# MYELOGRAPHY IN INTRACRANIAL HYPOTENSION SYNDROME: FROM DIAGNOSIS TO BLOOD PATCH

## DIAGNOSIS

Clinical manifestations can be inespecific, and diagnostic tests have an important role on investigation and confirmation, with emphasis to imaging, which allows to identify and localize SIH probable cause.

**non-imaging methods**

Lumbar puncture

Low CSF opening pressures (< 60 mm H2O) or typical imaging features directly or indirectly suggesting a CSF leak. Frequently, patients have normal or augmented CSF pressures.

**imaging methods**

- MRI
- CT myelography (CTM)
- Digital subtraction myelography (DSM)

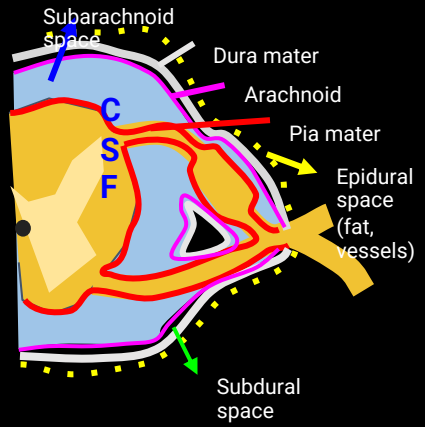
Able to detect intracranial and spinal evidences of SIH, but may not be capable of identify and topograph its cause.

- Ultrafast dynamic CTM
- Decubitus CTM

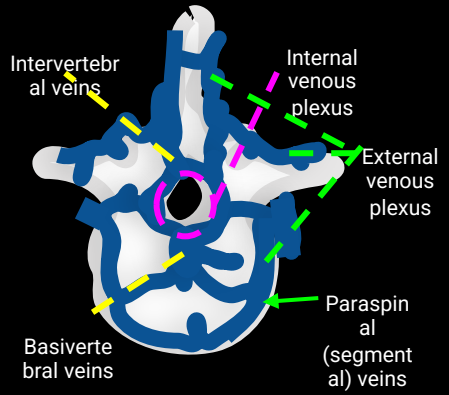
Due to their high spatial and temporal resolution, CTM (allied to special acquisition protocols) and DSM can localize the leak or fistula, and also guide therapeutics.

## ANATOMY

### Membranes and spaces




### Vertebral venous anatomy



# CAUSES

SIH main cause is a CSF depletion, which can come from multiple etiologies. As traumatic cases are easily linked to its clinical history, the diagnosis turns difficult when "spontaneous" causes are suspected. On that way, we can divide in two great groups - the former, more frequent, and the latter, far less common.

## "Idiopathic / spontaneous"

### degenerative

- osteophytes
- calcified disk protrusions

Degenerative causes are more common on **ventral surface of the thecal sac** in the **thoracic** or **lower cervical** spine.

### congenital

- dural thinning and dehiscence
- meningeal diverticula
- root sheath absence ("nude root")

Some of these conditions may be related to collagen diseases, like **Ehlers-Danlos** and **Marfan** syndrome, for an elevated risk of rupture with minor traumas.

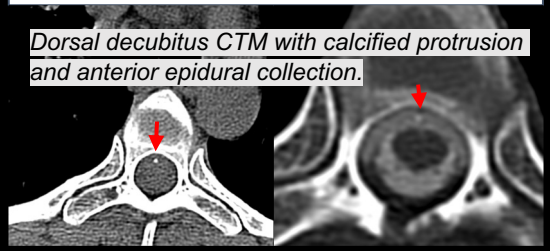
### CSF-venous

Communication between subarachnoid space and paraspinal veins, leading to CSF depletion.
**Epidural fluid collections are not typically expected**, and standard myelographic (MR/CT) technique may not be sufficient for diagnosis. More commonly affect thoracic segment.

## Traumatic

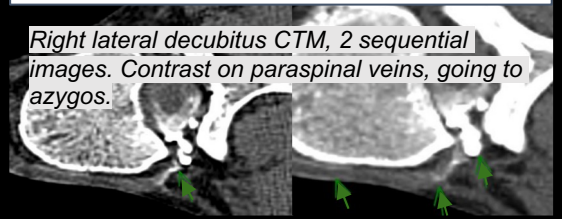
- post surgical
- lumbar puncture
- spinal trauma

calcified disk protrusions (**red arrow**)



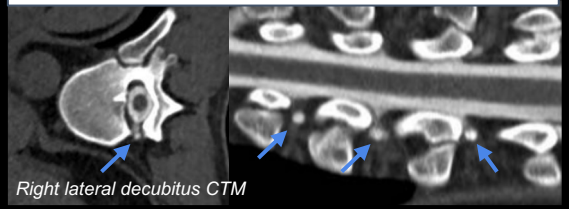
*Dorsal decubitus CTM with calcified protrusion and anterior epidural collection.*

CSF-venous fistula (**green arrow**)



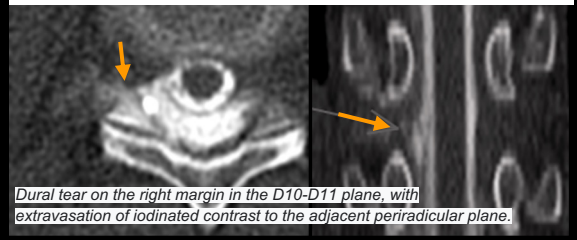
*Right lateral decubitus CTM, 2 sequential images. Contrast on paraspinal veins, going to azygos.*

meningeal diverticula (**blue arrow**)



*Right lateral decubitus CTM*

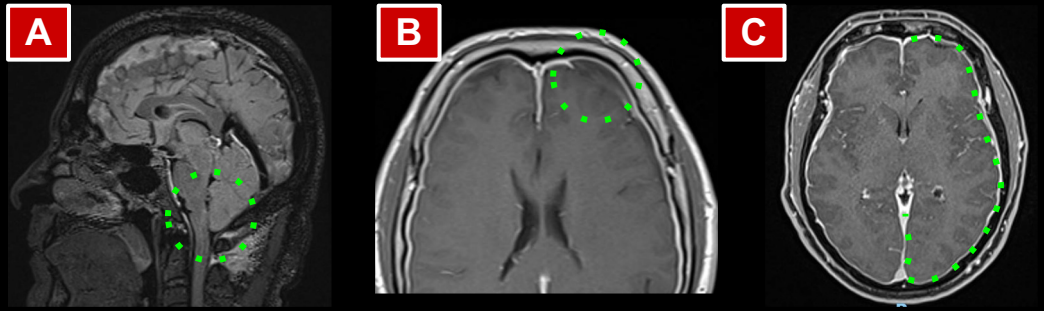
nerve sheath tear (**orange arrow**)



*Dural tear on the right margin in the D10-D11 plane, with extravasation of iodinated contrast to the adjacent periradicular plane.*

# MAGNETIC RESONANCE IMAGING

- Downward displacement of the brainstem and tonsils (A)
- Subdural effusion or hematoma (B)
- Diffuse pachymeningeal enhancement (C)
- Enlargement of the pituitary gland
- Engorgement of cerebral venous sinuses



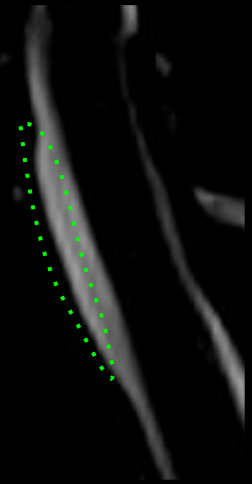

*MRI study of a 47 yo male with postural headaches. A: sagittal FLAIR 3D MRI shows tonsillar herniation and sulci reduction (green dotted circle); B: axial T1 MRI post-contrast shows frontal extra-axial effusion and pachymeningeal enhancement (green dotted circle); C - axial T1 post contrast MRI with pachymeningeal enhancement (green dotted line).*

- **Epidural T2 hyperintensity**, corresponding to spinal longitudinal epidural collections (SLEC).
- CSF pooling is generally near the dural tear, but it may disperse cranially or caudally and cannot be visible in all cases.
- **Heavy T2-weighted, thin-slice acquisitions** (FIESTA/SPACE) with maximum intensity projection (MIP) and 3D reconstruction (MR myelography) can identify some dural tears with CSF leak, but have less sensibility than a CTM or DSM.

Several investigators have reported that MR myelography using intrathecal gadolinium is more sensitive for slow-flow or intermittent leaks than CTM, but there are concerns about safety.

- Conventional spine MRI is not able to detect CSF-venous fistula.

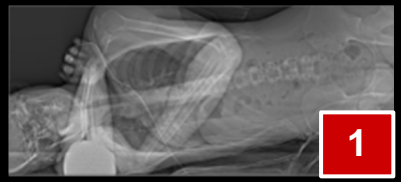
*MRI axial T2 of cervical spine shows **posterior epidural effusion (orange arrows)** in the same patient, at C5-C6 level.*

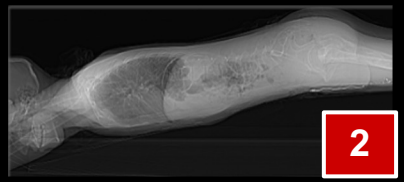


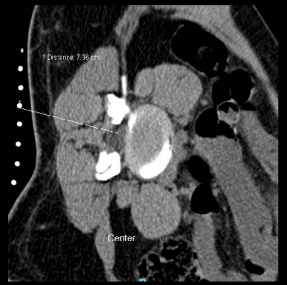
*MRI sagittal T2 SPACE of cervical spine shows **anterior epidural effusion (green dotted ellipse)** at C7-D1 on a 42y female with CSF leaks.*

# CT MYELOGRAPHY

*Puncture position will vary according to the used technique, as on the cases shown below: Trendelenburg lateral decubitus (1) or prone Trendelenburg (2), for decubitus CTM and ultrafast CTM, respectively.*

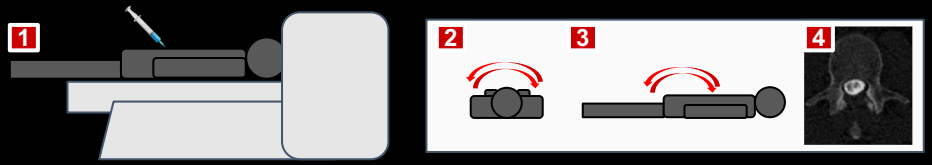


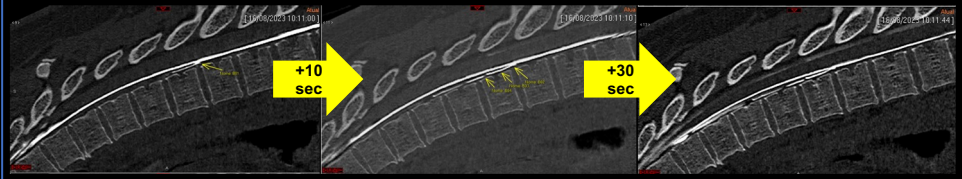



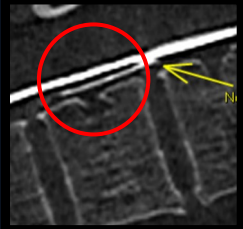
*Patient is positioned and a lumbar puncture is performed, to access CSF. After that, iodinated contrast (non-ionic) is injected. Lumbar puncture with placement of a needle under fluoroscopy or CT guidance on the scanner.*

*After intrathecal injection (1), patient will be rolled in its own axis (2) and in Trendenlenburg and reverse Trendelenburg position (3), to achieve an almost homogeneous contrast distribution (4).*



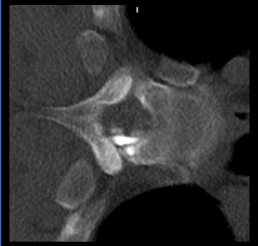

# DYNAMIC CT MYELOGRAPHY

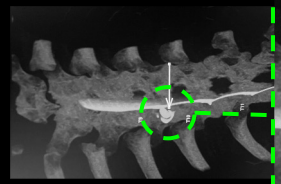


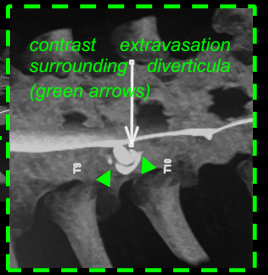



*Ultrafast dynamic CTM of a female undergoing postural headache investigation in which MRI has shown ventral cervicothoracic SLEC. 15 ml of iodinated myelographic contrast media were slowly injected. As it is denser than CSF, takes a dependant position and flows along with gravity.*

Trendelenburg position, table tilting and cushion placement allow progressive flow of contrast along dural surface. Ultrafast dynamic acquisitions can also be done in lateral or ventral decubitus.
When it reaches the CSF leak site, a **split sign** is observed: contrast passes through the dural tear and goes to the epidural space.
Therefore, high spatial resolution allied with positional changes and fast sequential image acquisition allow diagnose fast CSF-leaks.





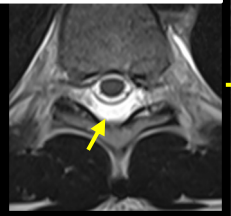



*Axial CT and 3D reconstruction shows CSF leak by a thoracic dural diverticula (T9-T10), obtained with a lateral decubitus dynamic CTM.*

# TREATMENT / BLOOD PATCHES

| NON - INVASIVE | BLOOD PATCH | FIBRIN GLUE | SURGICAL |
|---|---|---|---|
| Bed rest; Increase hydration; Caffeine; Theophylline; Analgesic; Non-steroidal drugs; Abdominal binders. | Autologous Epidural Blood Patch (CT guided blood patch is safer and successful). Some patients may require more than one EBP. | Can be used alone or associated with EBP or surgery, in special cases. | For clearly identified CSF leaks that failed other therapies. |

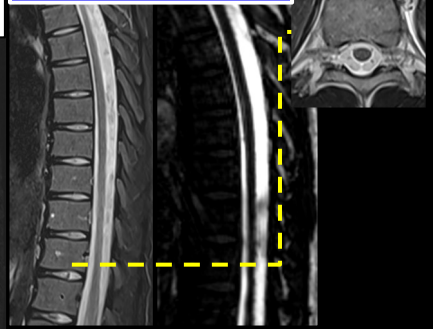
**Before treatment**



Axial T2 thoracic level shows **epidural fluid collection (yellow arrow)**. Sagittal STIR from the same patient.

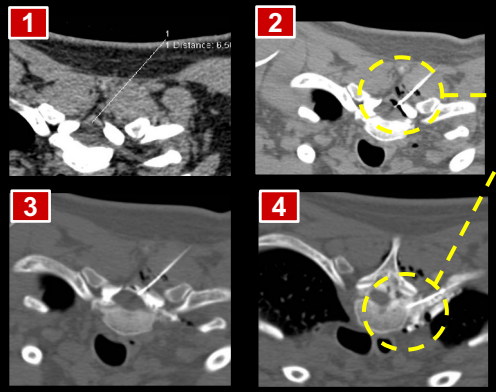
19 yo female with postural headache.

**After treatment**





Two months after two targeted blood patches (total 25 ml autologous blood on D10-D11 and D11-D12 space), sagittal STIR, CISS, and axial T2 shows absence of epidural fluid collection or CSF leaks, on the same level.



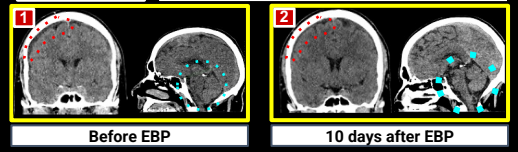

After the previous steps, epidural injection will be performed slowly (5 ml/min), always paying attention to pain and sensitive/motor symptoms and signs. There are two most common access to do it:

| Transforaminal | Interlaminar |
|---|---|
| Allows access to ventral or lateral leakage points via the intervertebral foramen. | Median or parasagittal injection can be used to treat posterior leaks. |

*CT scan of a 48 yo female with ventral CSF leak at T1-T2 level together with small disc calcification. A 20G chiba needle **(2)** was positioned in the posterior interlaminar epidural space of T1-T2, confirmed by gaseous epidurogram. Injected 15 ml of autologous blood into the epidural space, with predominantly posterior epidural spread **(3)**. For better coverage of the leak focus, transforaminal access was chosen. Same has been done with 10 cc of autologous blood on left conjugation foramen of T2-T3, with lateral epidural spread and anterior insinuation **(4)**.*

**After treatment**

42-year-old male with progressive postural and holocranial headache.




Before EBP | 10 days after EBP

**(1, 2)** Head CT with coronal and sagittal reformations comparing before and after the blood patch, showing improvement in intracranial hypotension signs. **Blue dotted circle:** reduced inferior displacement of the brainstem, with an increased mamillopontine distance and angle between the midbrain and the pons. Reexpansion of the fourth ventricle and cisterns in the posterior fossa. **Red dotted line:** reabsorption/metabolization of the right frontoparietal subdural fluid collection, which exhibits reduced thickness in the frontal right region.