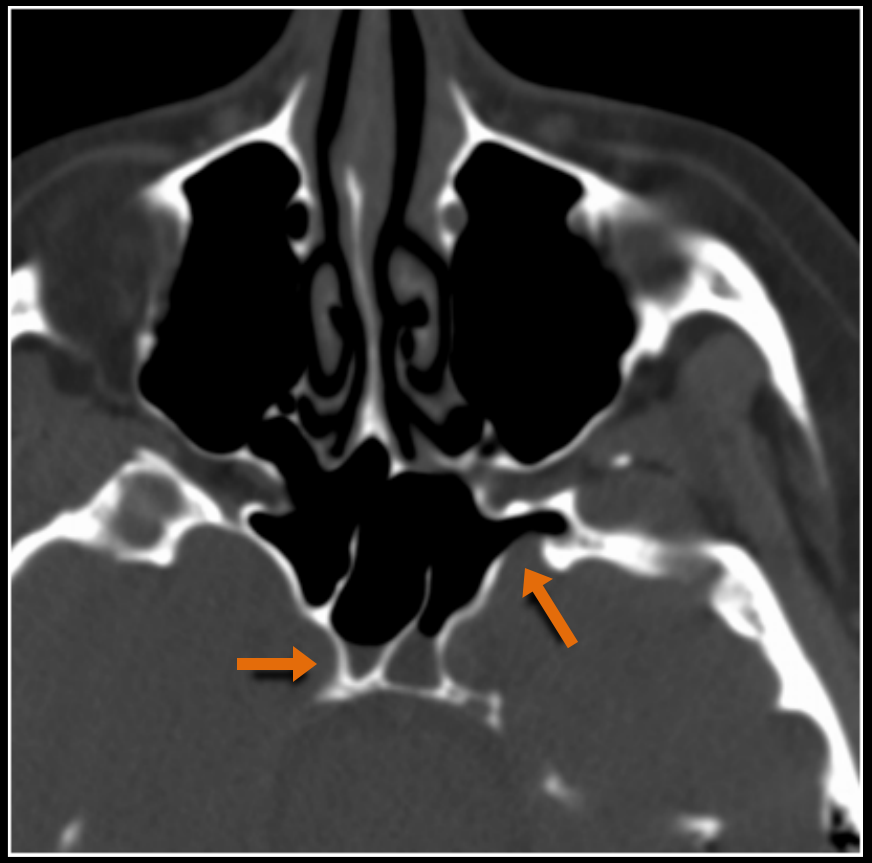
Imaging evaluation

- **Goals of imaging:**
  - LOCALIZE the leak
    - Characterize size of defect
  - Confirm diagnosis
  - Evaluate for underlying cause
  - Assess for meningocele
- **No definite imaging gold standard**
  - Difficult diagnosis
  - Lacking randomized controlled trials
  - CT/MRI/cisternography (CT, MR)

HRCT

- **Standard of care – first line**
- **Localize osseous defect (s)**
- **Do not need active leak to see defect**
- **MDCT : Thin slices (< 1mm) with reformats**
  - Image sinuses and mastoids
  - Manipulate data on workstation, optimize W/L settings
  - Measure defect in mutiple planes
  - Sens up to 95%
    - Correlates with size of defect within 2 mm in 75% in one study
- **Images used for intraop guidance**

HRCT – Imaging findings



Lloyd K, et al Radiology 2008

Osseous defect with fluid level in sinus or mastoid

HRCT – Imaging findings

- **Nondependent soft tissue in nasal cavity or ME cavity, especially if adj to bony defect**
  - Concerning for cephalocele
  - Consider MRI
  - Soft tissue in olfactory recess without defect 15/46 pts

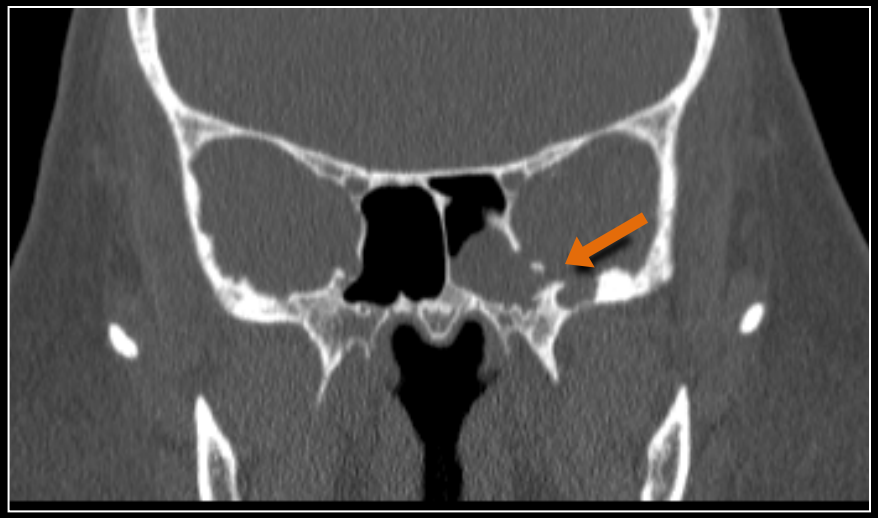
Manes, et al Int Forum Allergy Rhinol 2012

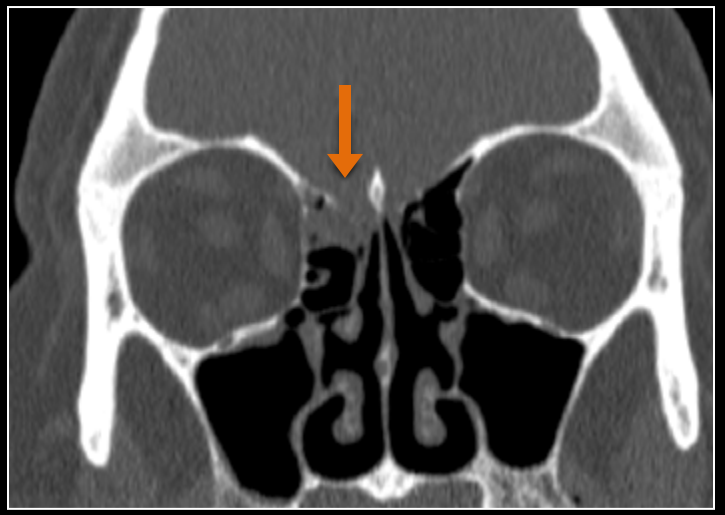
HRCT

- **If only one defect or potential site, and positive B2 transferrin → Surgery**

- **Limitations:**
  - Defect does not necessarily = leak
  - Multiple osseous defects with adjacent sinus opac

48 yo male, BMI 56, rhinorrhea + B2 transferrin





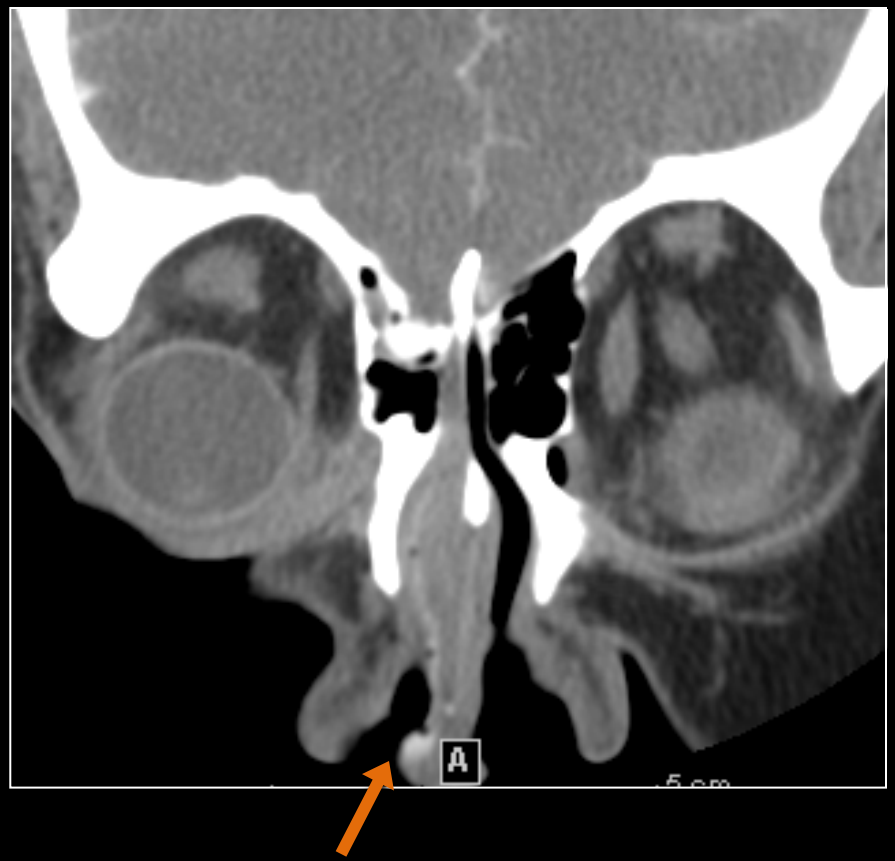
CT - cisternogram

- **Pt needs to be actively leaking (or can elicit)**
- **Technique:**
  - Pre-Cisternogram CT:
    - Supine MDCT with thin sections (reformats)
    - Blood, inspissated secretions, osteogenesis
  - LP: 5-7 cc of intrathecal contrast
    - Head down and provocative maneuvers
  - Post-Cisternogram CT:
    - Direct coronal in prone position (elicit leak)
    - Supine MDCT with thin section reformats

CT Cg - Findings

- Bony defect
- ↑ density adjacent to bony defect (measure ROI if no visible change)
- Pooling of high density in adjacent sinuses

Lloyd K, et al Radiology 2008

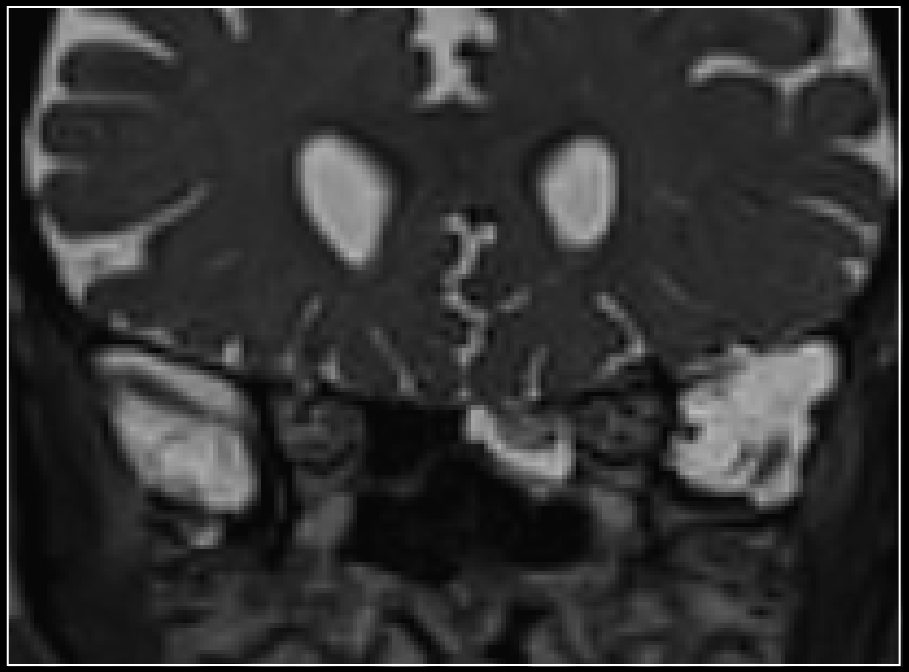

A

CT-Cg Limitations

- **Invasive**
  - Small but inherent risk of infection/lumbar CSF leak
  - Intrathecal contrast risk
- **Radiation**
- **Time intensive interpretation**
- **Limited usefulness in slow flow or intermittent leaks**

MR - Cg

- Noninvasive and non ionizing
- Suspected cephalocele
- Heavily T2w FS FSE sequences
- Sensitivity (85-89%)
- Best comb w HRCT



MR – Cg with IT Gad

- **Promising studies**
  - Sensitivity: up to 100% for high flow
  - Selculuk et al: 60-70% sens for intermittent or suspected leaks
    - Delayed imaging up to 24 hours later
- **No ionizing radiation**
- **Ease of interpretation**
- **Improved contrast resolution**
- **Assess cephaloceles**

MR – Cg with IT Gad - Limitations

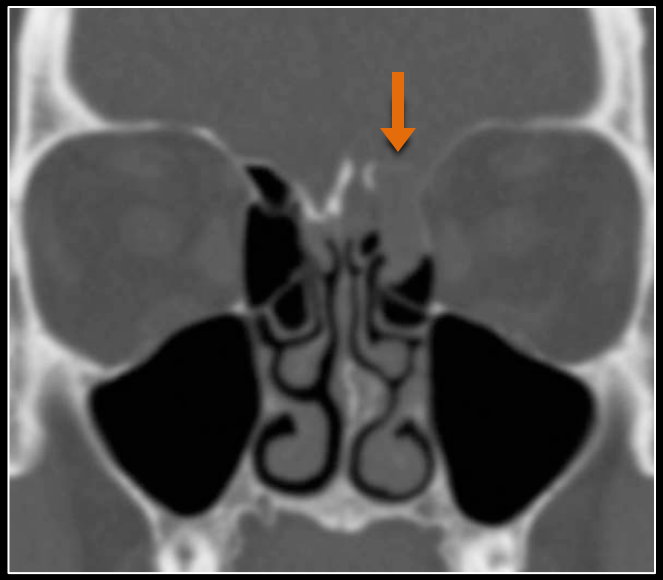
- **Off label use, not FDA approved in US**
  - Many studies from outside US
  - No unexpected adverse effects (HA) with doses and agents used (up to 85 pts in one study)
  - No long term safety or large trials yet
  - Consider carefully, only in pts with nl renal fxn

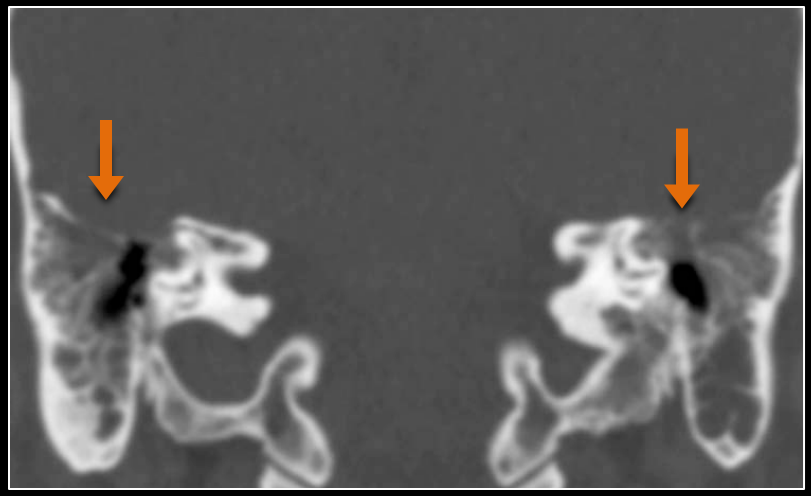
- **Still need HRCT!**

MR – Cg with IT Gad

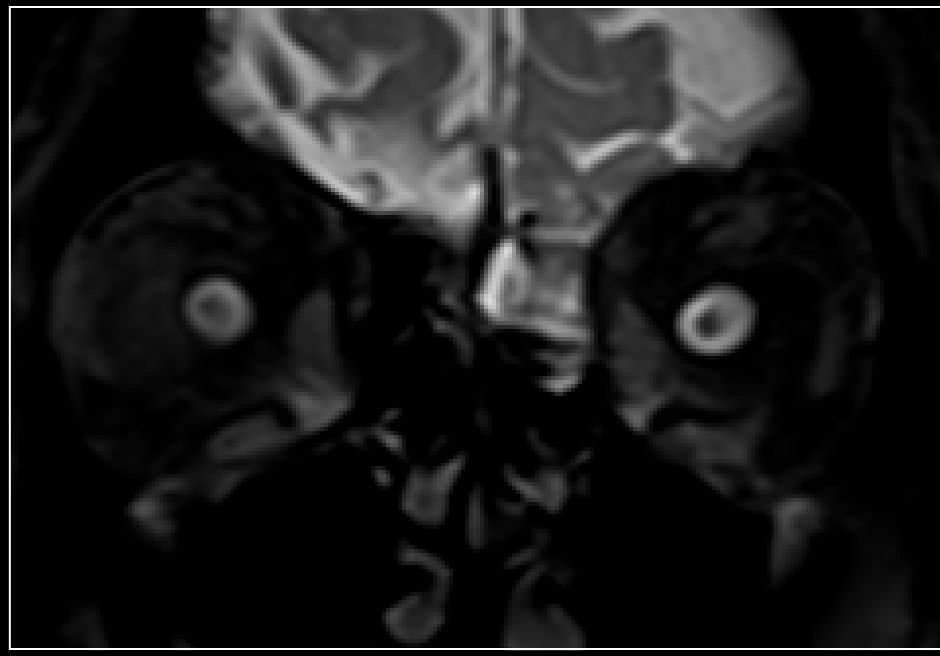
- **Technique:**
  - Complicated pts with mult osseous defects, and/or no/intermittent leaks
  - HRCT first
  - Off-label use consent
  - Pre-gad MR Cg sequences with T1 and T2w images
  - LP – 0.5 ml intrathecal gadopentetate dimegulmine in 4 cc sterile, pres free saline, or CSF
  - Scan at 1 hour, then again at 6-24 hours, as needed
    - Fat sat T1w post in multiple planes

60yo F w intermittent rhinorrhea



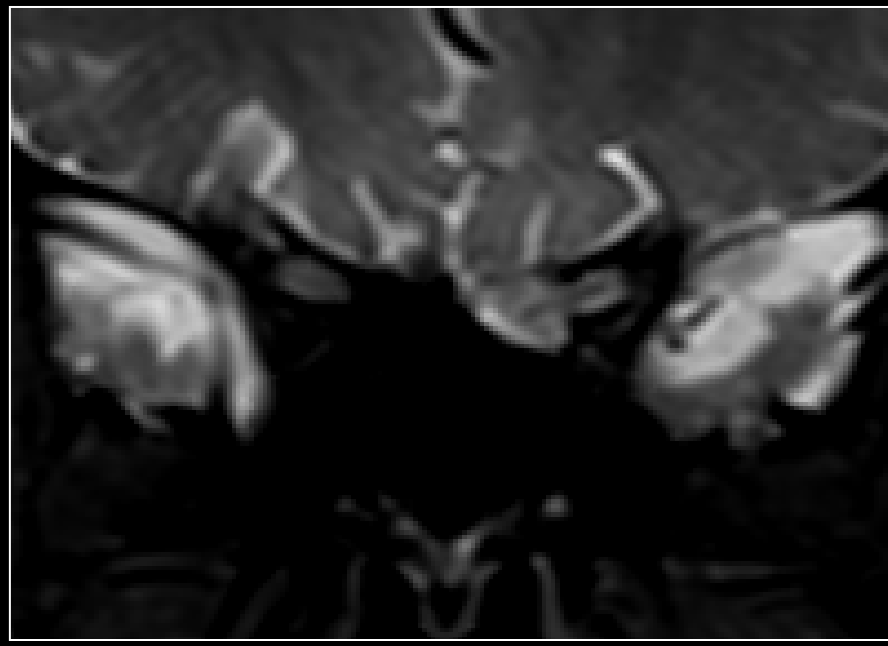


60 yo F w intermittent rhinorrhea



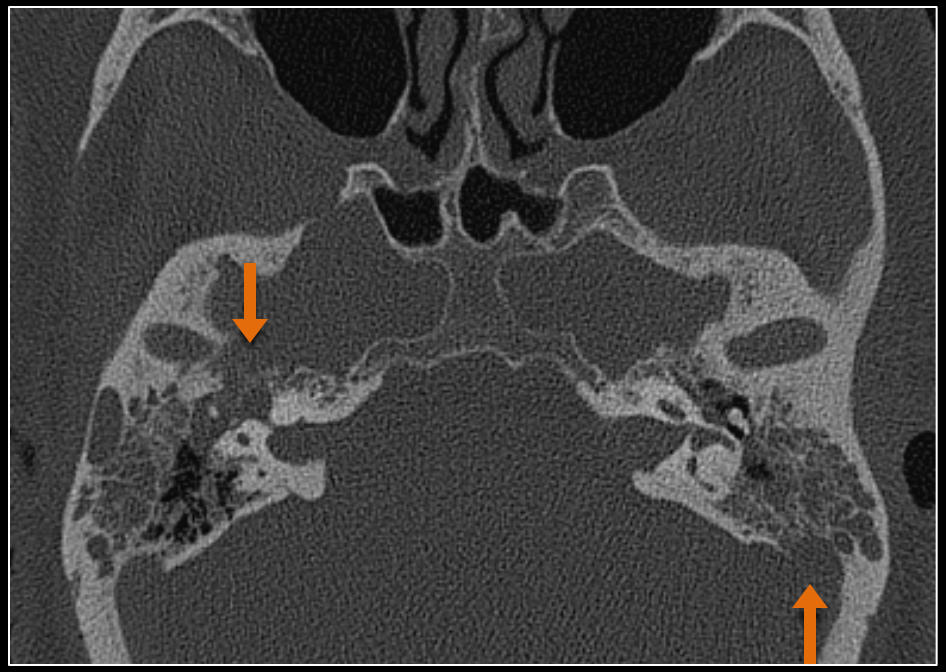
Cor T1W FS MR Cg w IT Gad

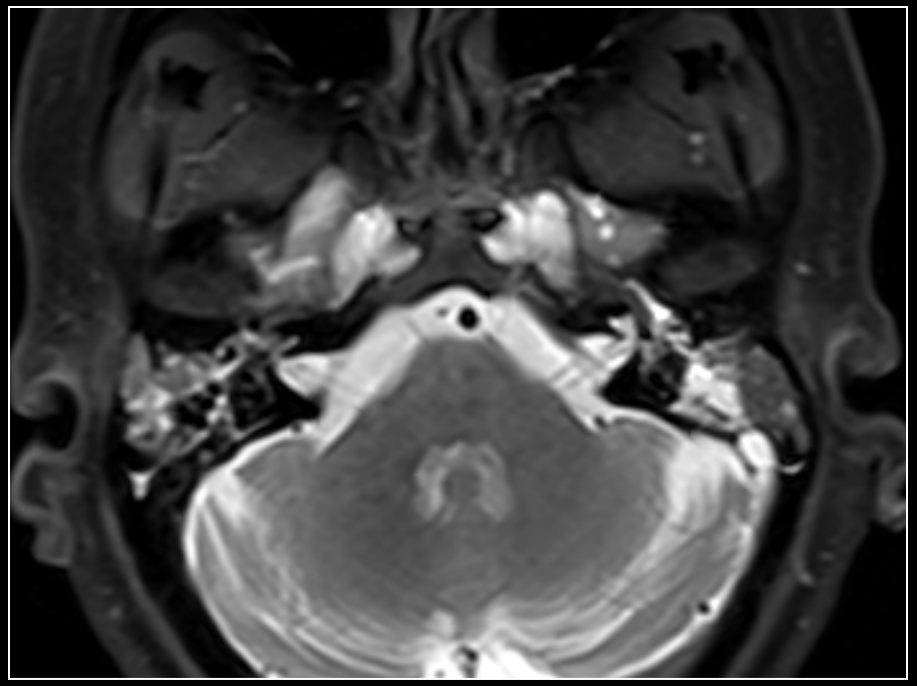
60 yo F w rhinorrhea



Cor T1W FS MR Cg w IT Gad

60 yo F w rhinorrhea

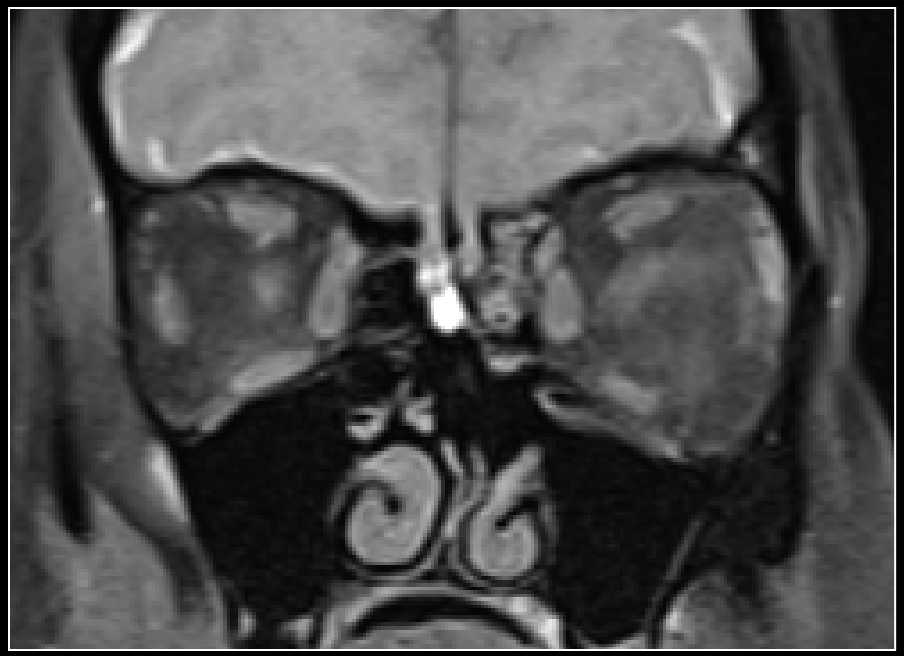




Axial T1W FS MR Cg w IT Gad

45 yo F w h/o int leak, mult potential osseous defects bilat

Cor T2W MR Cg



Cor T1W FS MR Cg w IT Gad

Conclusions

- **Randomized controlled trials are lacking**
- **Institution Algorithim:**
  - Start with beta 2 transferrin analysis, if possible
    - If negative x 2, unlikely CSF leak

Conclusions

- **Institutional Algorithim (cont)**
  - Initial imaging study: HRCT to include sinuses, central skull base, temporal bones
  - If single defect and + B2 transferrin: surgery
  - If suspected encephalocele: MR after HRCT

Conclusions

- **Institutional Algorithim (cont)**
  - If + B2 transferrin and > 1 potential site on CT: Cisternography
    - consider MRcg with IT Gad if intermittent or suspected leak
  - If + B2 transferrin and imaging negative, consider EUA, +/- intrathecal flourescein dye

Thank you!

References

- Bleier BS, et al. Preliminary study on the stability of beta-2 Transferrin in extracorporeal CSF. Otolaryngol Head Neck Surg 2011;144:101-3
- Stone JA, et al. Evaluation of CSF Leaks: High-resolution CT compared with contrast-enhanced CT and radionuclide cisternography. *AJNR* 1999;20:706-712
- Shetty PG et al. Evaluation of high-resolution CT and MR cisternography in the diagnosis of cerebrospinal fluid fistula. Am J Neuroradiol 1998;19:633-639
- El Gammal T, et al. Cerebrospinal fluid fistula: detection with MR cisternography. Am J Neuroradiol 1998;19:627-631
- Chi, et al. The Yo-Yo technique to prevent CSF rhinorrhea after anterior clinoidectomy for proximal ICA aneurysms. Operative Neurosurg 2006;59
- Lloyd MN, et al. Post-traumatic CSF rhinorrhoea: modern HRCT is all that is required for the effective demonstration of the site of leakage. *Clin Radiol* 1994;49:100-103
- Stone JA, et al. Evaluation of CSF Leaks: High-resolution CT compared with contrast-enhanced CT and radionuclide cisternography. *AJNR* 1999;20:706-712

References, cont

- Lloyd KM, Delgaudio JH, Hudgins PA Imaging of Skull Base Cerebrospinal Fluid Leaks in Adults. Radiology 2008;248:725-36.
- Dillon WP. Intrathecal Gadolinium: Its Time has Come? AJNR 2008;29:3-4.
- Manes, RP, Ryan MVV, Marple BF. A novel finding on CT in the diagnosis and localization of CSF leaks without a clear bony defect. Int Forum Allergy Rhinol 2012;2(5):402-404.
- Wang EW, Vandergrift WA, Schlosser RJ. Spontaneous CSF Leaks. Otolaryngol Clin N Am 2011; 44:845-856.
- Sampaio MH, et al. Predictability of quantification of beta-trace protein for diagnosis of cerebrospinal fluid leak: cutoff determination in nasal fluids with two control groups. Am J Rhinol Allergy 2009;23(6):585-90.
- Selcuk H, et al. Intrathecal Gadolinium-Enhanced MR Cisternography in the Evaluation of CSF leakage. AJNR 2010;31:71-75.

References, cont

- Algin O, et al. The contribution of 3D-CISS and contrast enhanced MR cisternography in detecting cerebrospinal fluid leak in patients with rhinorrhea. British Journal of Radiology 2010;83:225-232.
- LaFata V, et al. CSF leaks: Correlation of High-Resolution CT and Multiplanar reformations with Intraoperative Endoscopic findings. AJNR 2008;29:536-41.
- Vanopdenbosch LJ, et al. MRI with intrathecal Gadolinium to Detect a CSF leak: a prospective open-labe cohort study. J Neurol Neursurg Psychiatry 2011;82:456-458.
- Lee MH, et al. Prevalence and appearance of the posterior wall defects of the temporal bone caused by presumed arachnoid granulations and their clinical significane: CT findings. AJNR 2008; 29:1704-7.