Imaging and Treatment of Intracranial Hypotension

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Objectives

- Clinical Features
- Imaging Findings
  - Brain
  - Spine
- Etiologies
- Diagnostic Procedures
  - LP (CSF pressure)
  - Radioisotope cisternography
  - CT myelography
  - MR myelography
  - Digital subtraction myelography
  - Intrathecal gado MRI
- Therapeutic Options

Clinical presentation

- Orthostatic or postural headache
  - Starts 15 min → hours after upright positioning
  - Improves 15-30 min after lying down
- Secondary symptoms: Posterior neck pain or stiffness, vomiting, photophobia
  - Less common: hyperacusia, tinnitus, cranial neuropathies
- Typical clinical course is spontaneous resolution over weeks to months

Demographics

- 40-60 years old
- Females > Males, 3:2

Diagnostic Criteria for Spontaneous Spinal CSF Leak and Intracranial Hypotension

Criterion A: Spinal CSF leak (extrathecal CSF)
Criterion B: Cranial MRI findings
  - Subdural collection, pachymeningeal enhancement,
  And at least one of the following:
  - Low opening pressure ≤ 6 cm H2O
  - Spinal meningeal diverticulum
  - Improvement of symptoms after epidural blood patch

Schievink et al AJNR 2008

Diagnostic Criteria for Spontaneous Spinal CSF Leak and Intracranial Hypotension

Criterion C: presence of all following or at least 2 in the presence of orthostatic headaches

- Low opening pressure ≤ 6 cm H2O
- Spinal meningeal diverticulum
- Improvement of symptoms after epidural blood patch
- 20% of patients with clinically apparent ICH have no abnormal brain MRI findings

Schievink et al AJNR 2008
CT Findings

- Relatively insensitive
  - Normal
  - +/- Thick dura, enhancement
  - +/- Subdural fluid collections
    - Usually bilateral
    - Can be CSF (hygroma) or blood (hematoma)

- Suprasellar cistern may appear obliterated
- Atria of lateral ventricles may appear deviated medially, abnormally close ("tethered") to midline

Classic Imaging Findings

1. Diffuse thin dural enhancement, 85%
   - Supra-/infratentorial
   - Spares leptomeninges

2. Enlargement of intracranial venous +/- arterial structures
Classic Imaging Findings

3. Subdural collections, 15 - 50%

Subdural Collection in IC Hypotension

- Hygromas: due to transudation of fluid
  - Serum proteins, inflammatory cells
  - No mass effect
  - Over convexities, posterior fossa
- Hematoma: tearing of bridging veins
  → subdural hematoma
  - RBCs
  - Less common
  - +/- mass effect

Intracranial Hypotension Angles

Statistically significant difference between IC hypotension patients and controls
Shah LM et al AJR 2013

- Decreased pontomesencephalic angle ≤ 50 degrees
- Decreased mamillopontine distance ≤ 6.5 mm

Subdural Collection in IC Hypotension

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4. Midbrain sagging, 40 - 50%

- Midbrain displaced inferiorly below level of dorsum sella
- Pons compressed against clivus with obliteration of pre-pontine cistern

Classic Imaging Findings

- 93% showed at least 1 MRI finding
- All 3 findings seen in 43%

HOWEVER, WEAK correlation between individual brain or myelographic signs and CSF pressure

Presence of >= 1 MRI brain finding is relatively common
- 93% showed at least 1 MRI finding
- All 3 findings seen in 43%
Time-Dependent Changes in Dural Enhancement Associated With Spontaneous Intracranial Hypotension

- CSF pressure rises with time
- Clinical symptoms change with time
  - Headache evolves into NONORTHOSTATIC headache
- Significant differences in symptom duration between subjects with and those without dural enhancement
- Absence of dural enhancement assoc. with longer duration of symptoms
- Duration of symptoms of subjects with high-flow leaks was shorter relative to no-leak group (p = 0.17)
- Subjects with low-flow leaks were symptomatic 40.9 weeks (mean) longer than no-leak group (p = 0.01)

Optic chiasm and hypothalamus draped over sella

Caudal displacement of cerebellar tonsils in 25-75%

Height of pituitary gland increased above normal limits
- Sensitivity, 63%
- Specificity, 97%

Hyperprolactinemia due to spontaneous intracranial hypotension

- Prolactin level 97 ng/ml

Optic Nerve Sheath

- CSF signal surrounding optic nerve sheaths diminished → Decreased optic nerve sheath diameters (coronal STIR/T2 FS)
  - Sensitivity, 100%
  - Specificity, 97%

Optic Nerve Sheath with CSF rim

Decreased optic nerve sheath diameter in IC hypotension
**Additional MRI Brain Findings**

- Decrease in signal intensity in subcortical white matter and corpus callosum on FLAIR
  - Return to control signal level on follow-up
- Hypothesis: Venous stasis $\rightarrow$ increased deoxyHb $\rightarrow$ susceptibility effect

Adachi M, et al. AJNR 2009

**ADC Elevated in IC Hypotension**

- ADC values higher in ICH patients compared to control subjects
  - Avg diffusion constant from ADC histogram significantly higher in ICH patients ($p<0.008$)
  - Decreased with blood patch
- Cerebral edema
  - Venous stagnation
  - Functional stenosis of venous outflow


**Additional MRI Findings**

- Superficial siderosis
  - RBCs in CSF
  - May be due to intradural vascular engorgement
  - Dural pathology in ~8.7% of reported cases of SS
  - Meningocele, pseudomeningocele, pseudosubarachnoid, or root pathology

Kumar N. AJNR 2010

**Spinal MRI Findings**

- Epidural venous engorgement

Watanabe A, et al. AJNR 2009

**Journal of Neurosurgery: Spine**

- Spinal manifestations of spontaneous intracranial hypotension
  - Clinical armoire

- Occurs in ~6% of patients with intracranial hypotension
- Extradural/subdural collection compresses spinal cord +/- nerve roots:
  - Radiculopathy
  - Myelopathy
  - Brachial amyotrophy
- All spinal segments are involved
- Spinal manifestations are usually not positional

Watanabe A, et al. AJNR 2009

**Spinal MRI Findings**

- Subdural collection

Rabin BM, et al. AJNR. 1998

**Spinal MRI Findings**

- Epidural venous engorgement

Watanabe A, et al. AJNR 2009
Etiology

- **Dural leak** implicated in both spontaneous and secondary intracranial hypotension
  - Secondary intracranial hypotension etiologies:
    - Lumbar puncture
    - Surgery: spine vs. cranial
    - Head or spine trauma
  - Spontaneous intracranial hypotension

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Etiology of SIH

- Meningeal diverticulae
- Absence of dural covering of exiting nerve roots
- Holes or tears in dura
- Connective tissue disorders: Marfan’s, Ehlers-Danlos

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Diagnostic Procedures

- Radioisotope cisternography
- MR myelography
- CT myelography
  - Dynamic CT myelography
- Digital subtraction myelography
- Intrathecal gadolinium myelography
**Radioisotope Cisternography**

- 1 mCi Tc-99m or 500 uCi In-111 DTPA injected subarachnoid space via LP
- Pledgets in nasal cavity
- Image and remove pledgets at 4-6h
- Draw blood sample, spin down RBCs, remove 100 ul serum to count
- Compare pledget:serum counts, assuming 1g = 1ml ("*" ratio is > 1.5)

**MR Myelogram**

- Noninvasive delineation of subarachnoid space
- No contrast
- No ionizing radiation
- Heavily T2-weighted sequences
  - HASTE
  - CISS
  - STIR
  - T2 with fat saturation

**MR Myelogram Findings**

- Established association between spinal meningeal diverticula and SIH
- Irregularity of nerve root diverticulum can suggest site of CSF leak, particularly when there are multiple diverticula / cysts

**MR Myelogram Findings**

- No difference in proportion of patients with diverticula in SIH compared with controls (p=0.14) or mean number of diverticula per patient (0.099)
- No difference in morphology (p=0.95) or size of diverticula between groups
- No difference in prevalence or myelographic appearance of diverticula in SIH patients compared with controls

**MR Myelogram Findings**

- Abnormal hyperintense signal in left perineural soft tissues is concerning for site of CSF leak
  - Targeted epidural blood at this site was effective in alleviating this patient’s symptoms

**CT Myelography**

- Most widely used and current gold standard test
- Performed with intrathecal nonionic myelographically safe contrast via LP
  - Trendelenburg position, 10 min
  - Axial CT
- Most spontaneous CSF leaks are found near cervicothoracic junction or in thoracic spine
Subtle or slow leaks may only be seen on delayed CT imaging.

Intrathecal Gadolinium MR

- MR myelography via intrathecal administration of 0.5 mL gadolinium via LP currently not approved by FDA
  - Risk of seizures with intrathecal gadolinium
- Advantages: Lack of ionizing radiation, increased sensitivity for small leaks, possibility of additional delayed imaging

Higher rate of CSF leak detection with intrathecal gadolinium MR myelography, particularly for leaks related to meningeal diverticula.

Significant association between spinal extra-arachnoid fluid and fast leak (85% sens, 79% spec).
Dynamic CT Myelography: Localize High-flow Spinal CSF Leaks

Digital Subtraction Myelography

Localization of Rapid CSF Leak with Digital Subtraction Myelography

CSF-Venous Fistula

The “Hyperdense Paraspinal Vein” Sign: A Marker of CSF-Venous Fistula

- 46-55% patient with SIH without evidence of CSF leak on myelogram, CSF-venous fistula may be the cause
- Hyperdense paraspinal vein - rapid passage of myelographic contrast into venous system through fistula
- Generally unresponsive to epidural blood patch
- Surgical ligation of draining veins
- Average attenuation of hyperattenuated vessel on postmyelographic CT measured 105.7 +/- 23.0 HU, compared with attenuation values of 27.5 +/- 6.4 HU for same vessel on CT performed without intrathecal myelographic contrast
- Delayed images

Courtesy of P. Kranz
Treatment Options

- Bed rest
- Analgesics
- Sedatives
- Oral caffeine
- High salt intake
- Intravenous hydration
- Epidural blood patch
- Epidural saline infusion
- Fibrin Glue
- Surgery

Epidural Blood Patch

Spontaneous Intracranial Hypotension

CT Myelo
Intrathecal Gado MR

Epidural Blood Patch

Orthostatic Headache
MRI brain + C
MRI spine
CT Myelogram (CSF Pressure)

Intrathecal Gado Myelogram

Fast Leak
Targeted Epidural Blood Patch / Surgical

NO Leak
High Volume Epidural Blood Patch

慢 Leak
Targeted Epidural Blood Patch / Stereotaxic

Fast Leak
Targeted Epidural Blood Patch / Stereotaxic

NO Leak
High Volume Epidural Blood Patch
References