# The History of Surgical Treatment for CSF Leaks

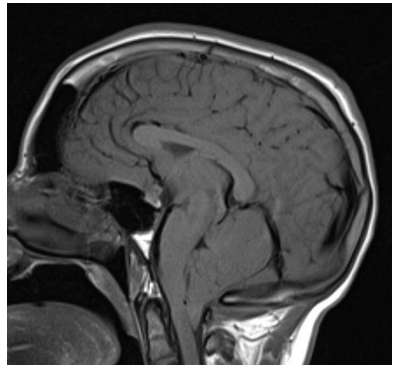
Wouter I Schievink, MD

Cedars Sinai

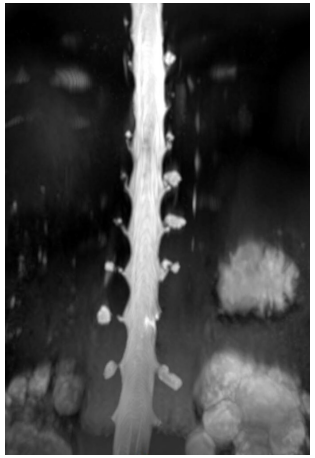
# The History of Surgical Treatment for Spontaneous Spinal CSF Leaks

# Diagnostic evaluation and treatment of SIH – A practical approach

**MRI brain**



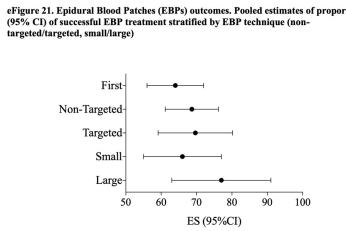
**MR-Myelography**



**Epidural blood patching**

**=**

**Curative for most patients with SIH if done expeditiously**



A classification system of spontaneous spinal CSF leaks

# Surgery – referral bias

**Table 3** Data for 568 patients with spontaneous intracranial hypotension

| | Leak classification | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | All patients | 1A | 1B | 2A | 2B | 3 | 4 | *p* Value |
| No. (%) | 568 | 145 (25.5) | 6 (1.1) | 218 (38.4) | 22 (3.9) | 14 (2.5) | 163 (28.7) | |
| Age at symptom onset, y | | | | | | | | <0.0001 |
| Mean (SD) | 45.7 (14.9) | 43.4 (10.5) | 32.0 (14.3) | 50.3 (14.7) | 33.0 (17.0) | 50 (9.6) | 43.7 (16.4) | |
| Median (IQR) | 46 (37-56) | 42 (37-51) | 29 (23-40) | 51 (41-60) | 35 (18-49) | 51 (46-56) | 44 (33-55) | |
| Range (min-max) | 2-88 | 17-77 | 16-55 | 11-88 | 2-58 | 31-66 | 4-87 | |
| Sex | | | | | | | | 0.13 |
| Male | 195 (34.3) | 44 (30.3) | 2 (33.3) | 84 (38.7) | 3 (13.6) | 2 (14.3) | 60 (36.8) | |
| Female | 373 (65.7) | 101 (69.7) | 4 (66.7) | 133 (61.3) | 19 (86.4) | 12 (85.7) | 103 (63.2) | |
| Surgery, n (%) | | | | | | | | <0.0001 |
| Yes | 285 (50.2) | 125 (86.2) | 5 (83.3) | 110 (50.7) | 9 (40.9) | 12 (85.7) | 23 (14.1) | |
| No | 283 (49.8) | 20 (13.8) | 1 (16.7) | 107 (49.3) | 13 (59.1) | 2 (14.3) | 140 (85.9) | |
| Extradural CSF | | | | | | | | <0.0001 |
| Positive | 287 (50.5) | 144 (99.3) | 6 (100) | 50 (23.0) | 3 (13.6) | 0 (0) | 84 (51.5) | |
| Negative | 281 (49.5) | 1 (0.7) | 0 (0) | 167 (77.0) | 19 (86.4) | 14 (100) | 79 (48.5) | |
| Los Angeles county cases, n (%) | | | | | | | | 0.03 |
| Yes | 138 (24.3) | 28 (19.3) | 2 (33.3) | 45 (20.7) | 2 (13.6) | 4 (28.6) | 56 (34.4) | |
| No | 430 (75.7) | 117 (80.7) | 4 (66.7) | 172 (79.3) | 19 (86.4) | 10 (71.4) | 107 (65.6) | |

Abbreviation: IQR = interquartile range.

Original Article

Cephalalgia
An International Journal of Headache

International Headache Society

# Incidence of spontaneous intracranial hypotension in a community. Beverly Hills, California, 2006–2020

*Cephalalgia*
0(0) 1–5

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**Wouter I Schievink[1], M Marcel Maya[2], Franklin G Moser[2], Paul Simon[3] and Miriam Nuño[4]**

**Abstract** [AQ1]

**Background:** Spontaneous intracranial hypotension is diagnosed with an increasing frequency, but epidemiologic data are scarce. The aim of this study was to determine the incidence rate of spontaneous intracranial hypotension in a defined population.

**Methods:** Using a prospectively maintained registry, all patients with spontaneous intracranial hypotension residing in Beverly Hills, California, evaluated at our Medical Center between 2006 and 2020 were identified in this population-based incidence study. Our Medical Center is a quaternary referral center for spontaneous intracranial hypotension and is located within 1.5 miles from downtown Beverly Hills.

**Results:** A total of 19 patients with spontaneous intracranial hypotension were identified. There were 12 women and seven men with a mean age of 54.5 years (range, 28 to 88 years). The average annual incidence rate for all ages was 3.7 per 100,000 population (95% confidence interval [CI]: 2.0 to 5.3), 4.3 per 100,000 for women (95% CI, 1.9 to 6.7) and 2.9 per 100,000 population for men (95% CI, 0.8 to 5.1).

**Conclusion:** This study, for the first time, provides incidence rates for spontaneous intracranial hypotension in a defined population.

Treatment consisted of conservative measures (bed rest, oral hydration, abdominal binder) only in two patients. Improvement of symptoms was noted within one week by both patients. Sixteen patients underwent epidural blood patching. Improvement of symptoms was noted within three days by all patients. Ten patients underwent epidural blood patching once (mean volume of blood: 36 mL; range, 10–61 mL) and six patients underwent repeat epidural blood patching (mean total volume of blood: 88 mL; range, 80–95 mL). Percutaneous fibrin glue injections were used in two patients who failed repeat epidural blood patching. Surgery was performed in one patient who failed percutaneous procedures and in the patient with bibrachial amyotrophy.

Surgery in only 2/19 patients

# Personal timeline of surgical treatment of spontaneous spinal CSF leaks

1991 – 1998 Learning about CSF leaks

Clipping of meningeal diverticula and exploratory surgeries

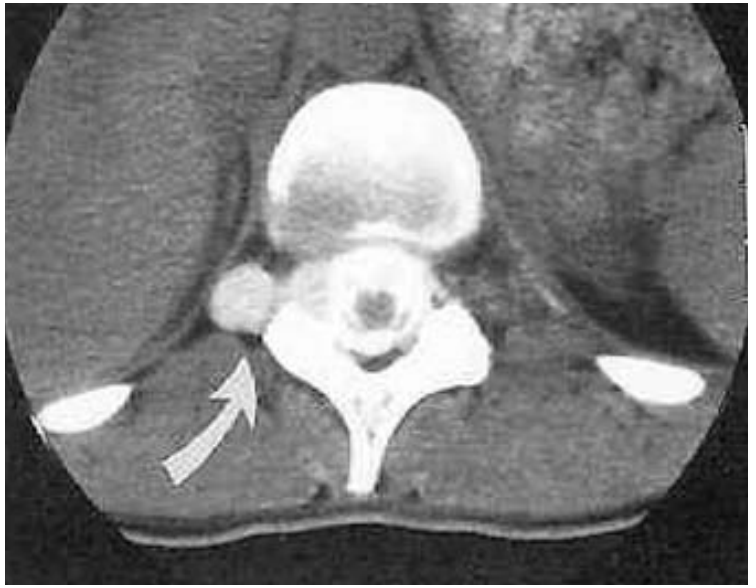
J Neurosurg 80:736–739, 1994

## Surgical treatment of spontaneous intracranial hypotension associated with a spinal arachnoid diverticulum

Case report

WOUTER I. SCHIEVINK, M.D., RONALD REIMER, M.D., AND W. NEATH FOLGER, M.D.

*Departments of Neurosurgery and Neurology, Mayo Clinic Jacksonville, Jacksonville, Florida*



J Neurosurg 88:243–246, 1998

# Surgical treatment of spontaneous spinal cerebrospinal fluid leaks

**Wouter I. Schievink, M.D., Vittorio M. Morreale, M.D., John L. D. Atkinson, M.D., Fredric B. Meyer, M.D., David G. Piepgras, M.D., and Michael J. Ebersold, M.D.**

*Department of Neurologic Surgery, Mayo Clinic, Rochester, Minnesota*

*Object.* Spontaneous spinal cerebrospinal fluid (CSF) leaks are an increasingly recognized cause of intracranial hypotension and may require neurosurgical intervention. In the present report the authors review their experience with the surgical management of spontaneous spinal CSF leaks.

*Methods.* Between 1992 and 1997, 10 patients with spontaneous spinal CSF leaks and intracranial hypotension were treated surgically. The mean age of the seven women and three men was 42.3 years (range 22–61 years). Preoperative imaging showed a single meningeal diverticulum in two patients, a complex of diverticula in one patient, and a focal CSF leak alone in seven patients. Surgical exploration in these seven patients demonstrated meningeal diverticula in one patient; no clear source of CSF leakage could be identified in the remaining six patients. Treatment consisted of ligation of the diverticula or packing of the epidural space with muscle or Gelfoam. Multiple simultaneous spinal CSF leaks were identified in three patients.

*Conclusions.* All patients experienced complete relief of their headaches postoperatively. There has been no recurrence of symptoms in any of the patients during a mean follow-up period of 19 months (range 3–58 months; 16 person-years of cumulative follow up). Complications consisted of transient intracranial hypertension in one patient and leg numbness in another patient.

Although the disease is often self-limiting, surgical treatment has an important role in the management of spontaneous spinal CSF leaks. Surgery is effective in eliminating the headaches and the morbidity is generally low. Surgical exploration for a focal CSF leak, as demonstrated on radiographic studies, usually does not reveal a clear source of the leak. Some patients may have multiple simultaneous CSF leaks.

# Personal timeline of surgical treatment of spontaneous spinal CSF leaks

J Neurosurg 80:736–739, 1994

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|---|---|
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| 2000 – 2009 | Establishing a CSF leak center (FGI & hvEBP) |
| | Clipping of meningeal diverticula and exploratory surgeries |
| | Rarely targeting of osteophytes (VATS, sternotomy, thoracotomy) |

J Neurosurg 100:1098–1100, 2004

# Treatment of spontaneous intracranial hypotension with percutaneous placement of a fibrin sealant

## Report of four cases

WOUTER I. SCHIEVINK, M.D., M. MARCEL MAYA, M.D., AND FRANKLIN M. MOSER, M.D.

*Maxine Dunitz Neurosurgical Institute and Imaging Medical Group, Cedars-Sinai Medical Center, Los Angeles, California*

› Reg Anesth Pain Med. 2019 Sep 20:rapm-2018-100158. doi: 10.1136/rapm-2018-100158. Online ahead of print.

# A two-level large-volume epidural blood patch protocol for spontaneous intracranial hypotension: retrospective analysis of risk and benefit

Ryan Martin [1], Charles Louy [2], Vijay Babu [3], Yi Jiang [4], Azita Far [5], Wouter Schievink [6]

J Neurosurg 89:483–484, 1998

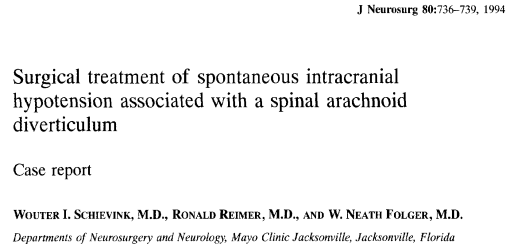
# Cervical bone spur presenting with spontaneous intracranial hypotension

## Case report

A. GIANCARLO VISHTEH, M.D., WOUTER I. SCHIEVINK, M.D., JONATHAN J. BASKIN, M.D., AND VOLKER K. H. SONNTAG, M.D.

*Division of Neurological Surgery, Barrow Neurological Institute, Mercy Healthcare Arizona, Phoenix, Arizona*

# Personal timeline of surgical treatment of spontaneous spinal CSF leaks



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| | Clipping of meningeal diverticula and exploratory surgeries |
| | Rarely targeting of osteophytes (VATS, sternotomy, thoracotomy) |
| 2009 | **DSM (Digital subtraction myelography)** |

# Classification of spinal CSF leaks as a cause of SIH

- Type 1: Dural tear
  - 1a: ventral
  - 1b: (postero-)lateral
- Type 2: Meningeal diverticulum
  - 2a: simple
  - 2b: complex/dural ectasia
- Type 3: CSF-venous fistula

- Type 4: Indeterminate



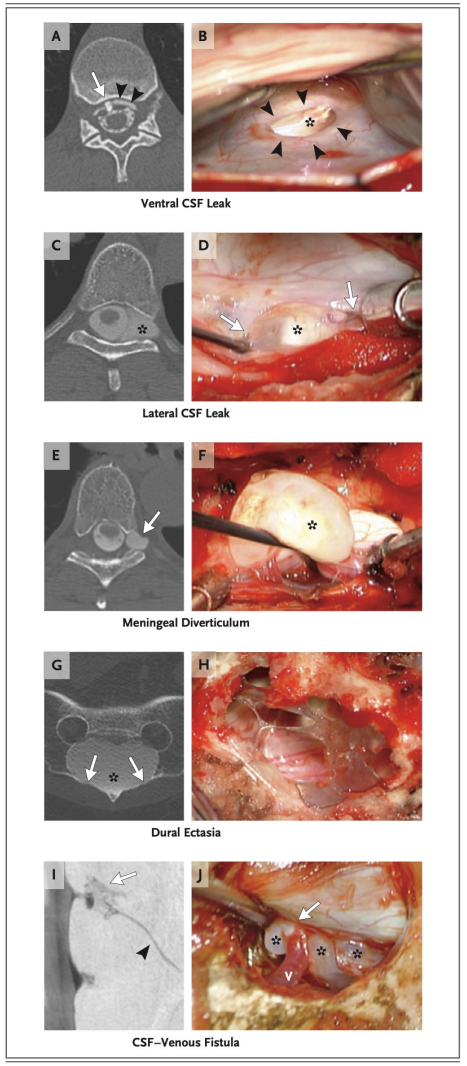



**Figure 1. Types of Spontaneous Spinal Cerebrospinal Fluid (CSF) Leaks.**

Ventral CSF leaks (type 1a) are ventral to the spinal cord and are usually associated with an osteophyte or calcified disk herniation. A computed tomographic (CT) myelogram (Panel A) shows an osteophyte penetrating the dura (arrow) and the ventral extradural CSF collection (arrowheads). An intraoperative photograph (Panel B, posterior intradural view) shows the ventral dural tear (arrowheads), with the jagged edge of the osteophyte (asterisk) penetrating the dura. Lateral CSF leaks (type 1b) usually cause the underlying arachnoid to billow through the dural tear. A CT myelogram (Panel C) shows a lateral extradural CSF collection (asterisk). An intraoperative photograph (Panel D) shows the cranial and caudal extent (arrows) of the lateral tear, with arachnoid billowing through the tear (asterisk). CSF leaks associated with simple meningeal diverticula are type 2a leaks. These diverticula generally arise from the nerve-root sleeve; multiple meningeal diverticula are common, but the CSF leak is usually from just one of the diverticula. A CT myelogram (Panel E) shows contrast material within a diverticulum (arrow). An intraoperative photograph (Panel F) shows the extent of the meningeal diverticulum (asterisk) dissected from the common thecal sac. CSF leaks associated with complex meningeal diverticula or dural ectasia (type 2b) may involve any spinal segment, but the sacrum is the most common site. A CT myelogram (Panel G) shows the sacral dural ectasia (asterisk) and associated bony erosion (arrows). An intraoperative photograph (Panel H) shows the bony erosion and extreme thinning of the dura, which may complicate surgical repair. CSF–venous fistulas (type 3) do not result in an extradural CSF collection, and special imaging is required to detect these fistulas. A digital-subtraction myelogram (Panel I, anteroposterior view) shows a CSF–venous fistula (arrow) with a prominent draining vein (arrowhead). An intraoperative photograph (Panel J, posterior view) shows meningeal diverticula (asterisks), the site of the CSF–venous fistula (arrow), and the draining vein (V).

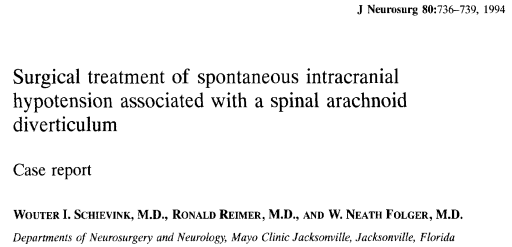
## EPIDEMIOLOGIC FEATURES

Data from large community-based studies of the epidemiology of spontaneous intracranial hypotension are not available, but an estimate of the annual incidence is 4 to 5 cases per 100,000 population,[7] which is about half the incidence of aneurysmal subarachnoid hemorrhage. Although spontaneous intracranial hypotension can affect patients at any age, including children and adolescents, women between the ages of 35 years and 55 years are most often affected.[1,4]

## CLINICAL MANIFESTATIONS

The cardinal symptom of spontaneous intracranial hypotension is a headache that worsens on

# Personal timeline of surgical treatment of spontaneous spinal CSF leaks



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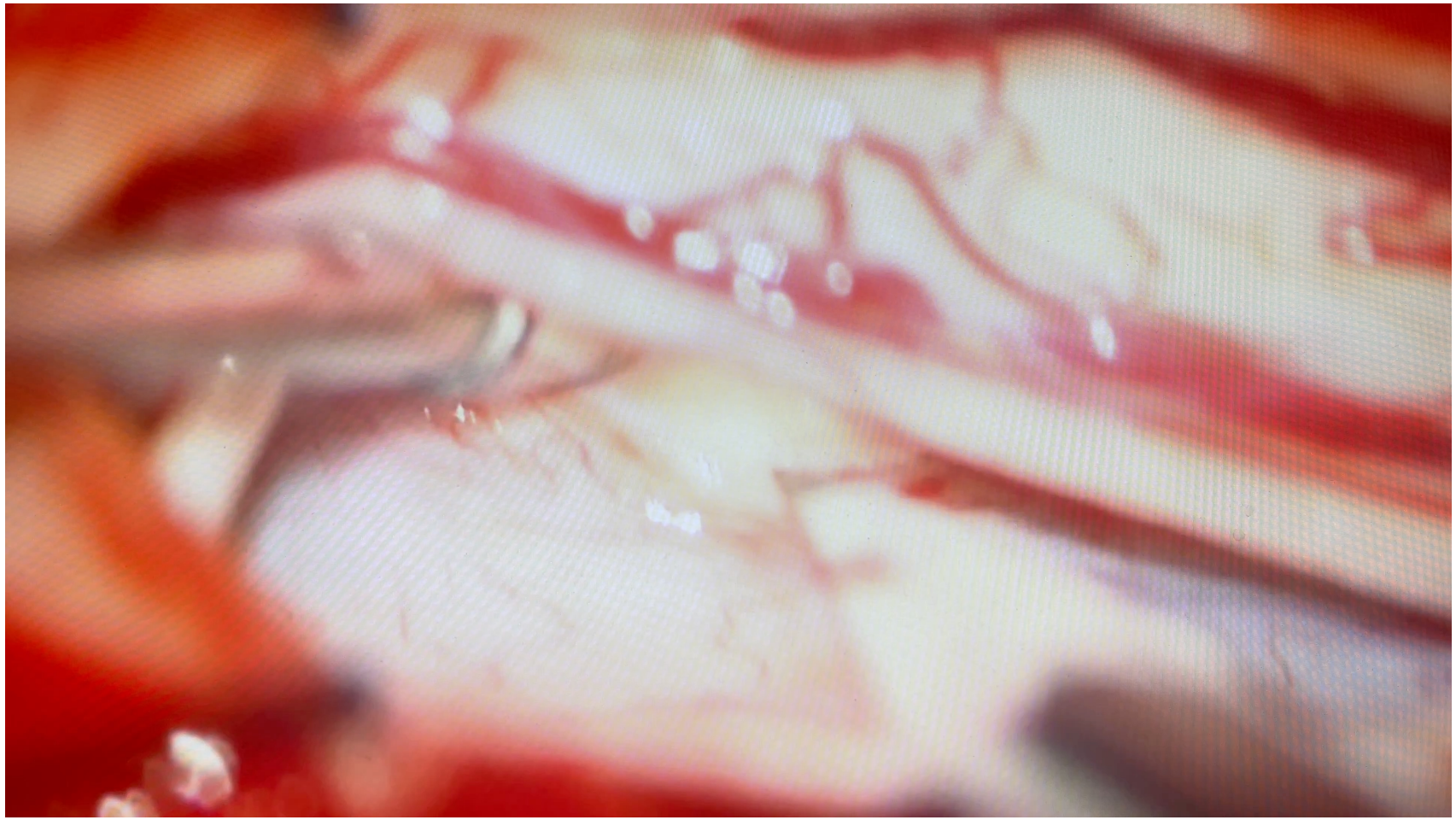
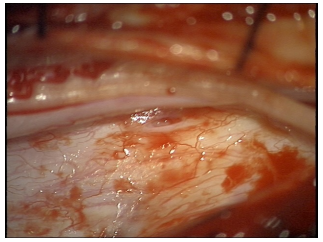
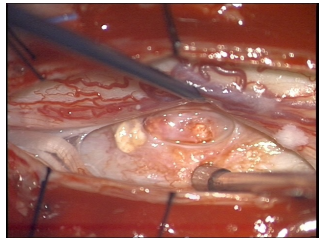
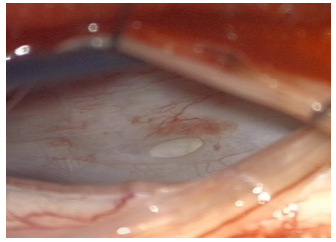
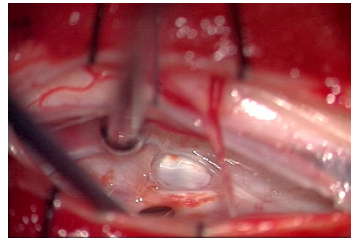
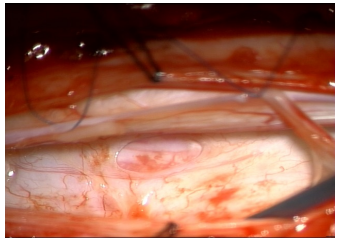
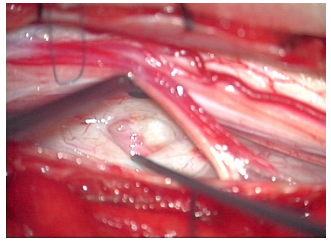
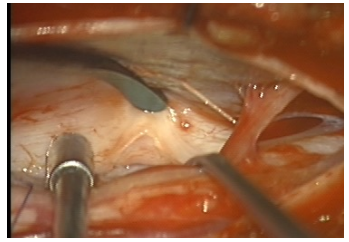
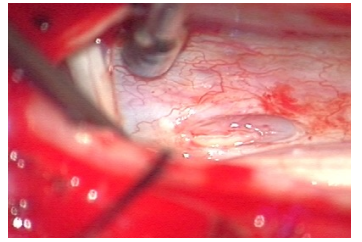
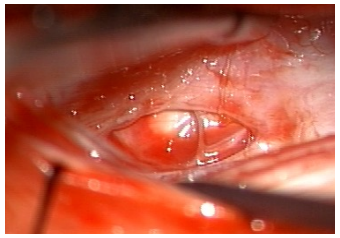
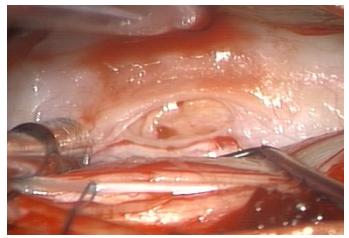
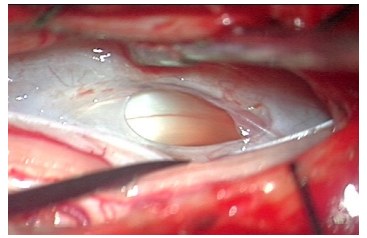
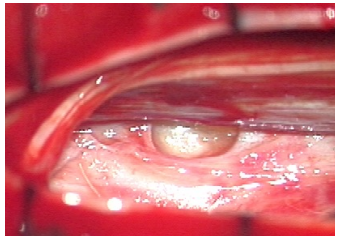
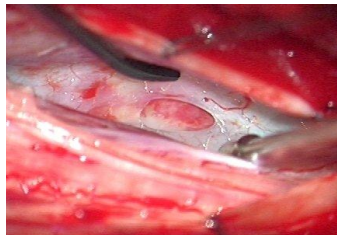
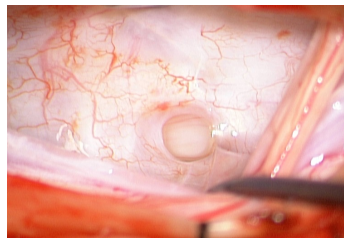
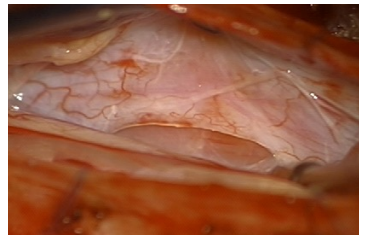
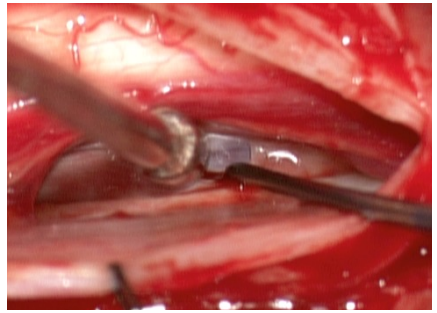
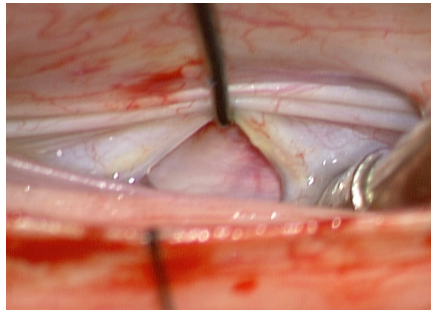
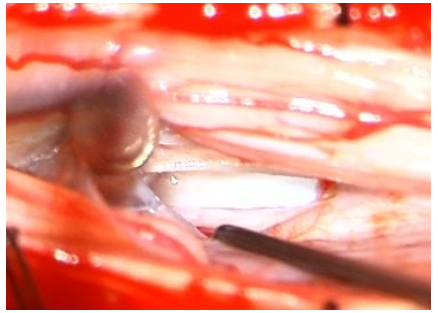
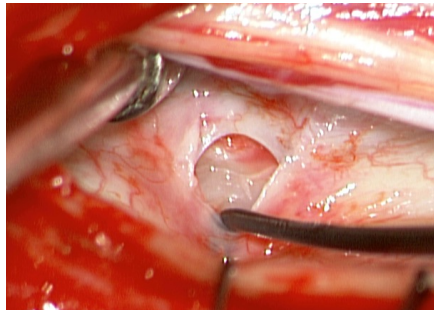
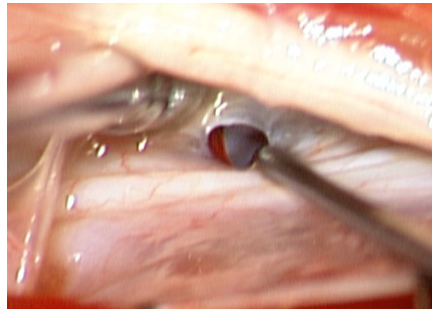
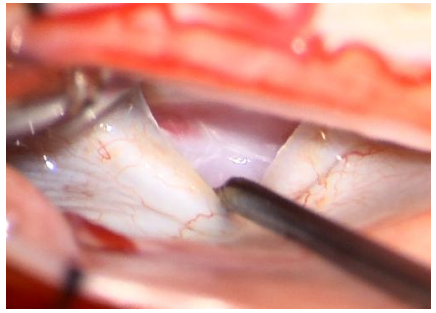
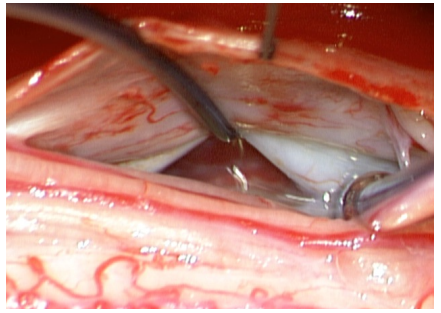
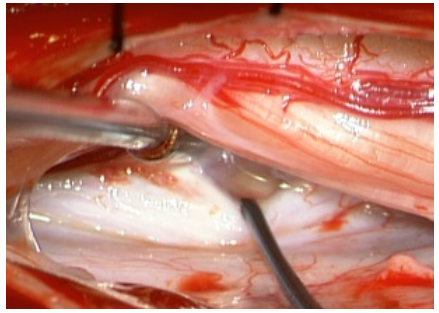
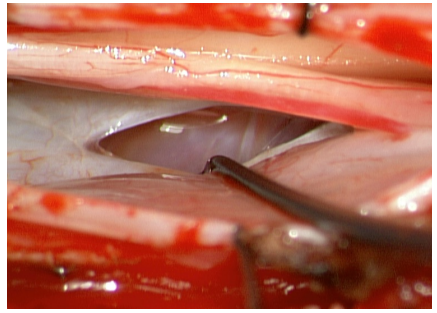
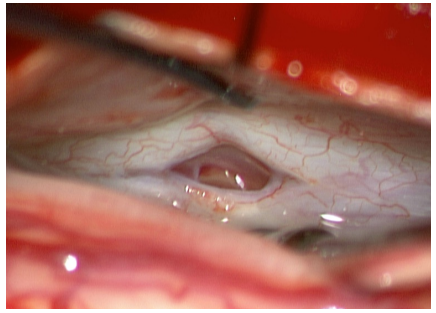
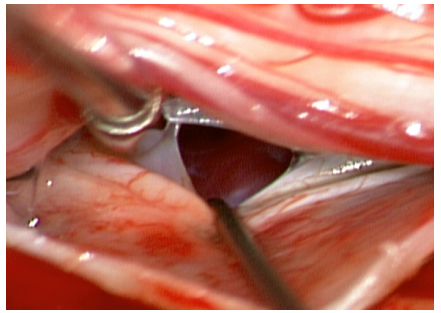
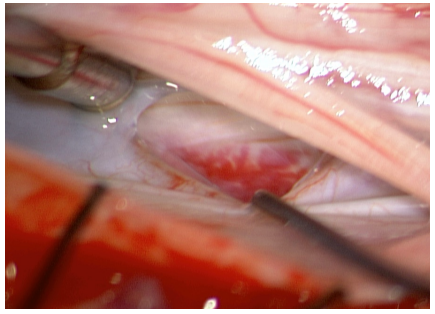
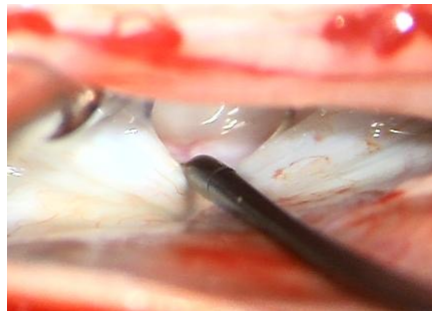
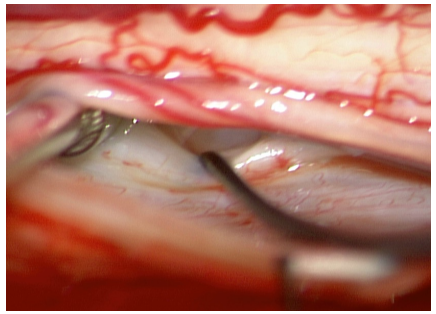
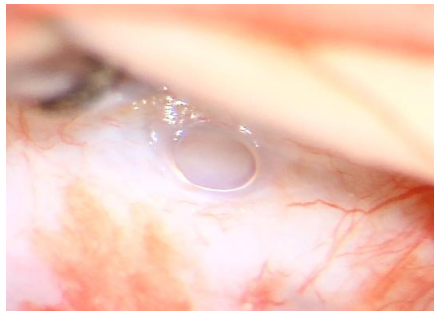
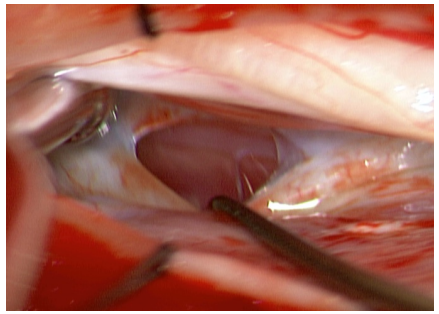
| | Rarely targeting of osteophytes (VATS, sternotomy, thoracotomy) |
| 2009-2011 | **DSM** -> Targeting ventral thoracic leak site **extradural** approach |
| | *Interim review: successful repair 40% with extradural approach* |
| 2011-2023 | Targeting ventral thoracic leak sites **intradural** approach |

# Resection of transdural disc herniation and repair ventral tear – need a steady hand



# Ventral thoracic spinal CSF leak repair (n=325) –
## With identification and repair of ventral dural tear

- Successful repair (radiographic): 311 (95.7%)

Complications

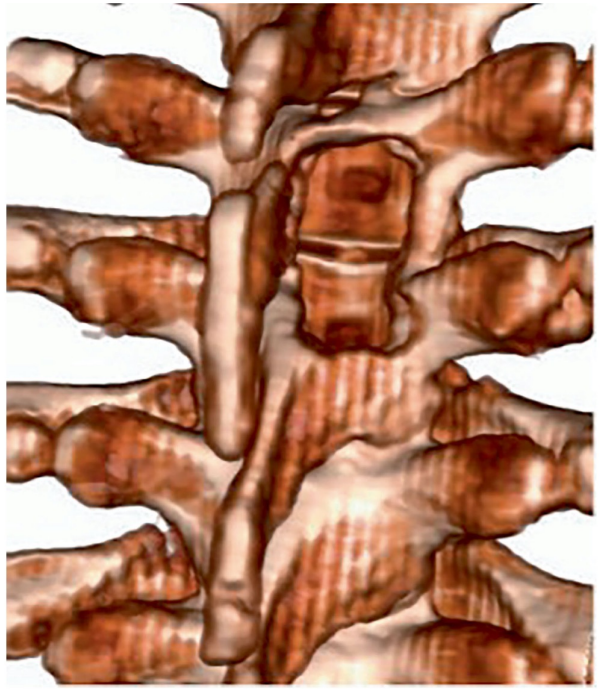
| | | |
|---|---|---|
| • Infection: | 3 | (0.9%) |
| • Neurologic deficit (transient): | 8 | (2.4%) |
| • Pseudomeningocele: | 13 | (4.0%) |
| • Pre-syrinx/cicatrix | 4 | (1.2%) |
| • Epidural hematoma: | 0 | |
| • Mortality: | 0 | |

# Size of laminectomy for ventral CSF leak repair

## Posterior Approach and Spinal Cord Release for 360° Repair of Dural Defects in Spontaneous Intracranial Hypotension

Jürgen Beck, MD*
Andreas Raabe, MD*
Wouter I. Schievink, MD‡
Christian Fung, MD*
Jan Gralla, MD§
Eike Piechowiak, MD§
Kathleen Seidel, MD*
Christian T. Ulrich, MD*

**BACKGROUND:** Spinal cerebrospinal fluid (CSF) leaks are the cause of spontaneous intracranial hypotension (SIH).
**OBJECTIVE:** To propose a surgical strategy, stratified according to anatomic location of the leak, for sealing all CSF leaks around the 360° circumference of the dura through a single tailored posterior approach.
**METHODS:** All consecutive SIH patients undergoing spinal surgery were included. The anatomic site of the leak was exactly localized. We used a tailored hemilaminotomy and intraoperative neurophysiological monitoring (IOM) for all cases. Neurological status was assessed before and up to 90 d after surgery.



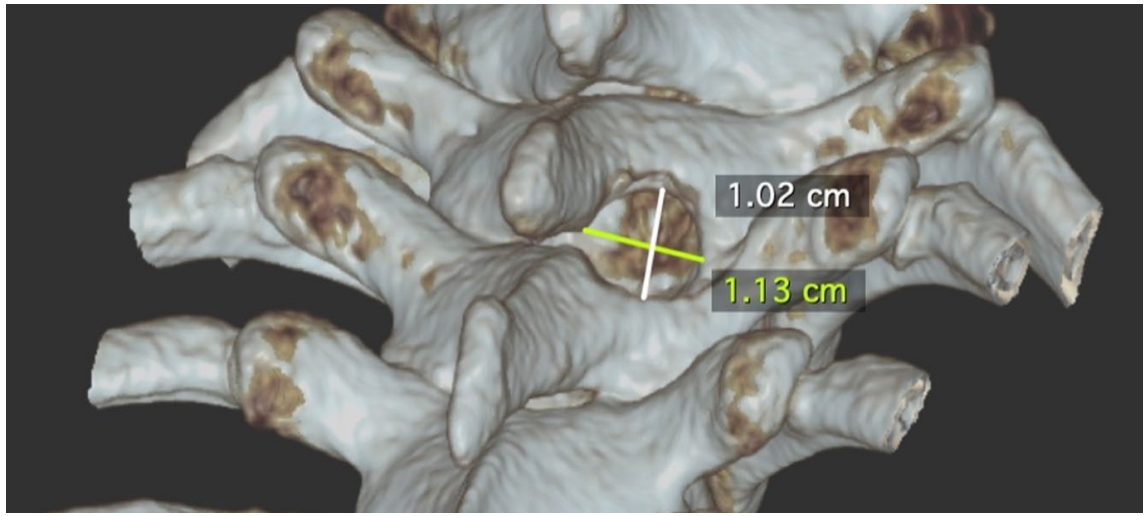
Acta Neurochirurgica
https://doi.org/10.1007/s00701-021-04987-w

HOW I DO IT - SPINE - OTHER

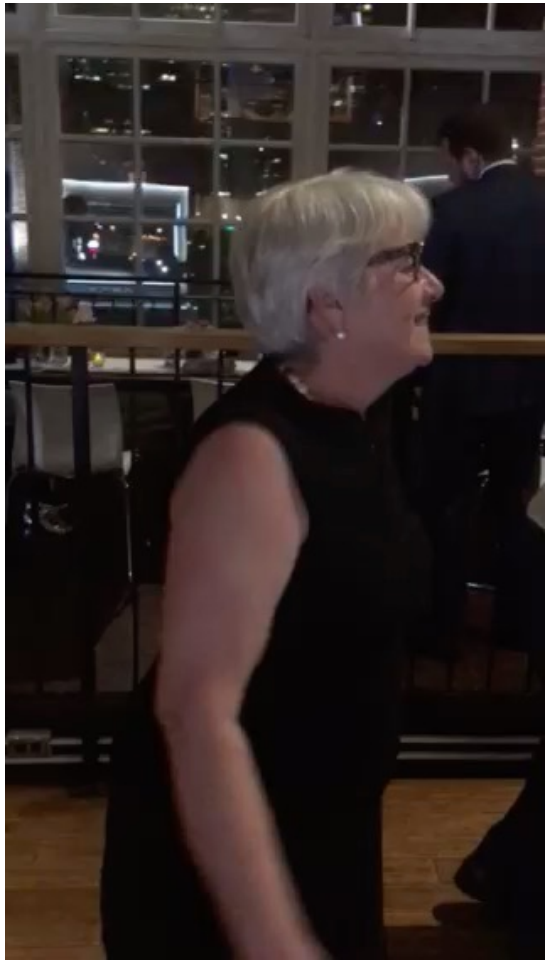
## How I do it: the trans-laminar, facet-joint sparing minimal invasive approach for ventral dural repair in spontaneous intracranial hypotension—a 2-dimensional operative video

Marco V. Corniola[1,2,3] · Torstein R. Meling[1,2]

Received: 5 August 2021 / Accepted: 20 August 2021

# Post-op recovery

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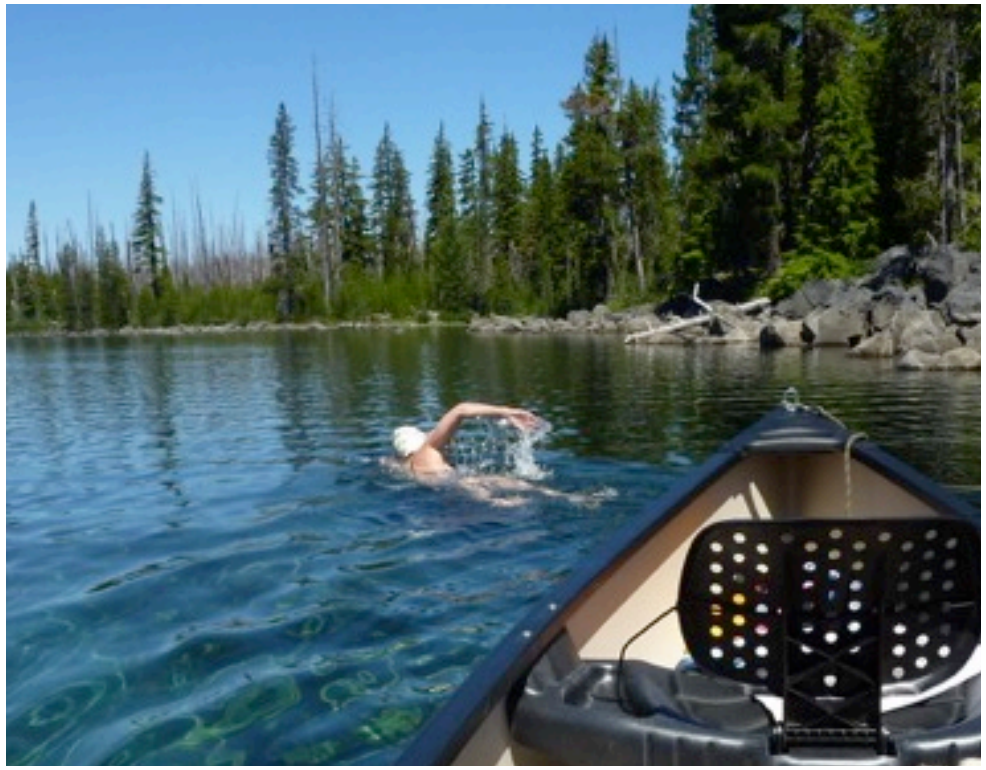

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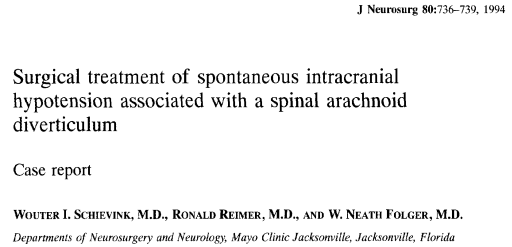
| • Pre-syrinx/cicatrix | 5 | (1.5%) |
| • Epidural hematoma: | 0 | |
| • Mortality: | 0 | |

- Persistent “low pressure” symptoms: 10-20%

# Personal timeline of surgical treatment of spontaneous spinal CSF leaks



J Neurosurg 80:736–739, 1994

Surgical treatment of spontaneous intracranial hypotension associated with a spinal arachnoid diverticulum

Case report

WOUTER I. SCHIEVINK, M.D., RONALD REIMER, M.D., AND W. NEATH FOLGER, M.D.

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1991 – 1998 Learning about CSF leaks

Clipping of meningeal diverticula and exploratory surgeries

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→ ***Clipping of meningeal diverticula*** and exploratory surgeries

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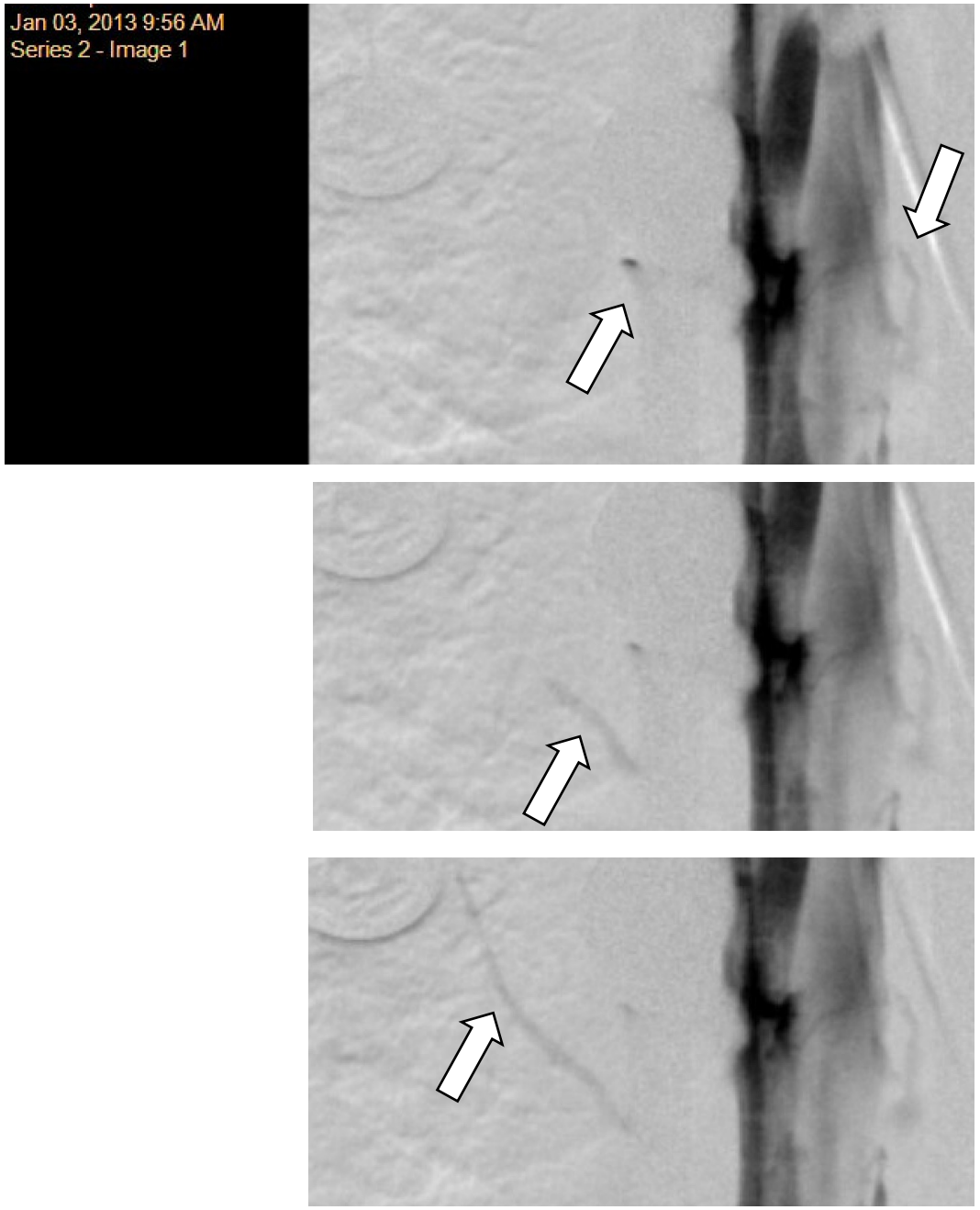
2009-2011 **DSM** -> Targeting ventral thoracic leak site **extradural** approach

*Interim review: successful repair 40% with extradural approach*

2011-2023 Targeting ventral thoracic leak sites **intradural** approach

2013-2023 → ***Clip ligation CSF-venous fistulas***




# Clinical/Scientific Notes

Wouter I. Schievink, MD
Franklin G. Moser, MD, MMM
M. Marcel Maya, MD

## CSF-VENOUS FISTULA IN SPONTANEOUS INTRACRANIAL HYPOTENSION

Spontaneous intracranial hypotension (SIH) is an important cause of new daily persistent headaches.[1] In most patients, the underlying cause is a CSF leak, always at the level of the spine.[2] Once escaped into the epidural space, CSF is rapidly absorbed by the spinal epidural venous plexus, which is often maximally dilated in the setting of SIH. With conventional imaging, the presence of contrast in epidural veins has not been demonstrated in SIH, but indirect evidence for rapid venous absorption such as contrast in the renal collection system on CT myelography or early activity of tracer in the bladder on nuclear cisternography is common.[1] We report the radiographic demonstration of direct CSF–venous fistulae in patients with SIH using digital subtraction myelography (DSM). DSM allows real-time high-resolution imaging of contrast injected through a lumbar puncture.[3–5]

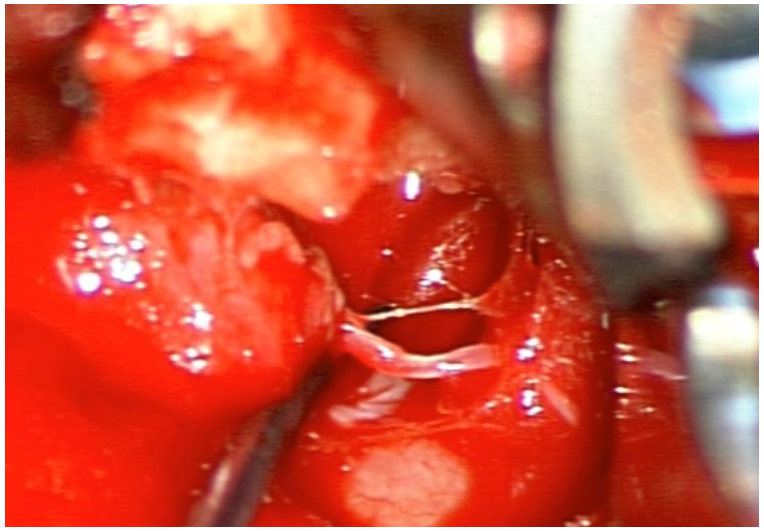
**Case reports.** ***Case 1.*** A 52-year-old woman noted a second half of the day headache, neck stiffness, and interscapular pain. Neurologic examination was normal. MRI showed pachymeningeal enhancement and brain sagging. CT and magnetic resonance (MR) myelography showed multiple thoracic cysts but no CSF leak. CSF examination was normal. Bed rest provided little relief. DSM showed a direct fistula originating from the left T-10 cyst into a spinal epidural vein (figure). Percutaneous fibrin glue injection resulted in resolution of symptoms.

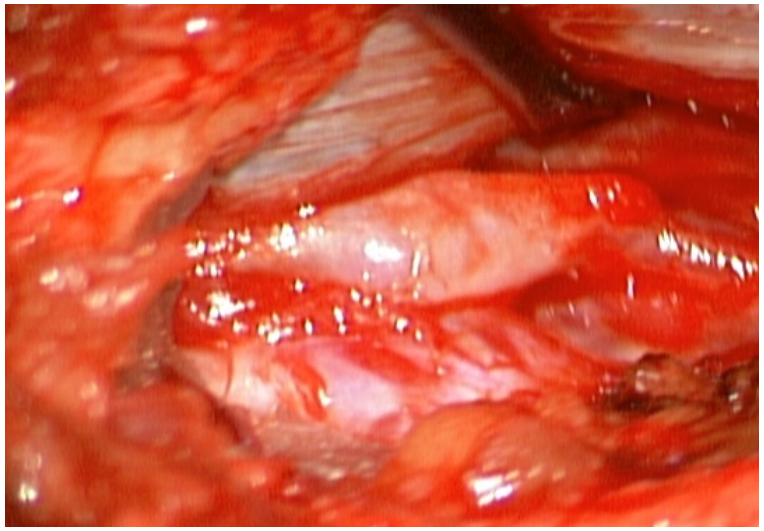
***Case 2.*** A 31-year-old woman noted an orthostatic headache, ringing in the ears, and neck stiffness. Neurologic examination was normal. MRI showed pachymeningeal enhancement, brain sagging, and pituitary enlargement. CT and MR myelography showed an extensive spinal ventral extradural CSF collection. CSF examination was normal. The patient underwent numerous epidural blood patches but symptoms persisted. DSM showed a ventral CSF leak at T-2/3 and she underwent surgical repair resulting in resolution of symptoms. Ten months later, symptoms recurred, but CT myelography did not show any CSF leak. DSM showed a direct fistula originating from the region of the left T-4 nerve root into a spinal epidural vein (figure). The ventral CSF leak was no longer demonstrable. At surgery, epidural venous dilation was significant and a dural tear at the axilla of the left T-4 nerve root was identified and this was sutured, resulting in resolution of symptoms.

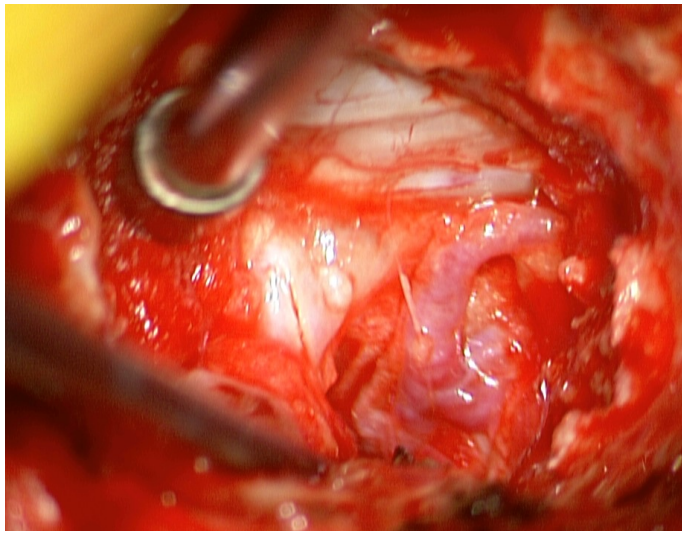
***Case 3.*** A 48-year-old woman noted an orthostatic headache, nausea, emesis, and neck stiffness. Neurologic examination was normal. MRI showed pachymeningeal enhancement and brain sagging. CT and MR myelography showed an extensive spinal ventral extradural CSF collection. CSF examination was normal. She underwent numerous epidural blood patches but symptoms persisted. DSM showed a ventral CSF leak at T-5/6 associated with a direct communication into a spinal epidural vein (figure). At surgery, epidural venous dilation was significant and a ventral dural tear was repaired resulting in resolution of symptoms.

**Discussion.** In this report, we demonstrate direct fistulae between the subarachnoid space and spinal epidural veins, a previously unreported finding in SIH. In 2 of the 3 patients, the fistula provided crucial information for localizing the site of the CSF leak. In fact, MRI and CT myelography had not shown any evidence for a CSF leak in these 2 patients. Whether or not DSM should be considered for all patients with refractory SIH but unrevealing conventional spinal imaging remains to be determined. DSM usually is reserved for rapid CSF leaks visible on MRI or CT myelography as extensive longitudinal intraspinal extradural fluid collections.[3–5] DSM allows visualization of rapid CSF leaks due to its inherent temporal resolution advantage. The procedure differs from conventional myelography in several aspects, although associated risks are similar.[4] We have found that the best diagnostic information is obtained when DSM is completed with the patient under anesthesia and complete paralysis with breath hold, although others have reported excellent results without anesthesia.[4] DSM technique requires a bolus injection of intrathecal contrast to maximize visualization and allow breath hold imaging. The radiation dose of DSM is slightly higher than that of conventional myelography, but it is less than that of conventional CT myelography because demonstration of a leak is not dependent on post myelography CT imaging.

Iatrogenic CSF venous fistulae following myelography have been reported previously.[6] Our cases show that venous injury by a needle is not necessary to







75%

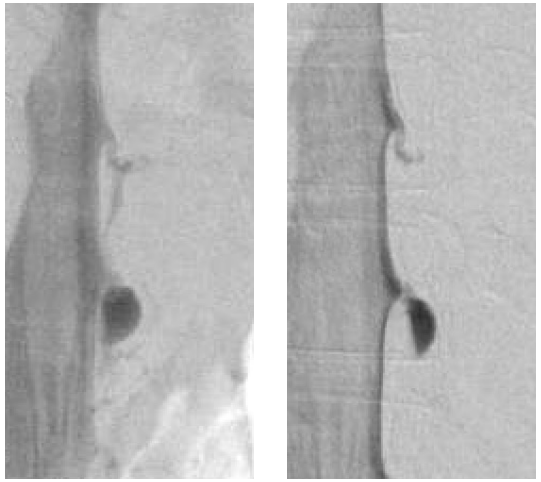
15%

10%

# Pros and cons of CSF-venous fistula treatments

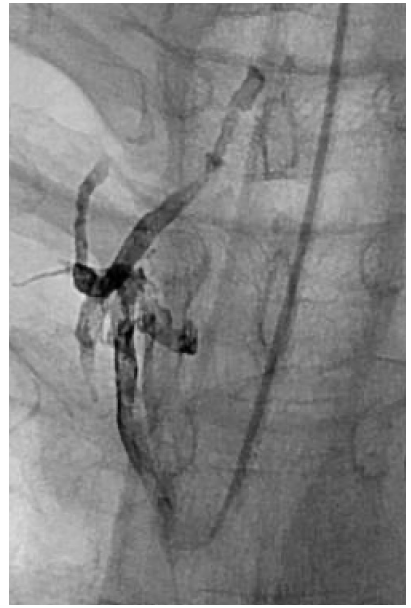
1 Percutaneous fibrin glue injection (outpatient)

- Since 2013
- local/MAC
- 70-80% cure rate



FGI

Endo onyx



2 Onyx embolization (outpatient)

- Since 2020
- General anesthesia
- 70-80%? cure rate

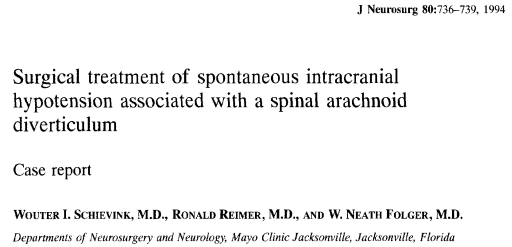
3 Surgical ligation (inpatient)

- Since 2013
- General anesthesia
- >98% cure rate

hemoclips

aneurysm clips

# Personal timeline of surgical treatment of spontaneous spinal CSF leaks



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Case report

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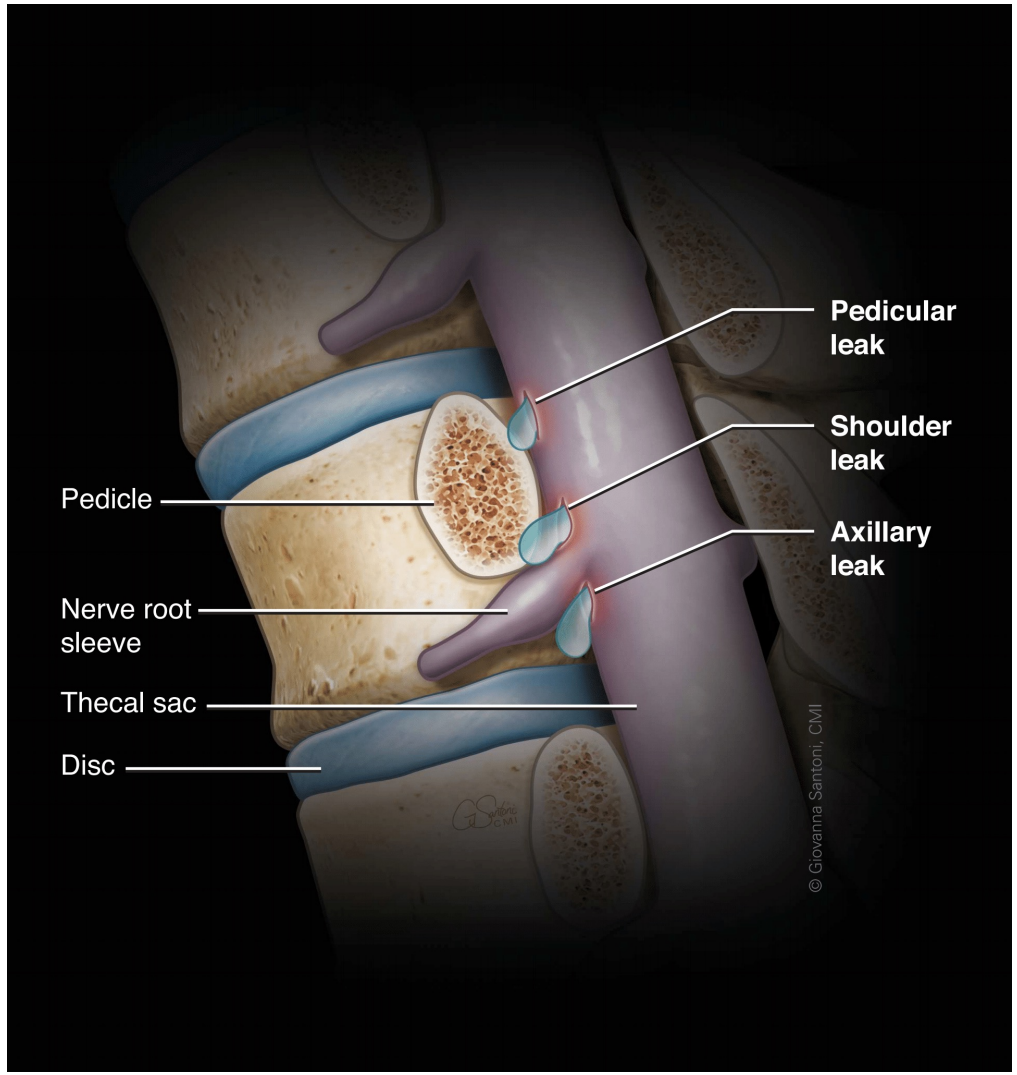
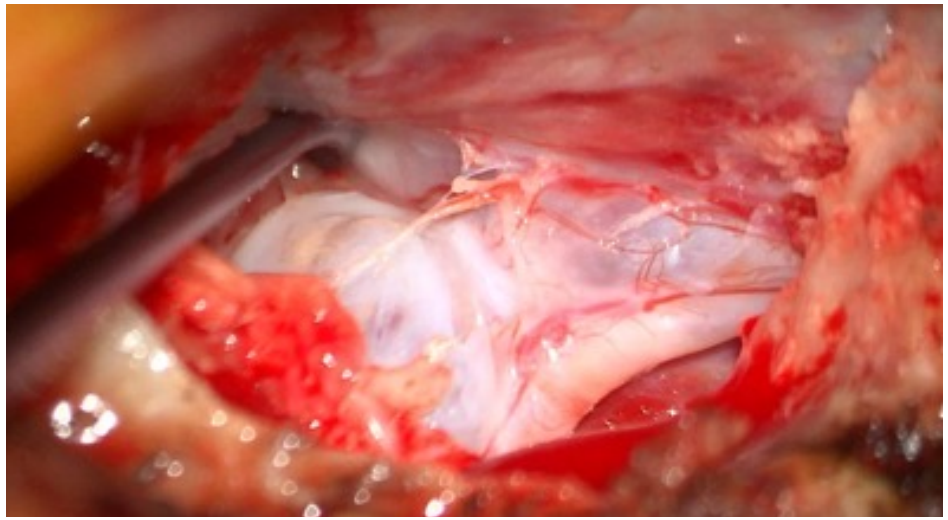
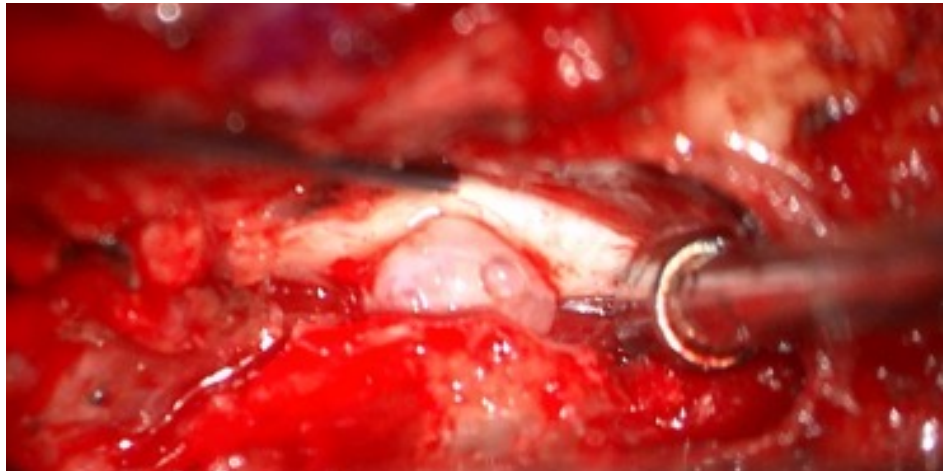
| | |
|---|---|
| 1991 – 1998 | Learning about CSF leaks |
| | Clipping of meningeal diverticula and exploratory surgeries |
| 2000 – 2009 | Establishing a CSF leak center (FGI & hvEBP) |
| | Clipping of meningeal diverticula and exploratory surgeries |
| | Rarely targeting of osteophytes (VATS, sternotomy, thoracotomy) |
| 2009-2011 | **DSM** -> Targeting ventral thoracic leak site **extradural** approach |
| | *Interim review: successful repair 40% with extradural approach* |
| 2011-2023 | Targeting ventral thoracic leak sites **intradural** approach |
| 2013-2023 | Clip ligation CSF-venous fistulas |
| 2018 | 95% of “leaking meningeal diverticula” are primary lateral dural tears |


Pedicular leak
Shoulder leak
Axillary leak
Pedicle
Nerve root sleeve
Thecal sac
Disc
© Giovanna Santoni, CMI





# The History of Surgical Treatment for Iatrogenic Spinal CSF Leaks

# How to prevent post dural puncture headaches?

1 Don’t do it
2 Don’t do it
3 Don’t do it

# How to prevent post dural puncture headaches?

1 Don’t do it

2 Don’t do it

3 Don’t do it

RESEARCH LETTER

**Computed Tomography vs Heavily T2-Weighted Magnetic Resonance Myelography for the Initial Evaluation of Patients With Spontaneous Intracranial Hypotension**

Spontaneous intracranial hypotension (SIH) is an important cause of headaches. For the initial evaluation of patients with suspected SIH, post-myelography computed tomography (CT myelography or CTM) has long been considered the gold standard for the detection of cerebrospinal fluid (CSF) leaks,[1] but spine magnetic resonance imaging including heavily T2-weighted magnetic resonance myelography (MRM) may be a noninvasive alternative.[2-4] We compared the diagnostic accuracy of MRM with CTM for the identification of spinal CSF leaks.

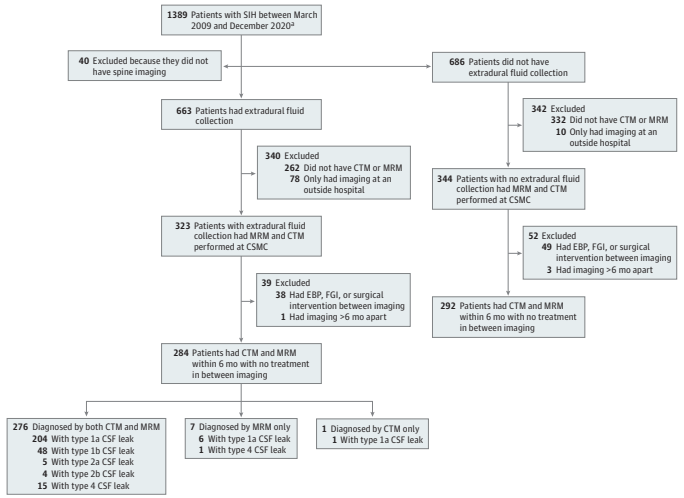
Supplemental content

**Methods** | This study was approved by the Cedars-Sinai Medical Center institutional review board.

Using a prospectively maintained registry, we identified all patients with SIH who had MRM and CTM without any intervening treatment. Patients who had MRM and CTM performed more than 6 months apart were excluded from the study.

The diagnosis of SIH was based on International Classification of Headache Disorders, third edition (ICHD-III) criteria[5] with a modification of also including patients without headaches but whose symptoms are best explained by

Figure. Schematic Flowchart of Patient Selection




Type of cerebrospinal fluid (CSF) leak based on previously published classification of spontaneous spinal CSF leaks.[6] CSMC indicates Cedars-Sinai Medical Center; CTM, post-myelography computed tomography; EBP, epidural blood patch; FGI, fibrin glue injection; MRM, spine magnetic resonance imaging with heavily T2-weighted magnetic resonance myelography; SIH, spontaneous intracranial hypotension.

[a] SIH diagnosed using modified International Classification of Headache Disorders, third edition criteria.[5]



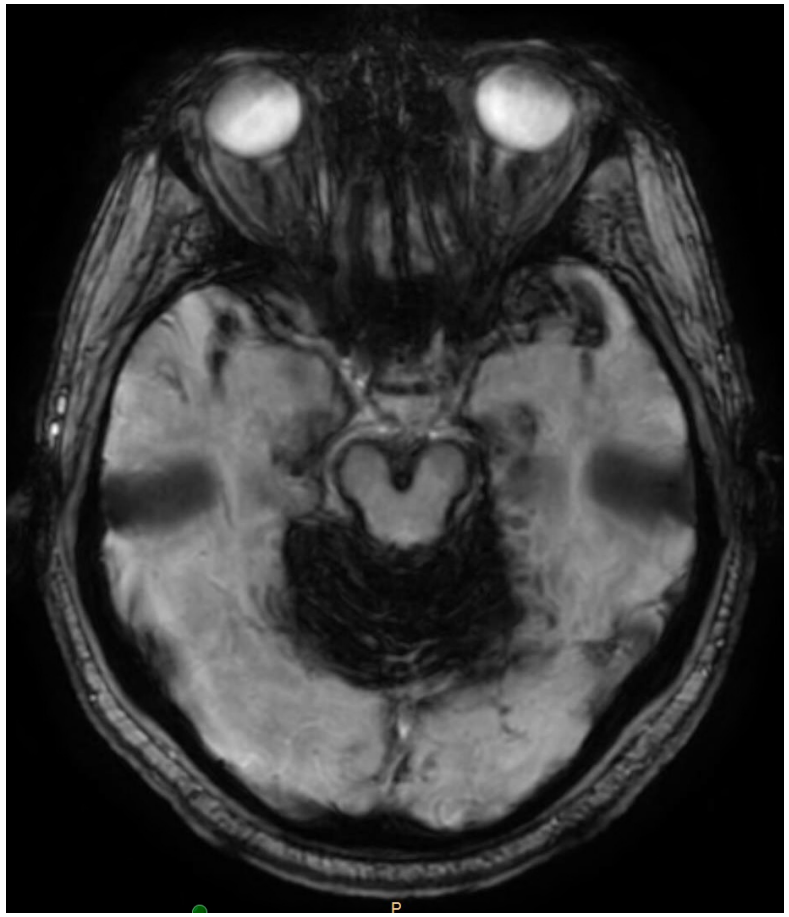


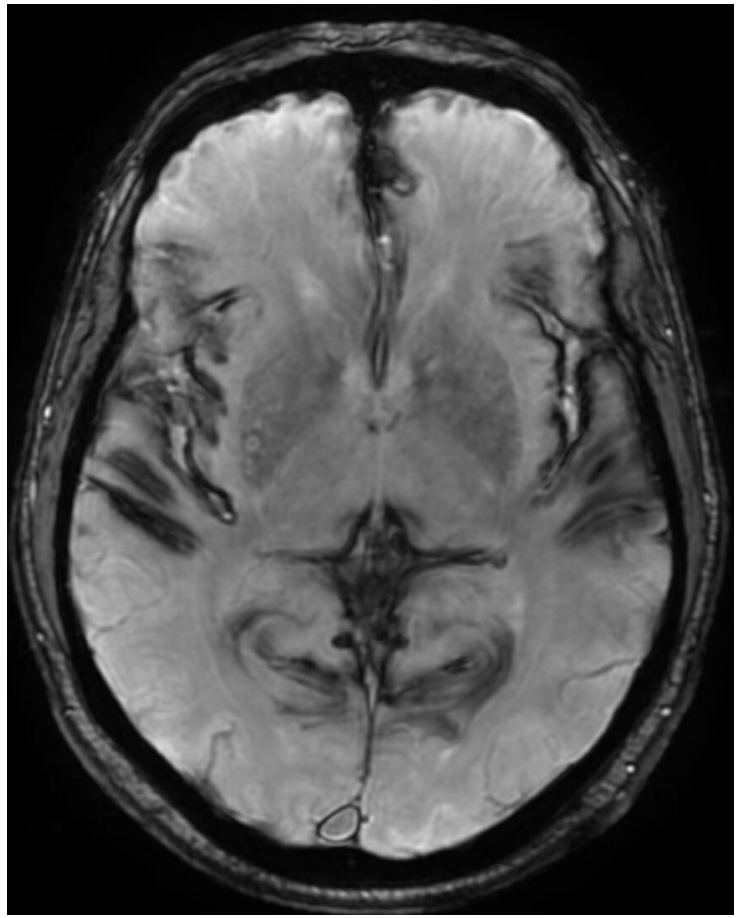
1. Use MR-Myelo instead of CT-myelo

2. Trust CT to rule out SAH

3. Medico-legalities

71 year-old man with iSS, S/P anterior cervical surgery 20 years prior





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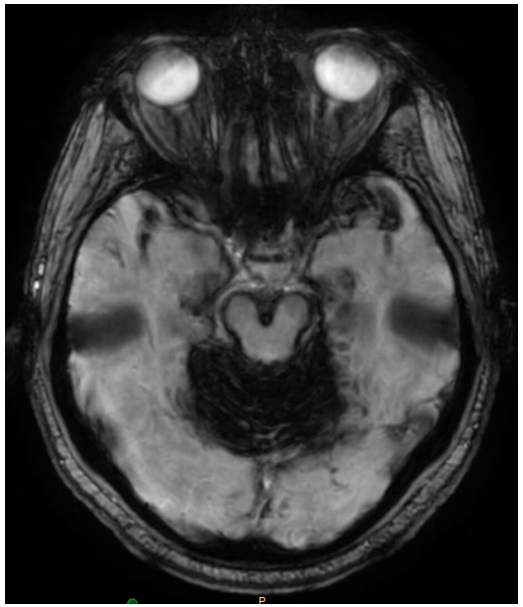

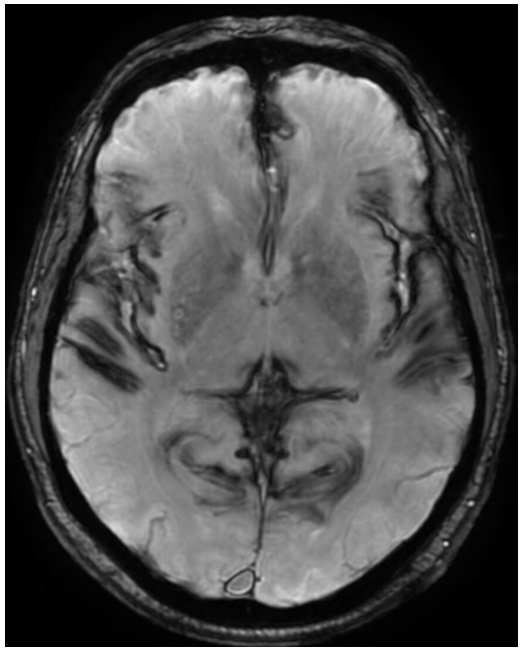

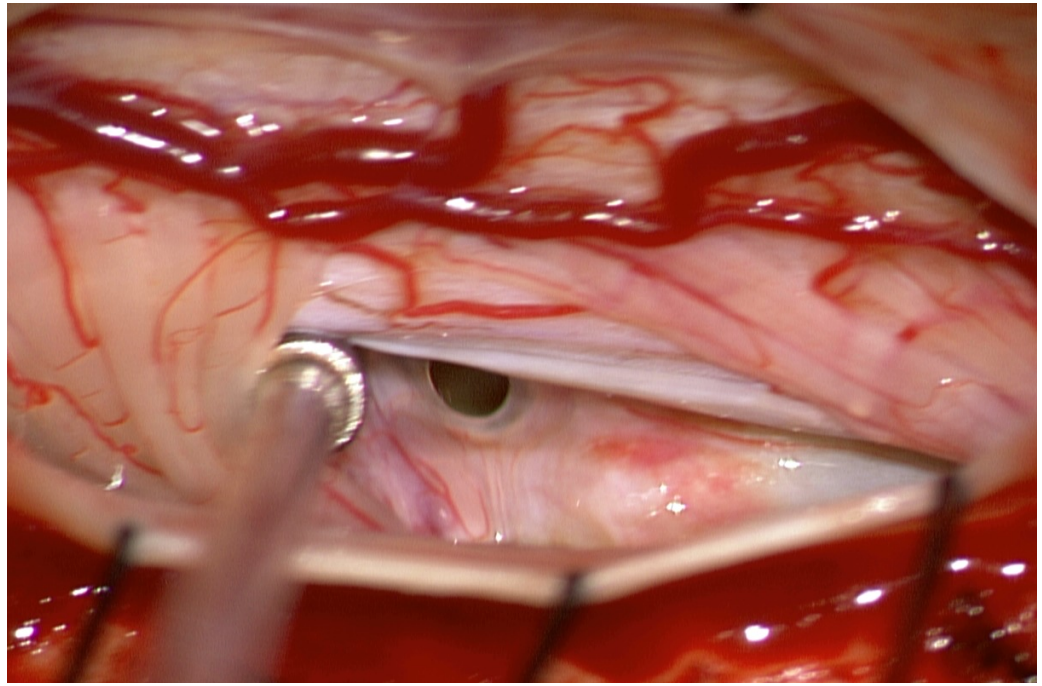

# Thank you!


schievinkw@cshs.org