Types of spontaneous leaks – anatomy and pathogenesis

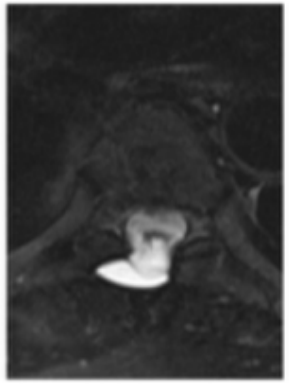
Wouter I Schievink, MD

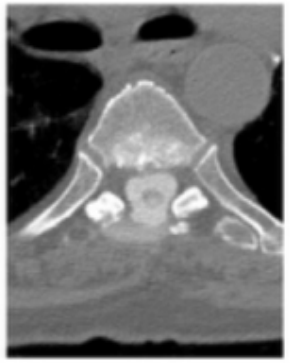
Types of spontaneous CSF leaks

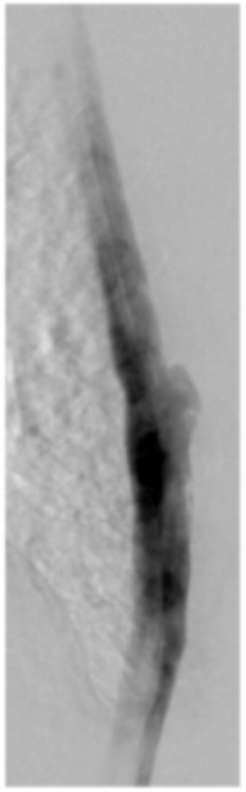
- Spontaneous vs traumatic

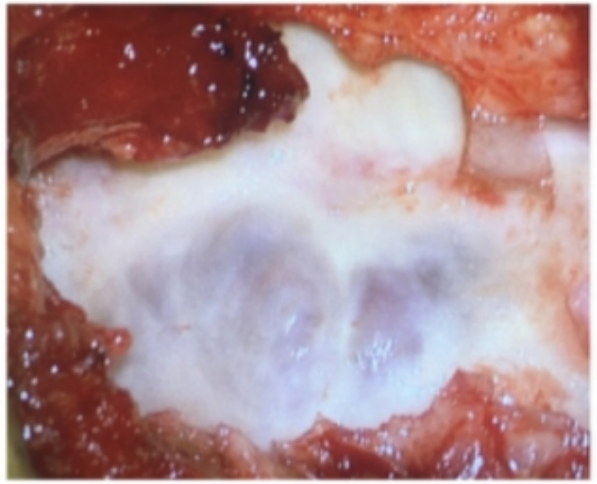
Types of spontaneous CSF leaks

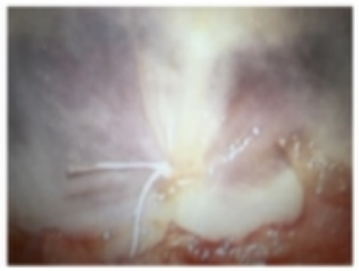
- Spontaneous vs traumatic?











73-year-old MD with 1 year of orthostatic headaches

S/P resection spinal cord tumor in Ukraine in 1970s

Types of spontaneous CSF leaks

- Spontaneous vs traumatic – what does ICHD-3 say?

Table 2. Modified ICHD-III Diagnostic Criteria for Spontaneous Intracranial Hypotension.*

A. Any headache attributed to low CSF pressure or CSF leakage that meets criterion C, below

B. Either or both of the following:

Low CSF pressure (<60 mm CSF)

Evidence of CSF leakage on imaging

C. Headache that developed in temporal relation to the low CSF pressure or CSF leakage or that led to its discovery

D. Headache not better accounted for by another ICHD-III diagnosis

* The modified ICHD-III criteria[16] also apply to patients who do not have headache but whose symptoms are best explained by spontaneous intracranial hypotension. Headache attributed to spontaneous intracranial hypotension cannot be diagnosed in a patient who, within the prior month, has had a procedure or trauma known to be able to cause CSF leakage.

Types of spontaneous CSF leaks

- Spontaneous vs traumatic

TITLE: Post dural puncture or post spinal durotomy patients with persistent positional headaches should be considered for evaluation of spontaneous cerebrospinal fluid leaks

AUTHORS**: Angelique Sao-Mai Sy Tay, MD**, Marcel M Maya, MD, and Wouter I Schievink, MD

2023 Congress of Neurological Surgeons Annual Meeting, Sept 9-13, Washington, DC

TITLE: Post dural puncture or post spinal durotomy patients with persistent positional headaches should be considered for evaluation of spontaneous cerebrospinal fluid leaks

AUTHORS: Angelique Sao-Mai Sy Tay, MD, Marcel M Maya, MD, and Wouter I Schievink, MD

Reviewed all new patients from 1-1-2022 to 6-30-2023 with documented spontaneous spinal CSF leaks

n = 246

How many were originally referred to us as a traumatic/iatrogenic spinal CSF leak

n = 8 (3.3%)

TITLE: Post dural puncture or post spinal durotomy patients with persistent positional headaches should be considered for evaluation of spontaneous cerebrospinal fluid leaks

AUTHORS: Angelique Sao-Mai Sy Tay, MD, Marcel M Maya, MD, and Wouter I Schievink, MD

8 women (age range, 23 – 57 years)

2 post lumbar spine surgery
2 post epidural steroid injection
2 post lumbar puncture
1 post epidural for childbirth
1 post facet block

TITLE: Post dural puncture or post spinal durotomy patients with persistent positional headaches should be considered for evaluation of spontaneous cerebrospinal fluid leaks

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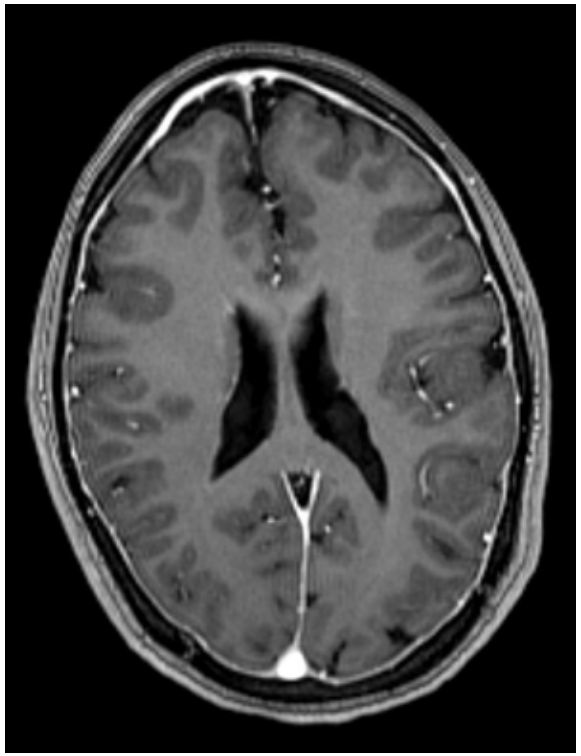

23-year-old woman undergoes L5-S1 facet blocks at 3:30 pm. Orthostatic headaches at 6:30 pm same day.

TITLE: Post dural puncture or post spinal durotomy patients with persistent positional headaches should be considered for evaluation of spontaneous cerebrospinal fluid leaks

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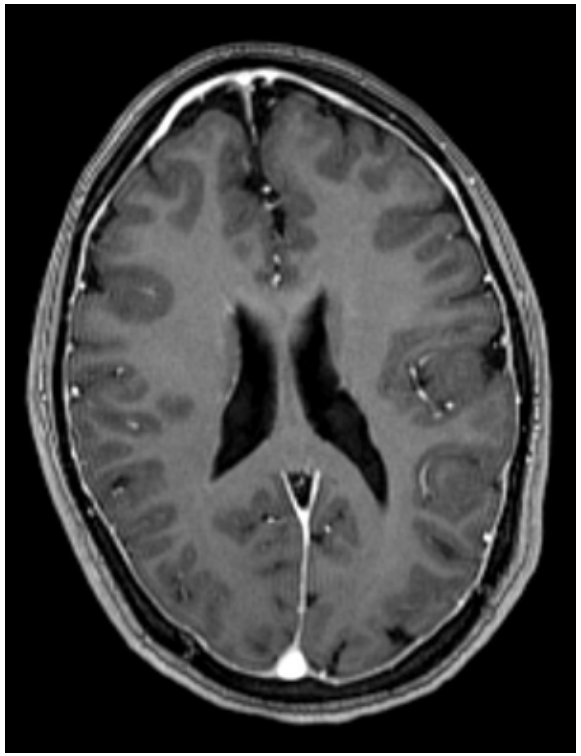
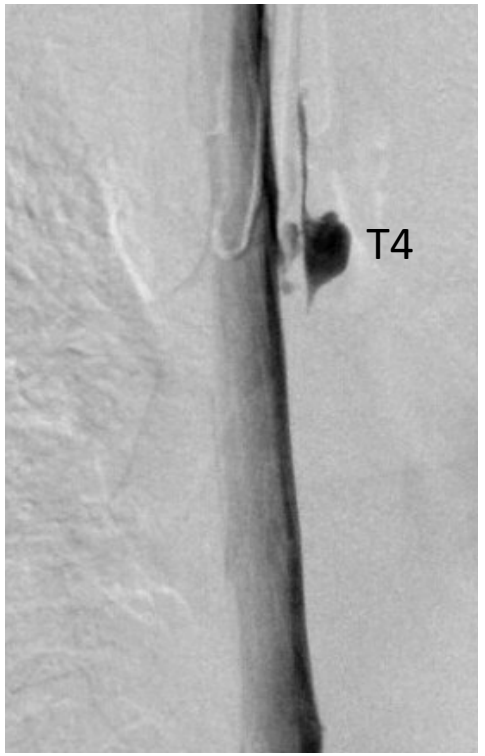
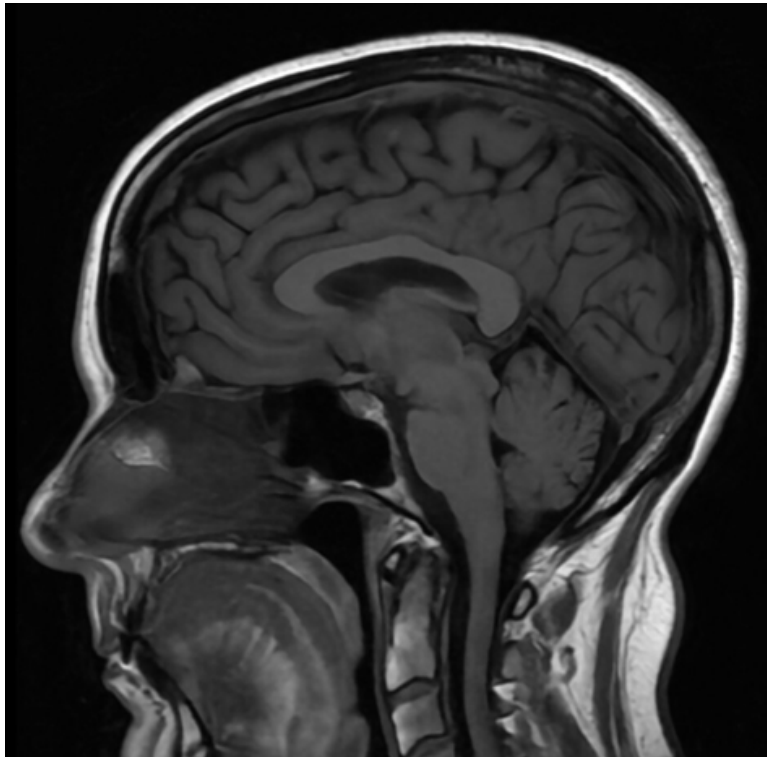


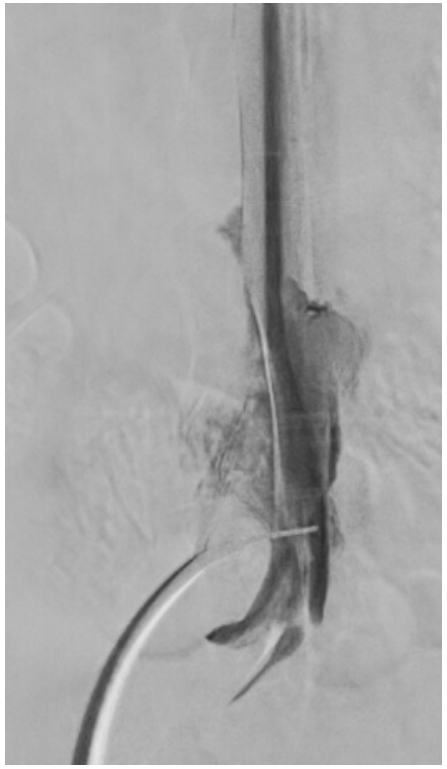


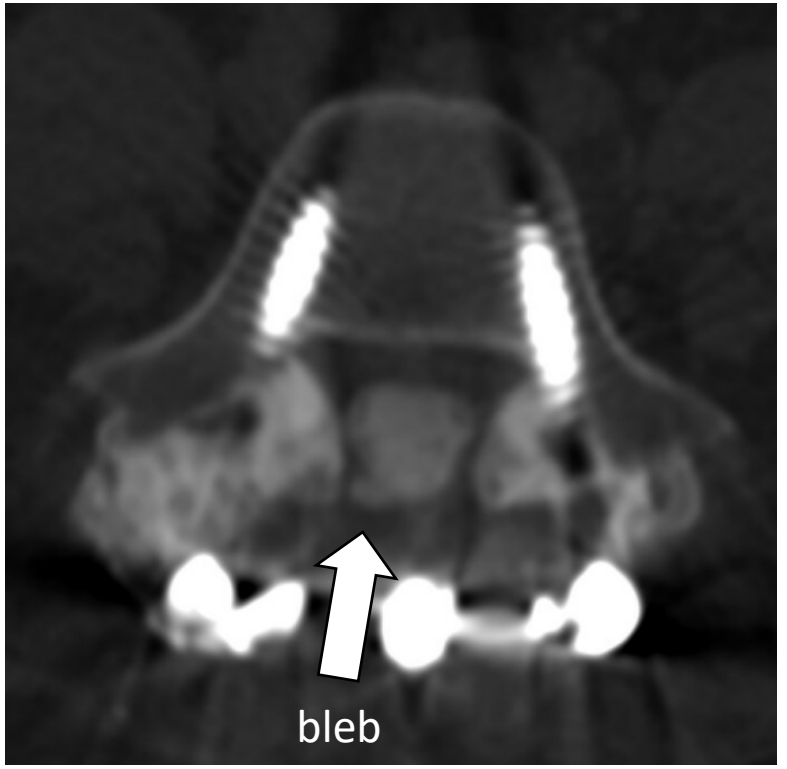
23-year-old woman undergoes L5-S1 facet blocks at 3:30 pm. Orthostatic headaches at 6:30 pm same day. Lateral type 1b CSF leak identified at T4.

TITLE: Post dural puncture or post spinal durotomy patients with persistent positional headaches should be considered for evaluation of spontaneous cerebrospinal fluid leaks

AUTHORS: Angelique Sao-Mai Sy Tay, MD, Marcel M Maya, MD, and Wouter I Schievink, MD



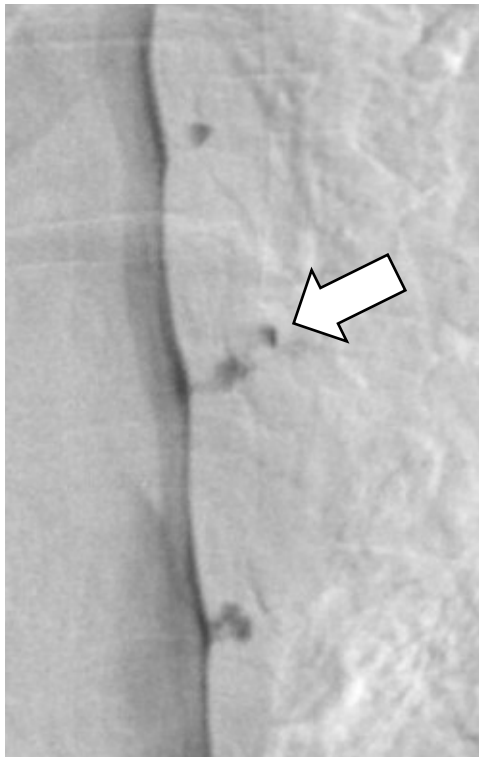


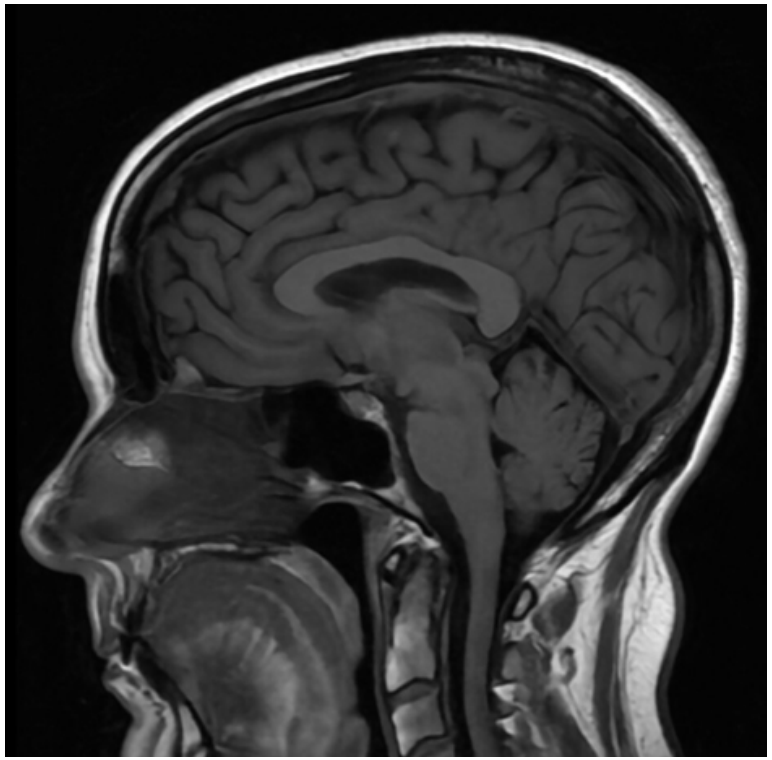


57-year-old woman with orthostatic headaches “a few weeks” after lumbar spinal decompression/fusion

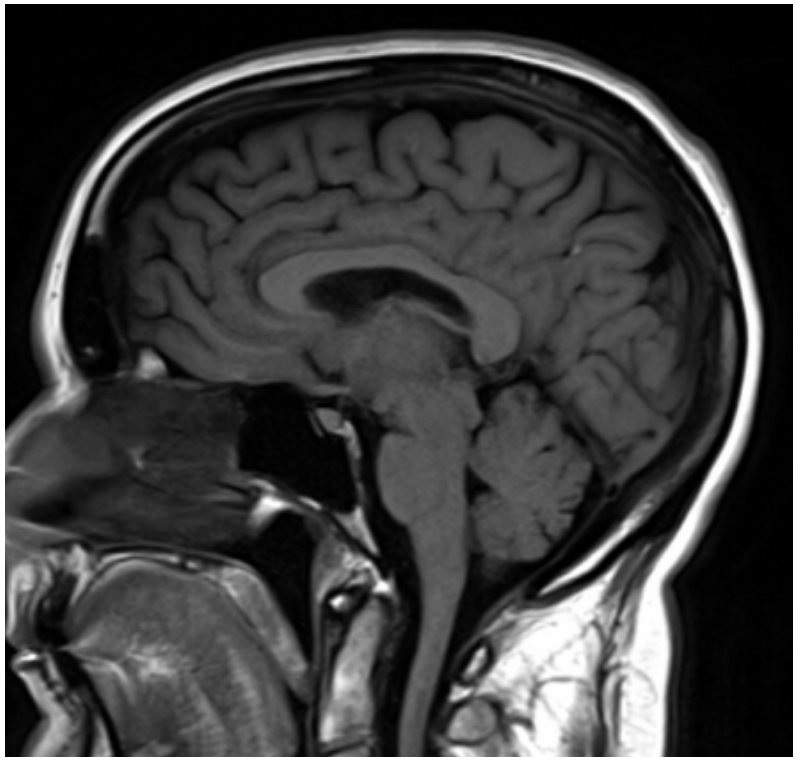
TITLE: Post dural puncture or post spinal durotomy patients with persistent positional headaches should be considered for evaluation of spontaneous cerebrospinal fluid leaks

AUTHORS: Angelique Sao-Mai Sy Tay, MD, Marcel M Maya, MD, and Wouter I Schievink, MD





pre-op



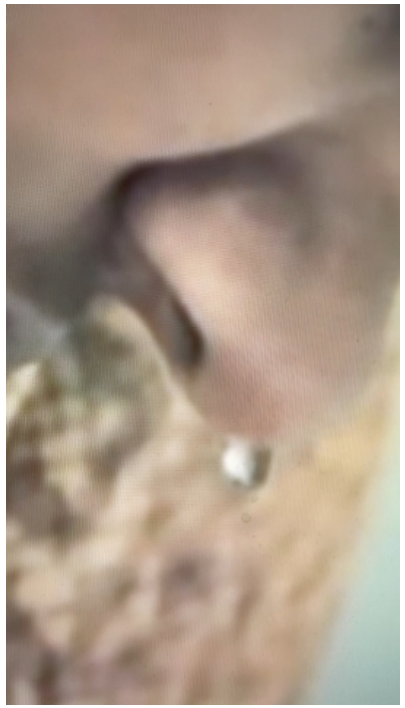
12 hours post-op

Types of spontaneous CSF leaks as a cause of SIH

- Spinal vs skull base

Classification of CSF leaks as a cause of SIH

- Spinal



Lack of causal association between spontaneous intracranial hypotension and cranial cerebrospinal fluid leaks

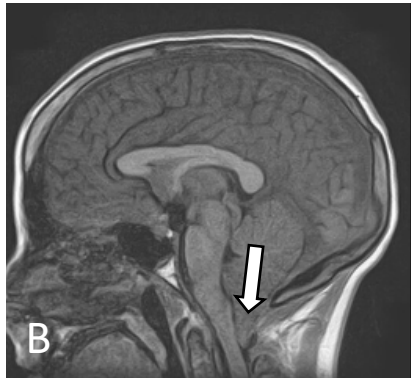
Clinical article

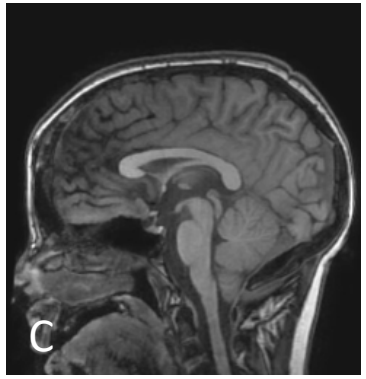
Wouter I. Schievink, M.D.,[1] Marc S. Schwartz, M.D.,[1,2] M. Marcel Maya, M.D.,[3] Franklin G. Moser, M.D., M.M.M.,[3] and Todd D. Rozen, M.D.[4]

Departments of [1]Neurosurgery and [3]Radiology, Cedars-Sinai Medical Center; [2]House Clinic, Los Angeles, California; and [4]Department of Neurology, Geisinger Specialty Clinic, Wilkes-Barre, Pennsylvania

- CSF rhinorrhea?

NEVER!

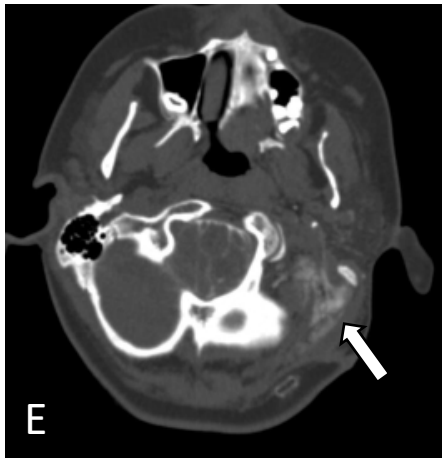




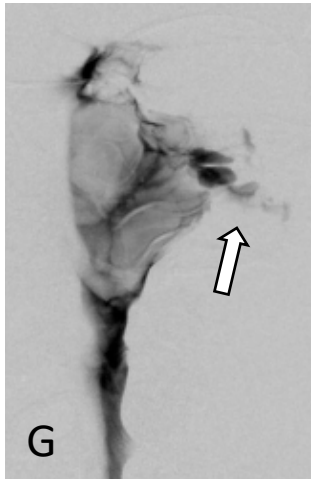
Spontaneous Intracranial Hypotension Due to Skull-Base Cerebrospinal Fluid Leak

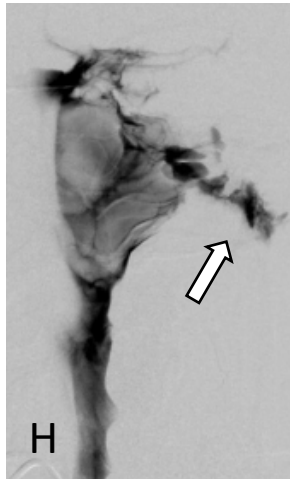
Wouter I. Schievink, MD,[1] L. Madison Michael II MD,[2,3,4] Marcel Maya, MD,[5] Paul Klimo Jr MD,[2,3,4] and Lucas Elijovich, MD[2,3,4,6]

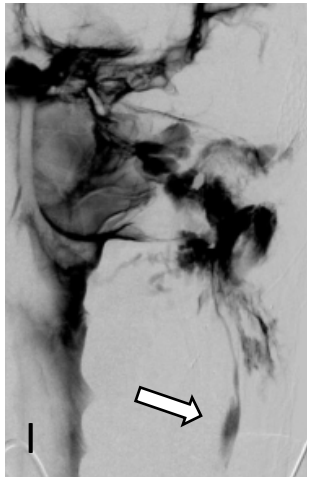
Annals of NEUROLOGY
An Official Journal of the American Neurological Association and the Child Neurology Society
ANA AMERICAN NEUROLOGICAL ASSOCIATION



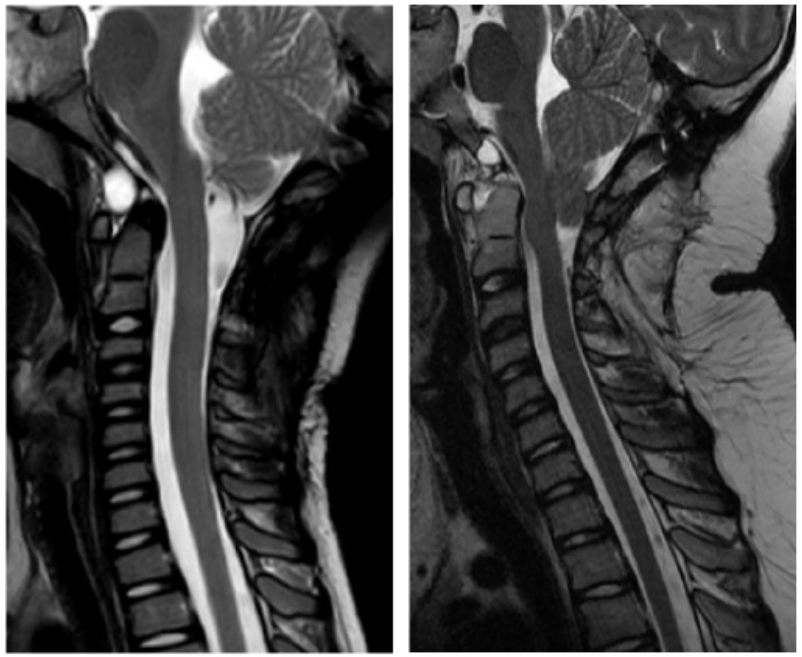
13-year-old boy





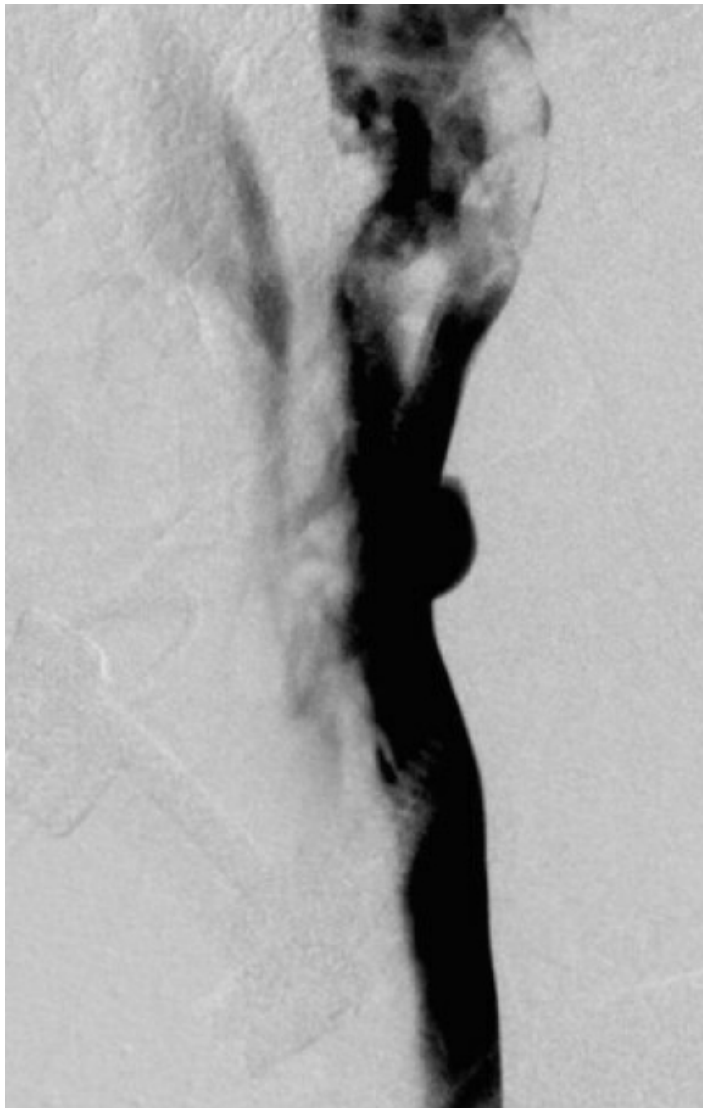


Another 13-year-old boy



Age 6 Age 12

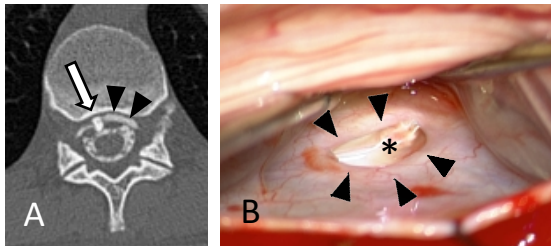
Pre-op



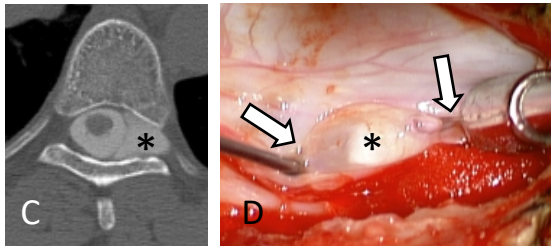
Post-op

Types of **spontaneous spinal** CSF leaks as a cause of SIH

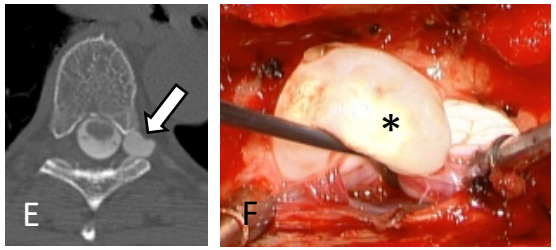
Ventral CSF leak



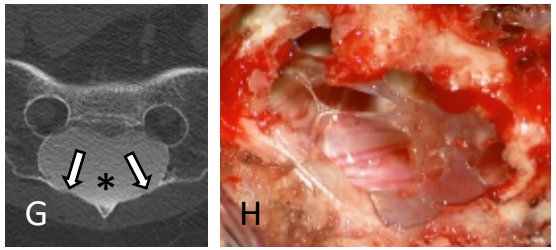
Lateral CSF leak



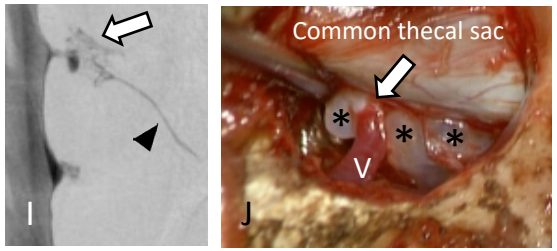
Meningeal diverticulum



Dural ectasia



CSF-venous fistula



A classification system of spontaneous spinal CSF leaks

Wouter I. Schievink, MD
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Stacey Jean-Pierre, PA-C
Miriam Nuño, PhD
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Franklin G. Moser, MD, MMM

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ABSTRACT

Objective: Spontaneous spinal CSF leaks cause spontaneous intracranial hypotension but no systematic study of the different types of these CSF leaks has been reported. Based on our experience with spontaneous intracranial hypotension, we propose a classification system of spontaneous spinal CSF leaks.

Methods: We reviewed the medical records, radiographic studies, operative notes, and any intraoperative photographs of a group of consecutive patients with spontaneous intracranial hypotension.

Results: The mean age of the 568 patients (373 [65.7%] women) was 45.7 years. Three types of CSF leak could be identified. Type 1 CSF leaks consisted of a dural tear (151 patients [26.6%]) and these were almost exclusively associated with an extradural CSF collection. Type 1a represented ventral CSF leaks (96%) and type 1b posterolateral CSF leaks (4%). Type 2 CSF leaks consisted of meningeal diverticula (240 patients [42.3%]) and were the source of an extradural CSF collection in 53 of these patients (22.1%). Type 2a represented simple diverticula (90.8%) and type 2b complex meningeal diverticula/dural ectasia (9.2%). Type 3 CSF leaks consisted of direct CSF-venous fistulas (14 patients [2.5%]) and these were not associated with extradural CSF collections. A total of 163 patients (28.7%) had an indeterminate type and extradural CSF collections were noted in 84 (51.5%) of these patients.

Conclusions: We identified 3 types of spontaneous spinal CSF leak in this observational study: the dural tear, the meningeal diverticulum, and the CSF-venous fistula. These 3 types and the presence or absence of extradural CSF form the basis of a comprehensive classification system.

Neurology® 2016;87:673-679

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

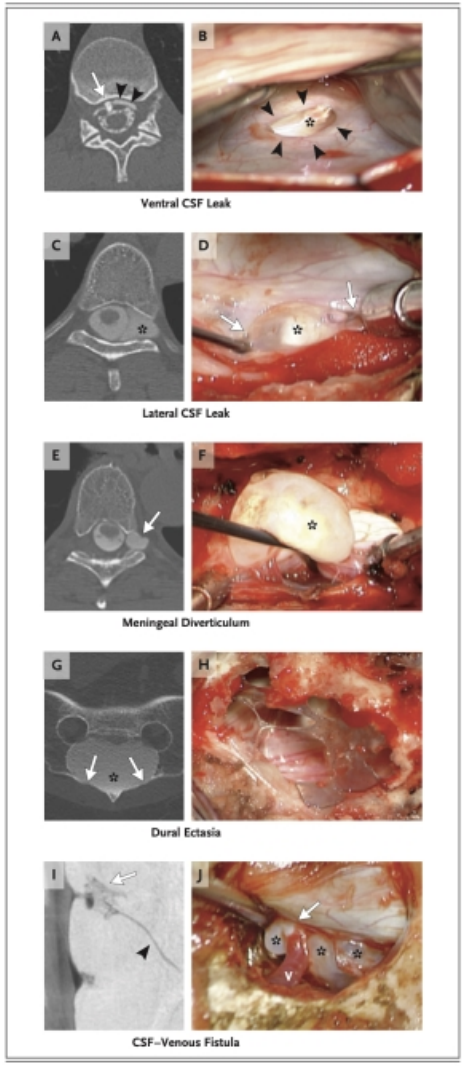


Figure 1. Types of Spontaneous Spinal Cerebrospinal Fluid (CSF) Leaks.

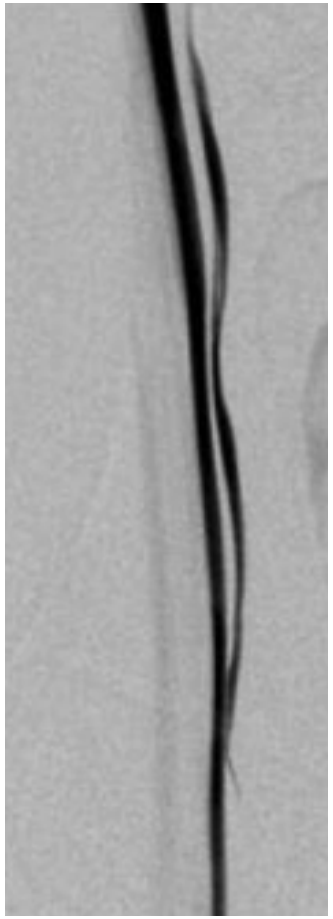
Ventral CSF leaks (type 1a) are ventral to the spinal cord and are usually associated with an osteophyte or calcified disk herniation. A computed tomographic (CT) myelogram (Panel A) shows an osteophyte penetrating the dura (arrow) and the ventral extradural CSF collection (arrowheads). An intraoperative 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).

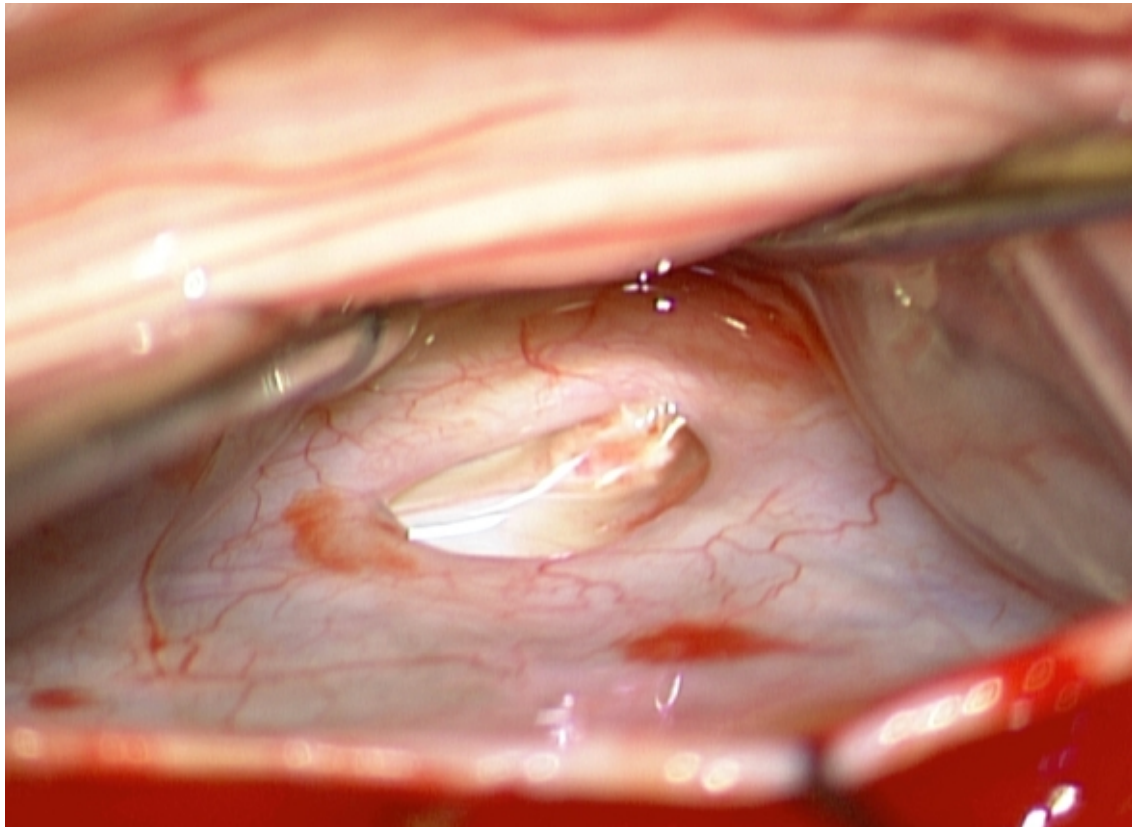
EPIDEMIOLOGIC FEATURES

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.[1,8]

CLINICAL MANIFESTATIONS

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



Type 1a – Ventral leak

Bone spur as cause of ventral CSF leak

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

Spontaneous intracranial hypotension due to a spinal cerebrospinal fluid (CSF) leak is a rare but increasingly recognized cause of postural headaches. The exact cause of these CSF leaks often remains unknown. The authors treated a 32-year-old man with a unique cause of spontaneous intracranial hypotension. He suffered an excruciating headache that was exacerbated by his being in an upright position. The results of four-vessel cerebral angiography were negative; however, magnetic resonance (MR) imaging of the brain revealed pachymeningeal enhancement and hindbrain herniation. A presumptive diagnosis of spontaneous intracranial hypotension was made. Myelography revealed extrathecal contrast material ventral to the cervical spinal cord as well as an unusual midline bone spur at C5–6. The patient's symptoms did not resolve with the application of epidural blood patches, and he subsequently underwent an anterior approach to the C5–6 spur. After discectomy, a slender bone spur that had pierced the thecal sac was found. After its removal, the dural rent was closed using two interrupted prolene sutures. The patient was discharged home 2 days later. On follow up his symptoms had resolved, and on MR imaging the pachymeningeal enhancement had resolved and the cerebellar herniation had improved slightly.

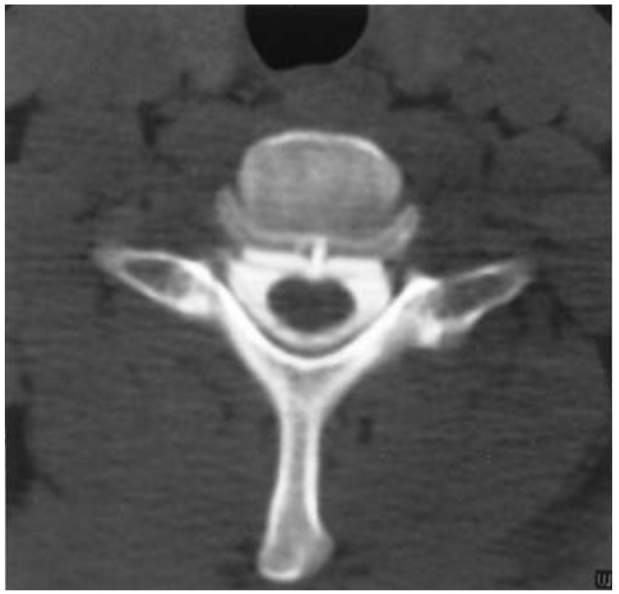
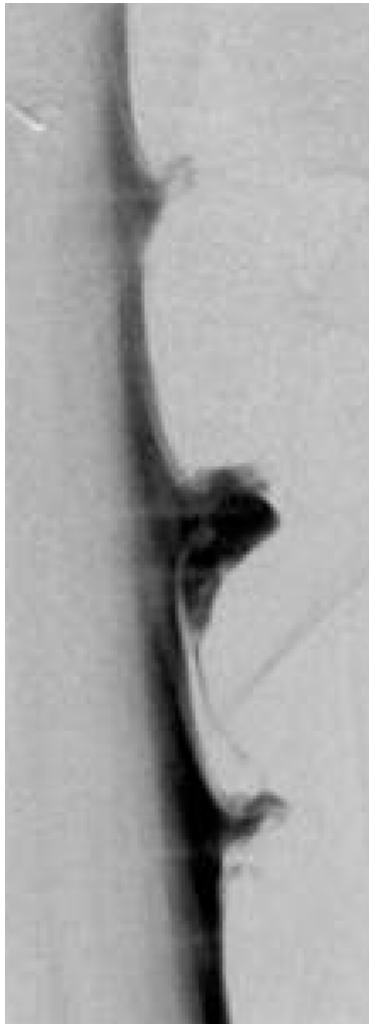
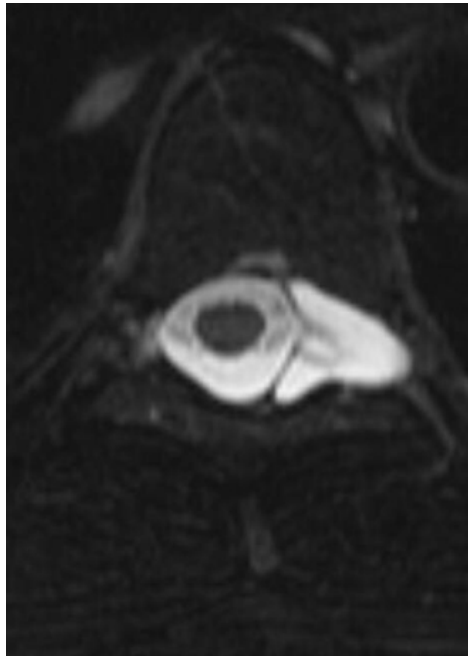
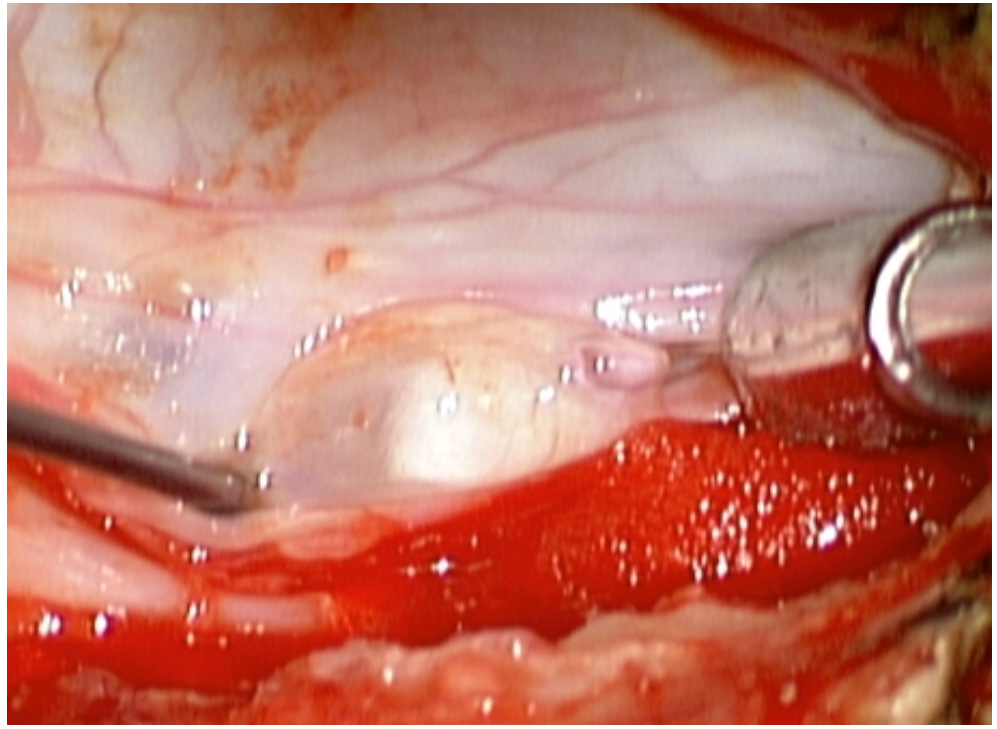


FIG. 1. Postmyelography axial CT obtained at the C5–6 level, showing the bone spur protruding into the thecal sac and associated extrathecal contrast.

Ventral spinal CSF leak

- Curable with non-directed epidural blood patching even in presence of large bony spur if performed “early”
- Directed percutaneous approach between “early” and 3-6 months
- When present >3-6 months direct to surgery



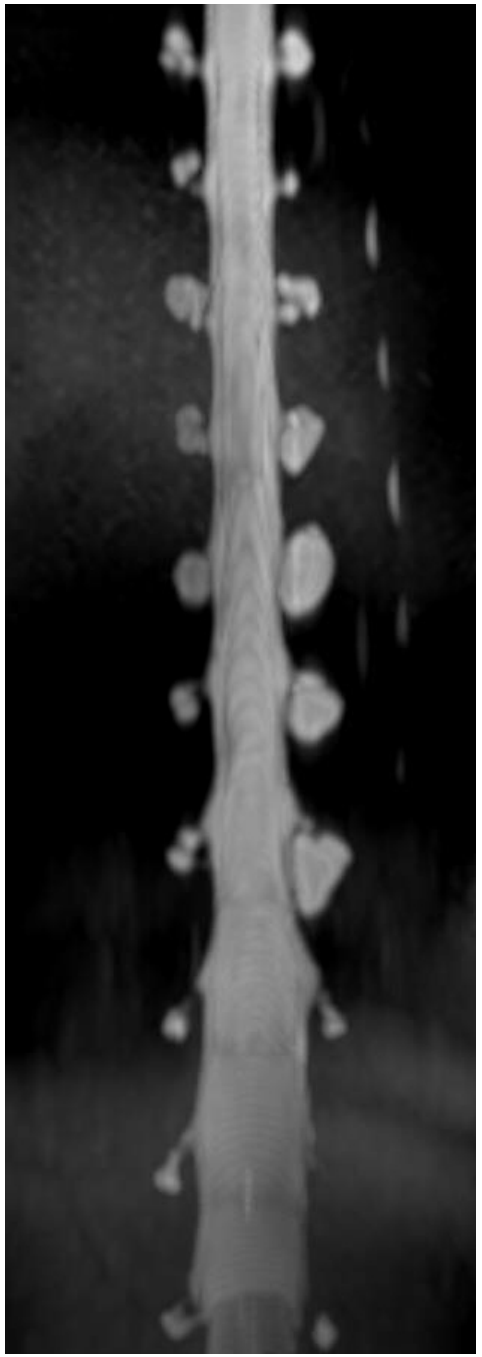
Type 1b – Lateral or posterior leak

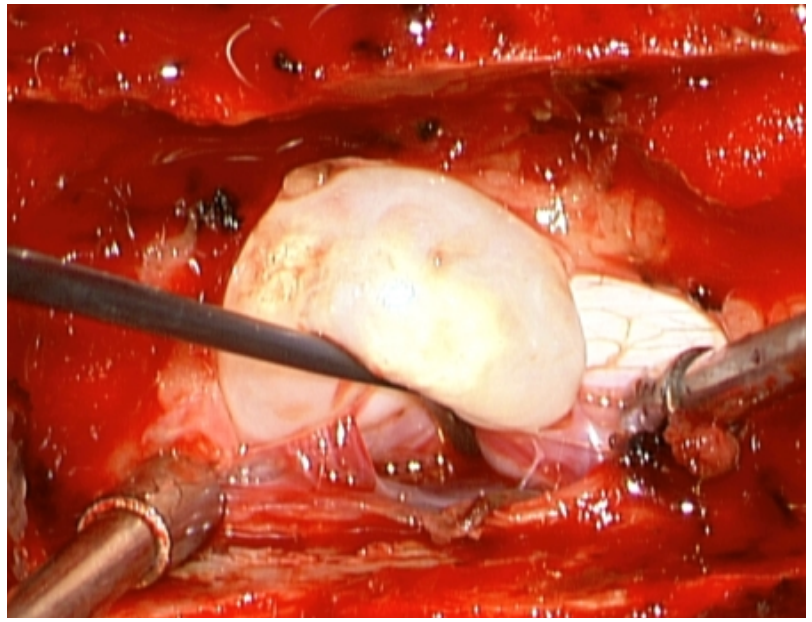
Type 1 b (postero-)lateral CSF leaks

Consider percutaneous fibrin glue injection for cure, regardless of duration of symptoms

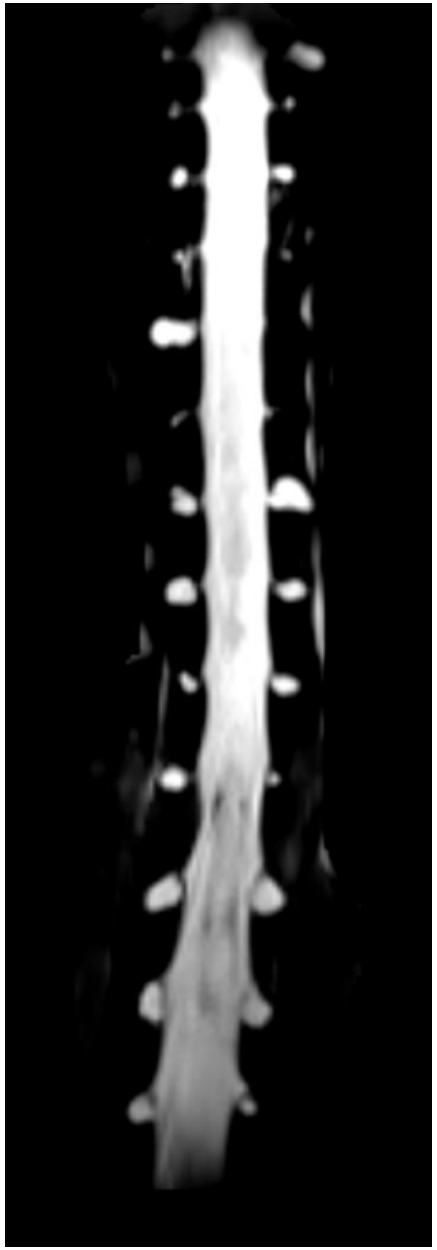
Extradural surgical approach, clip or suture

Associated with nerve root sleeve





Type 2a – simple meningeal diverticulum



Spinal Meningeal Diverticula in Spontaneous Intracranial Hypotension: Analysis of Prevalence and Myelographic Appearance

P.G. Kranz, S.S. Stinnett, K.T. Huang, and L. Gray

Table 1: Demographic data

	Control	SIH	*P* Value
Age (mean) (SD) (yr)	55.56 (13.85)	50.37 (13.27)	
Min/median/max	35/58/77	30/52/81	.186[a]
Sex			
Male (No.) (%)	12 (67)	5 (26)	
Female (No.) (%)	6 (33)	14 (74)	.014[b]

Note:—Min indicates minimum; max, maximum.
[a] *P* value based on the Wilcoxon rank sum test of the difference between medians.
[b] *P* value based on a χ^2 test of the difference in proportions.

Table 2: Prevalence of spinal meningeal diverticula by sex

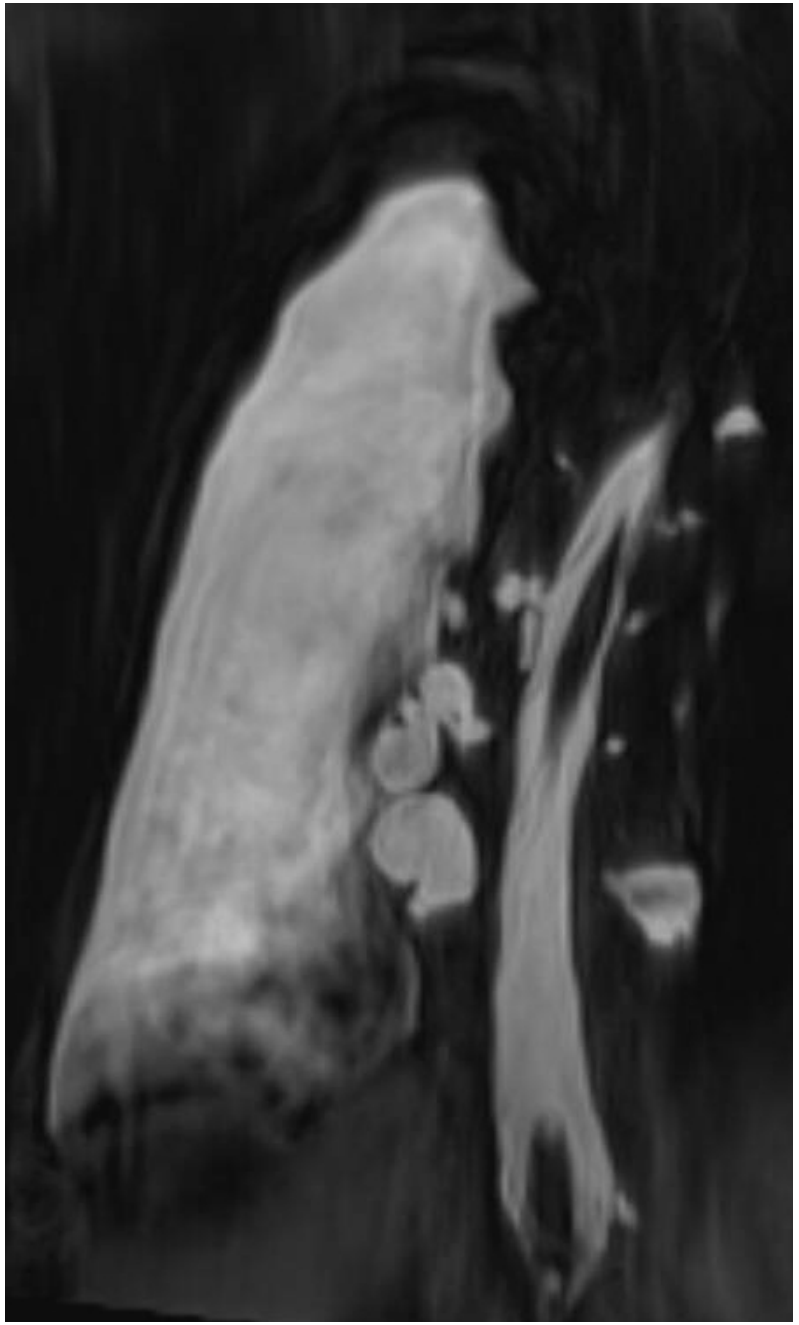
Diverticula per Patient	Male	Female	*P* Value[a]
Mean (SD)	1.6 (2.3)	6.5 (7.9)	.166
Min/median/max	0/1/7	0/1.5/23	

Note:—Min indicates minimum; max, maximum.
[a] *P* value based on the Wilcoxon rank sum test of the difference between medians.

Table 3: Prevalence of spinal meningeal diverticula and prominent nerve sheaths

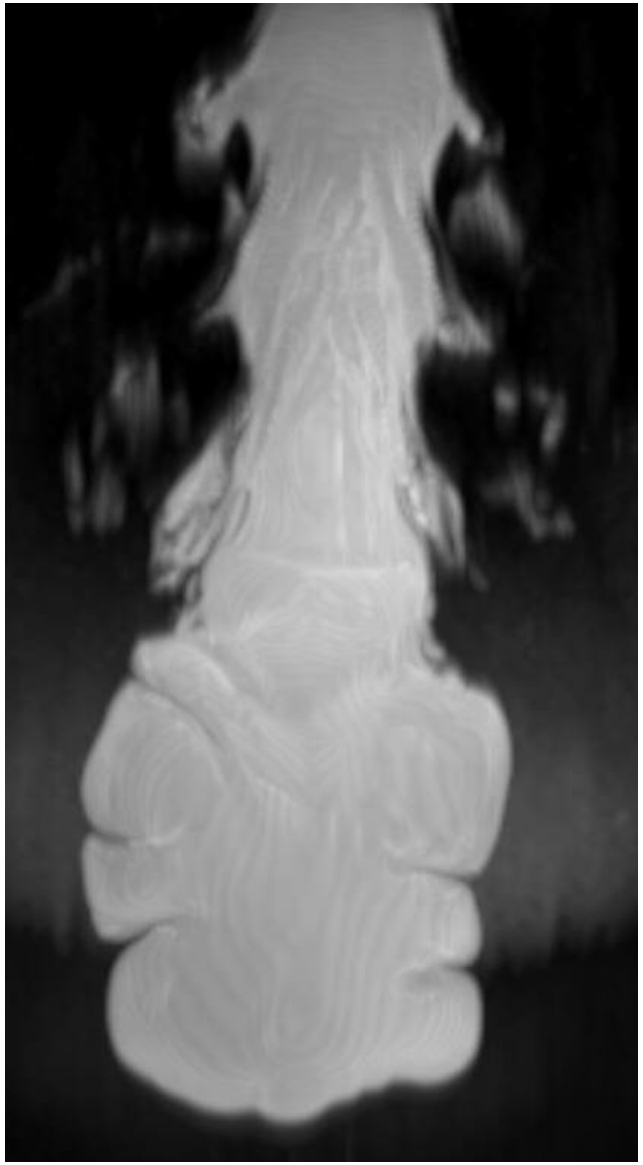
	Control	SIH	*P* Value
Patients with diverticula present (No.) (%)	8 (44)	13 (68)	.141[a]
Diverticula per patient (mean)	2.2 (3.3)	6.3 (8.0)	.099[b]
Min/median/max	0/0/10	0/2/23	
Patients with prominent nerve sheaths present (No.) (%)	14 (78)	17 (89)	.405[c]
Prominent nerve sheaths per patient (mean)	2.6 (3.1)	6.1 (4.2)	.004[c]
Min/median/max	0/1.5/13	0/5/15	

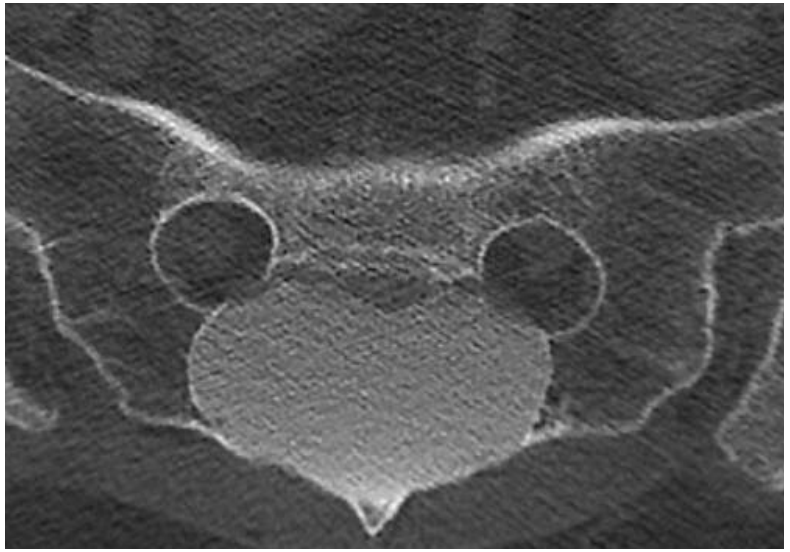
Note:—Min indicates minimum; max, maximum.
[a] *P* value based on a χ^2 test of the difference between proportions.
[b] *P* value based on the Wilcoxon rank sum test of the difference between medians.
[c] *P* value based on the Fisher exact test of the difference between proportions.

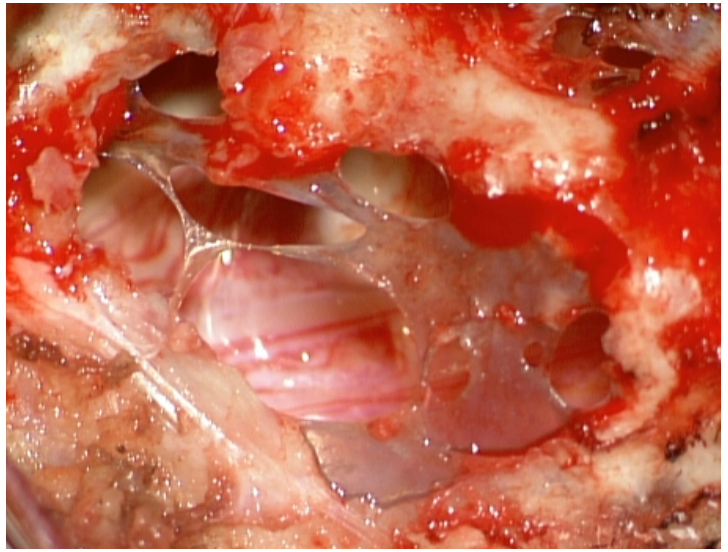


Meningeal diverticula with extradural CSF

CSF hydrothorax

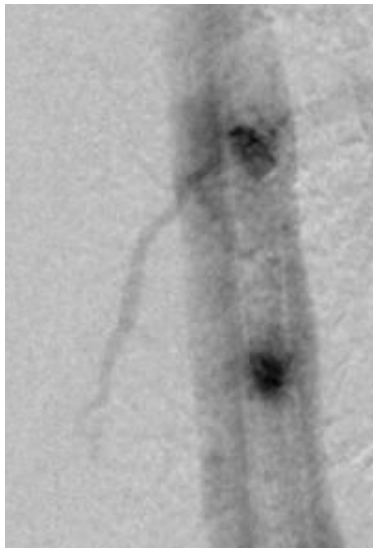


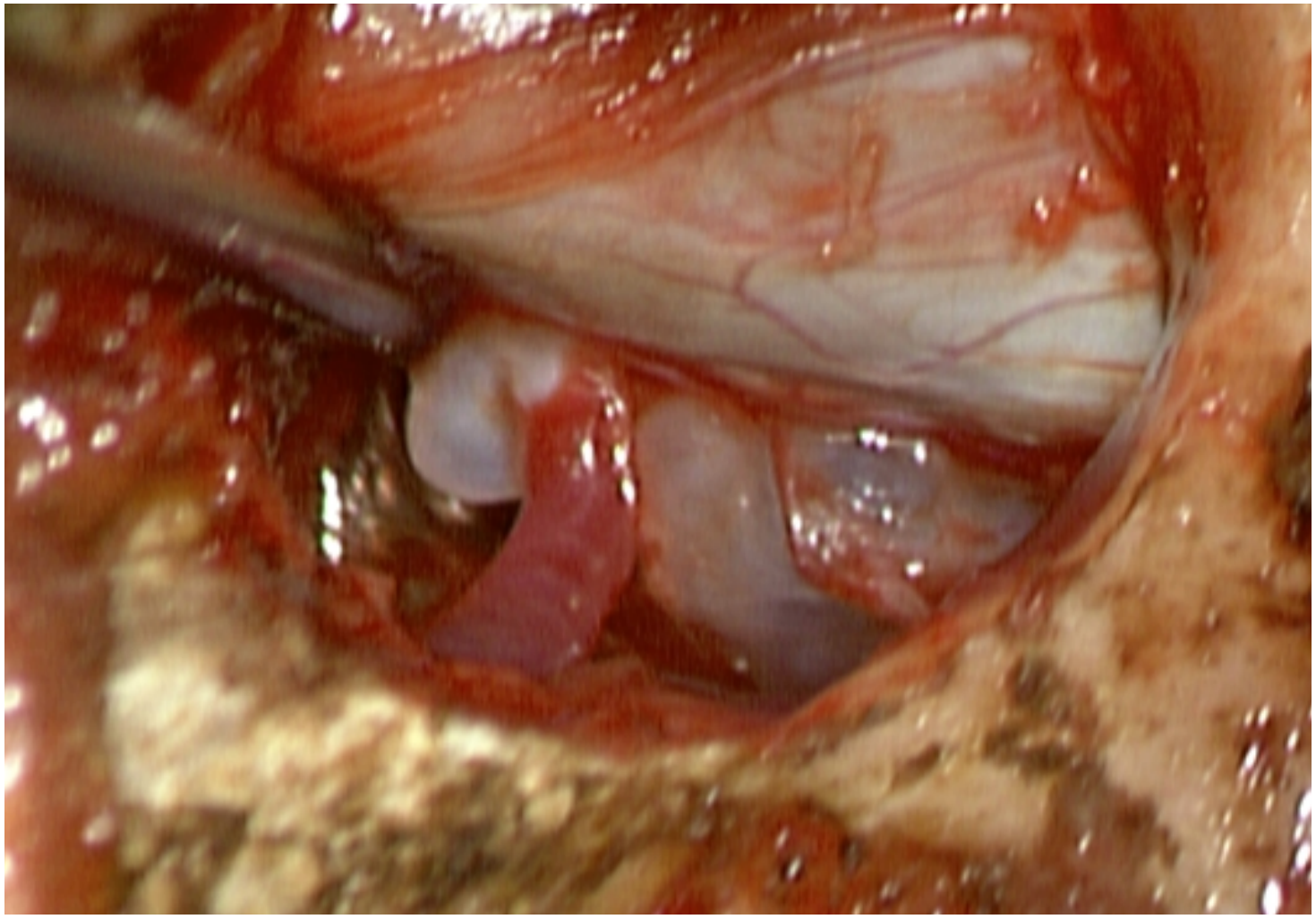




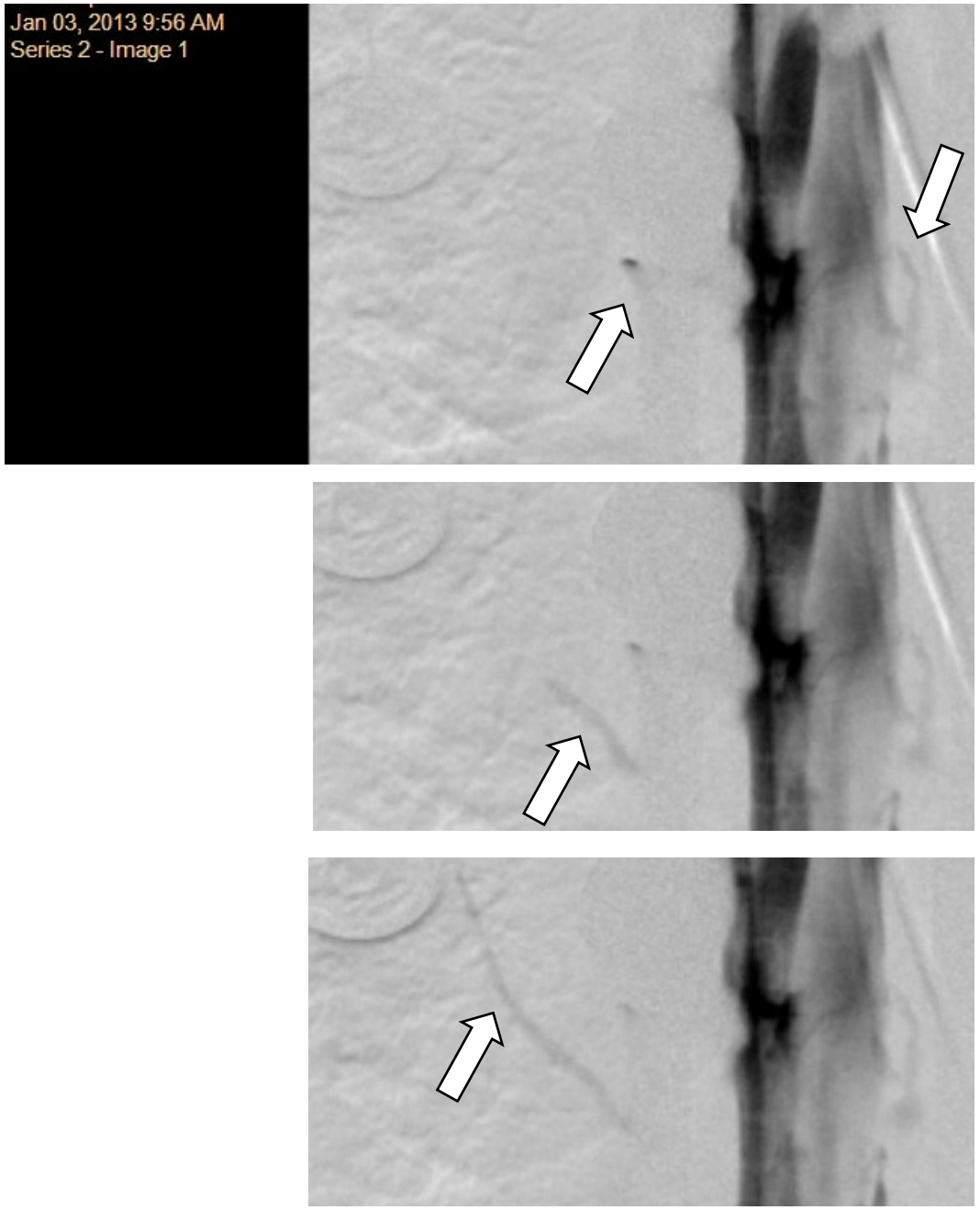
Type 2b – complex meningeal diverticula/dural ectasia

Although surgery for simple cysts is simple, surgery for complex cysts/dural ectasia is not





Type 3 – CSF-venous fistula



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.

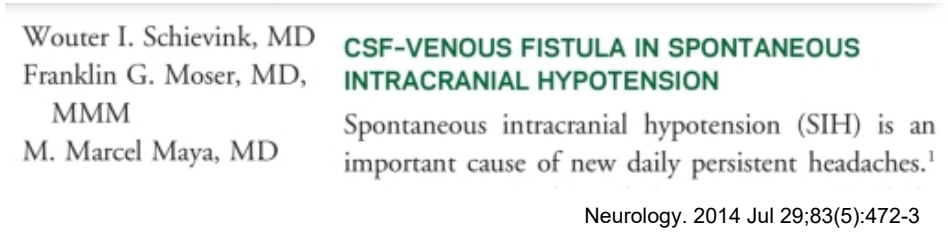
Case 2. A 31-year-old woman noted an orthostatic headache, ringing in the ears, and neck stiffness. Neurologic examination was normal. MRI showed pachymeningeal enhancement, brain sagging, and pituitary enlargement. CT and MR myelography showed an extensive spinal ventral extradural CSF collection. CSF 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

Type 3 – CSF-venous fistula



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CSF-VENOUS FISTULA IN SPONTANEOUS INTRACRANIAL HYPOTENSION

Spontaneous intracranial hypotension (SIH) is an important cause of new daily persistent headaches.[1]

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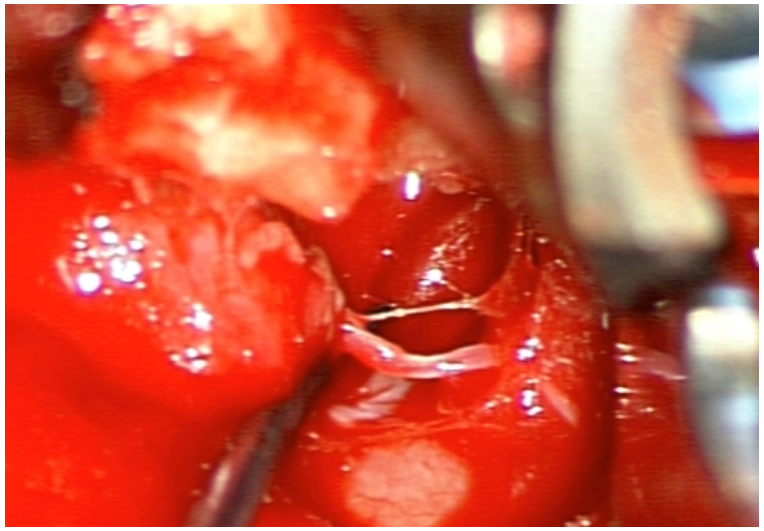
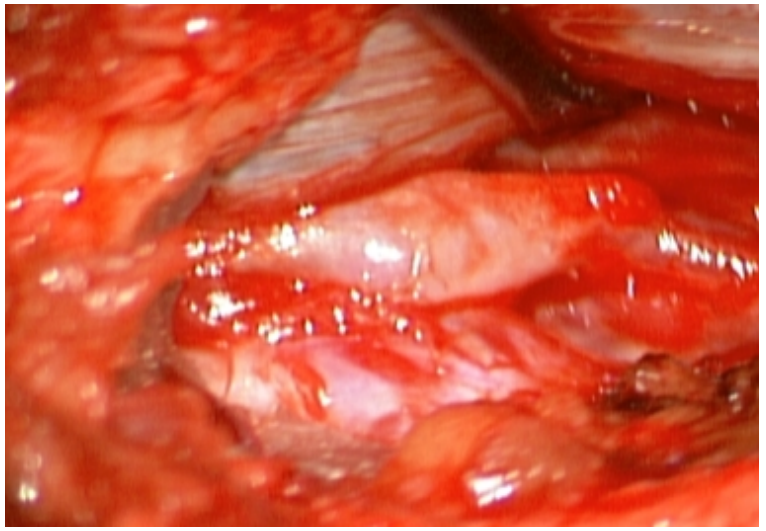
- Ruptured arachnoid granulation
- Associated with meningeal diverticula or arise from common thecal sac (different types)
- Associated with venous or veno-lymphatic vascular malformations
- Any spinal level but >90% thoracic

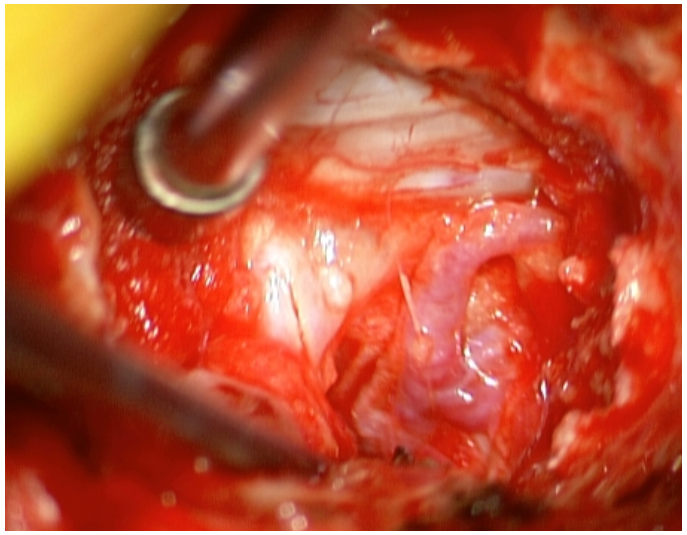
- How common?

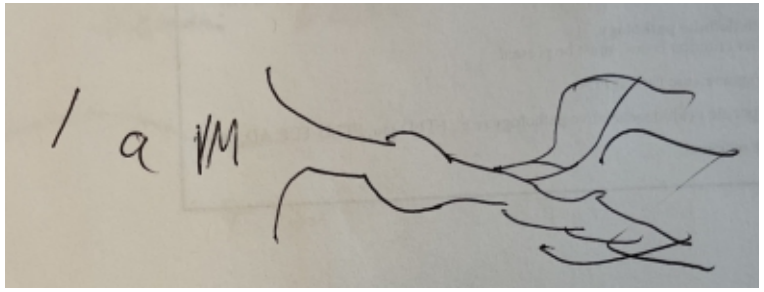
Yield of DSM in identifying CSF-venous fistulas – in patients without extradural CSF on spine imaging

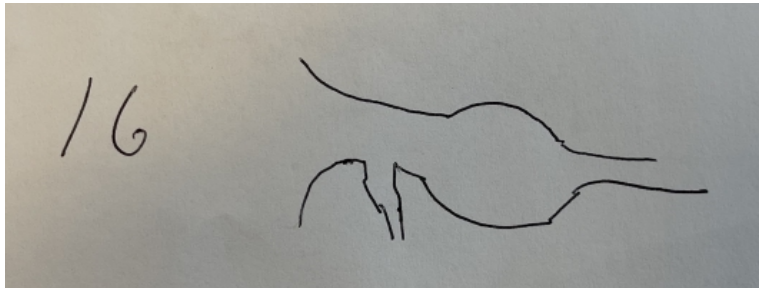
- Positive brain MRI: 75% (J Neurosurg Spine, 2019)
- Negative brain MRI: 10% (Headache, 2021)
- Brain sagging/bvFTD: 40% (Alzheimer & Dementia, 2023)

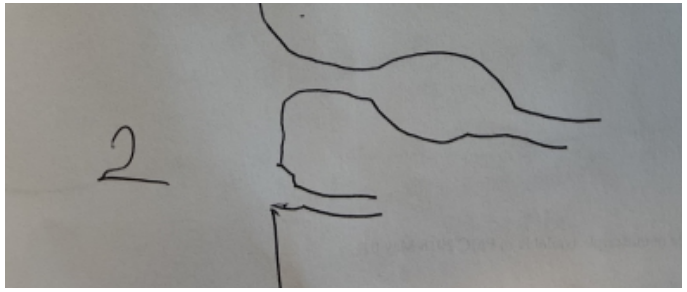










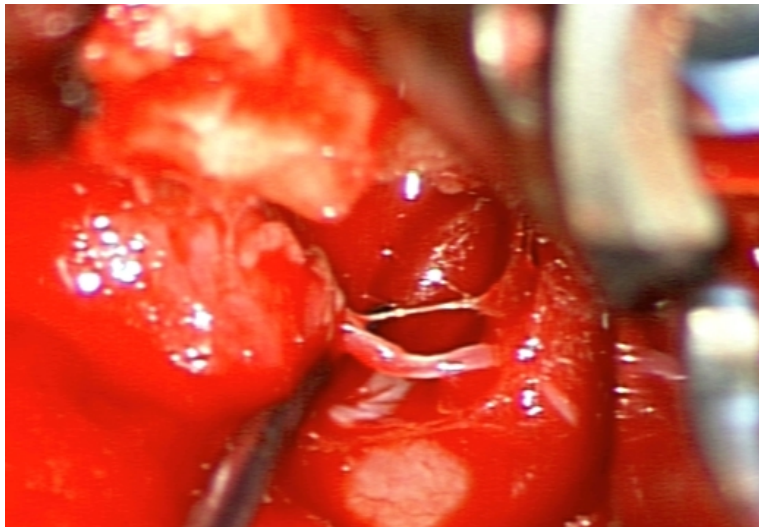


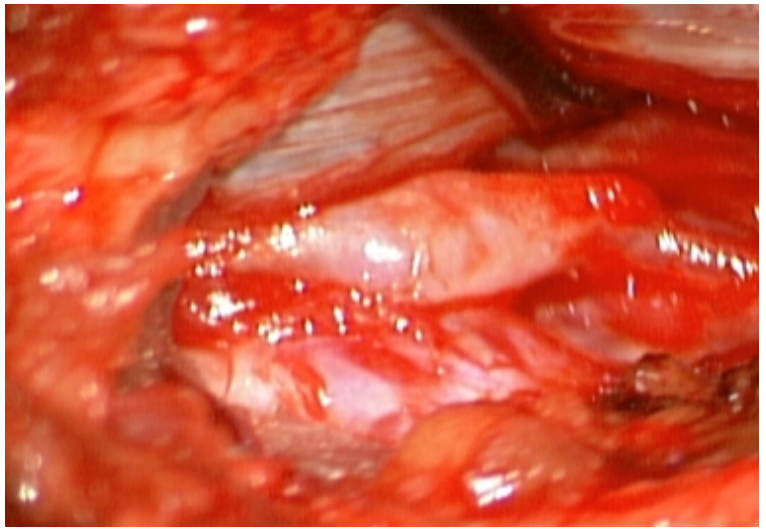
Type 1a - 75%
Nerve root sleeve - distal

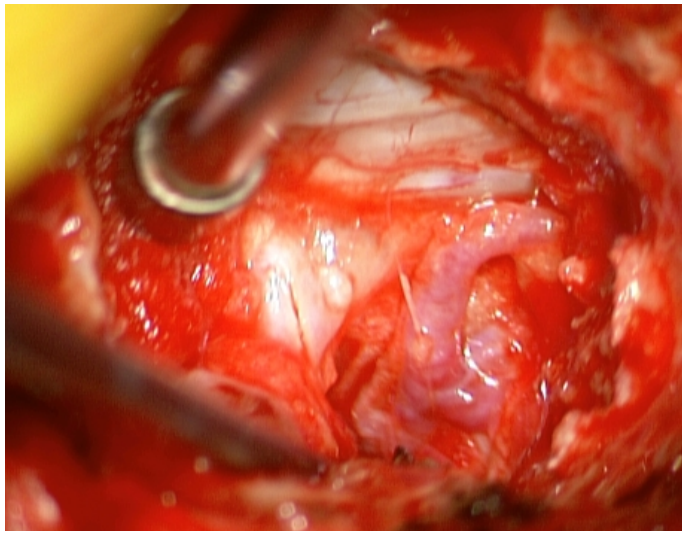
Type 1 b - 15%
Nerve root sleeve - proximal

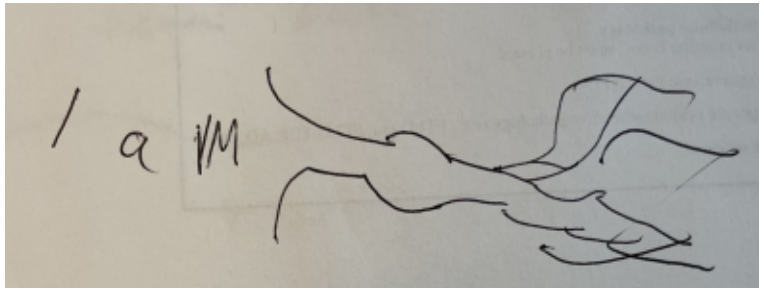
Type 2 - 10%
Common thecal sac

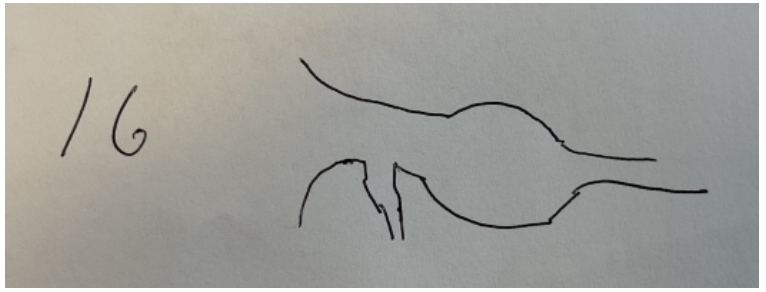
VM+ or VM-

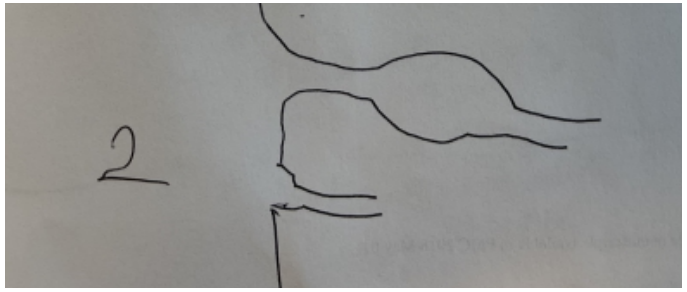












Type 1a - 75%
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Type 1 b - 15%
Nerve root sleeve - proximal

Type 2 - 10%
Common thecal sac

VM+ or VM-

Spontaneous spinal CSF–venous fistulas associated with venous/venolymphatic vascular malformations: report of 3 cases

Wouter I. Schievink, MD,[1] Marcel M. Maya, MD,[2] Franklin G. Moser, MD, MMM,[2] Alexander Tuchman, MD,[1] Rachelle B. Cruz, MSN, APRN, NP-C,[1] Richard I. Farb, MD,[3] Ryan Rebello, MD,[4] Kesava Reddy, MD, MBBS, FRCSC,[5] and Ravi S. Prasad, MD[2]

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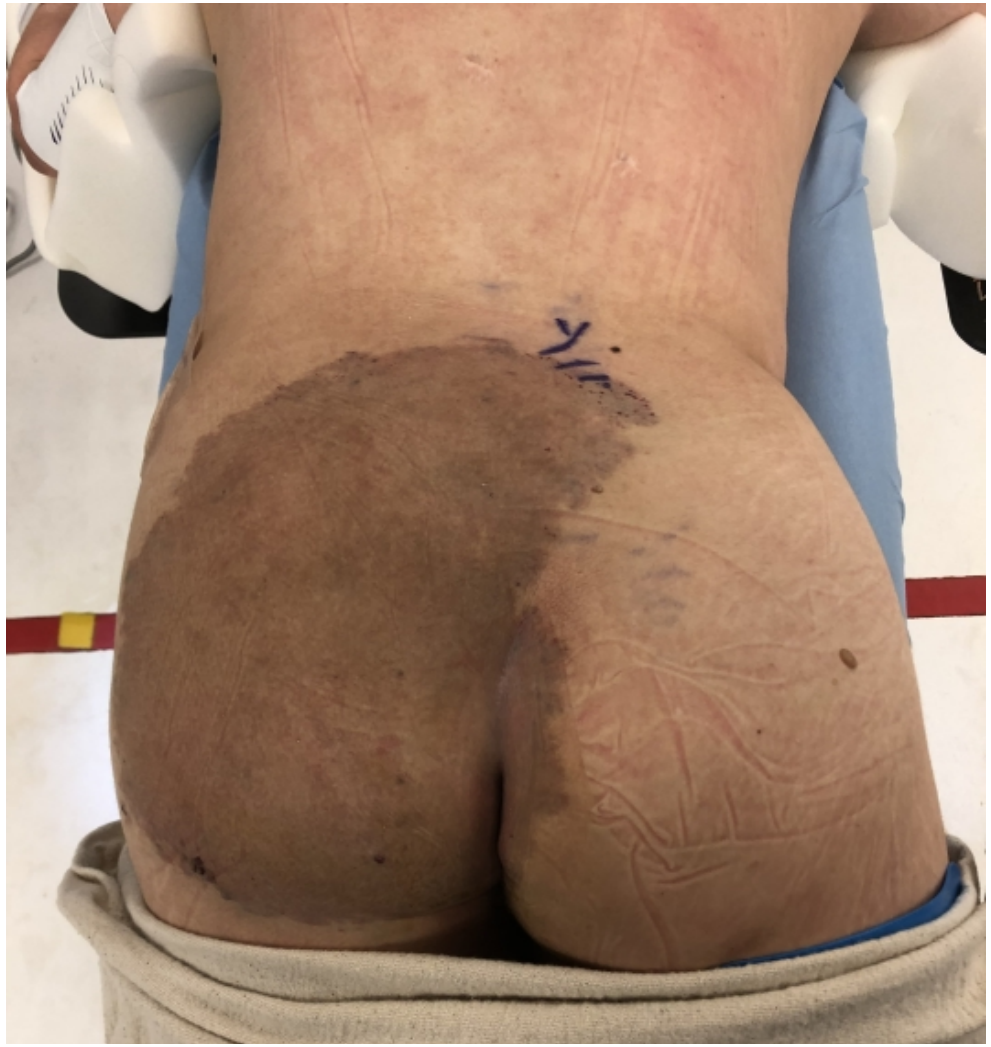
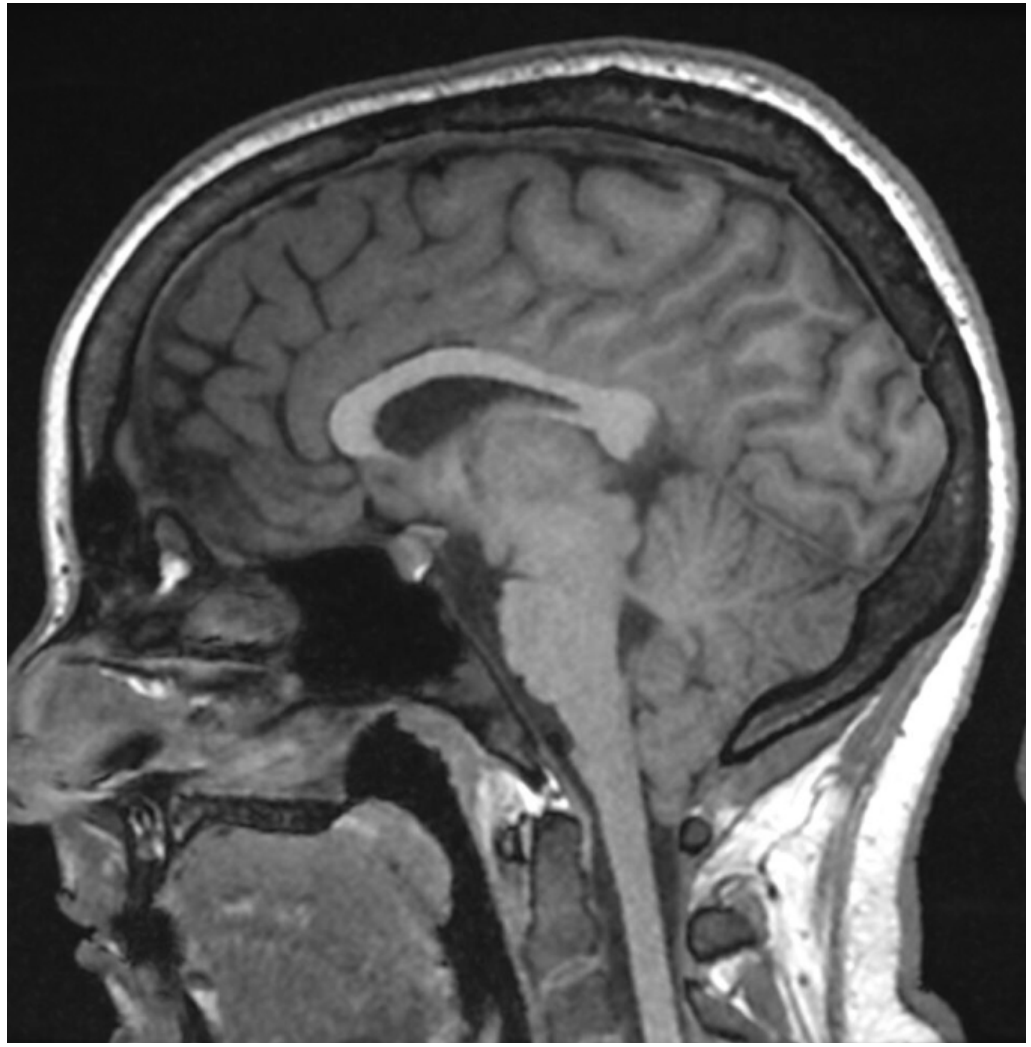
Spontaneous CSF–venous fistulas may be present in up to one-fourth of patients with spontaneous intracranial hypotension. This is a recently discovered type of CSF leak, and much remains unknown about these fistulas. Spinal CSF–venous fistulas are usually seen in coexistence with a spinal meningeal diverticulum, suggesting the presence of an underlying structural dural weakness at the proximal portion of the fistula. The authors now report the presence of soft-tissue venous/venolymphatic malformations associated with spontaneous spinal CSF–venous fistulas in 2 patients with spontaneous intracranial hypotension, suggesting a role for distal venous pathology. In a third patient with spontaneous intracranial hypotension and a venolymphatic malformation, such a CSF–venous fistula is strongly suspected.

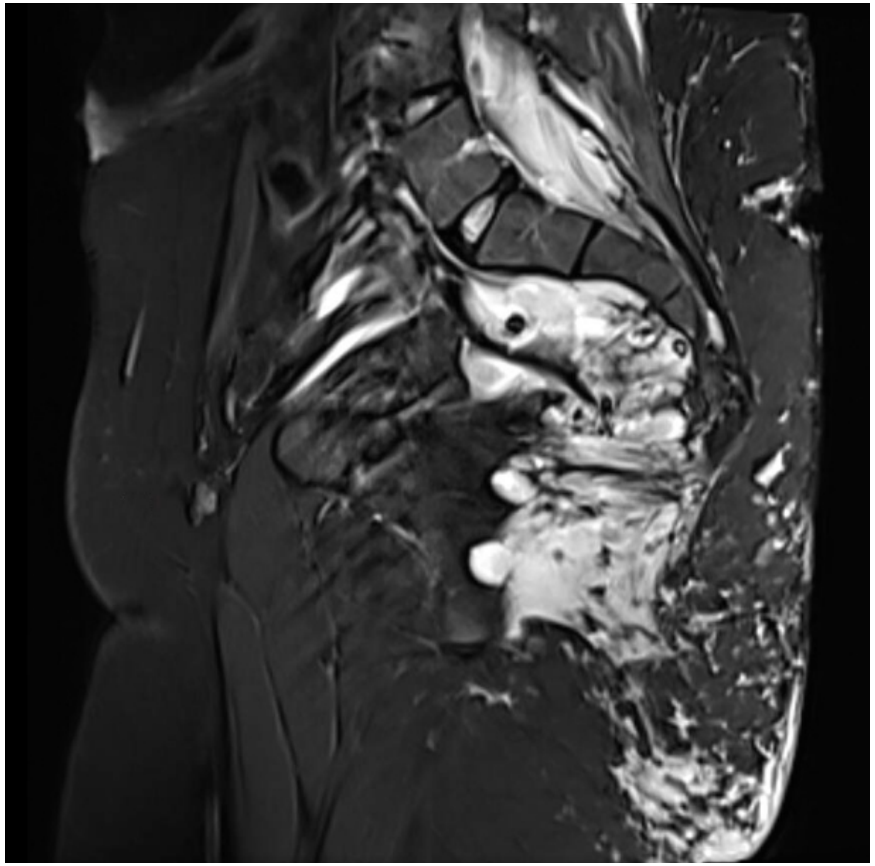
https://thejns.org/doi/abs/10.3171/2019.8.SPINE19716

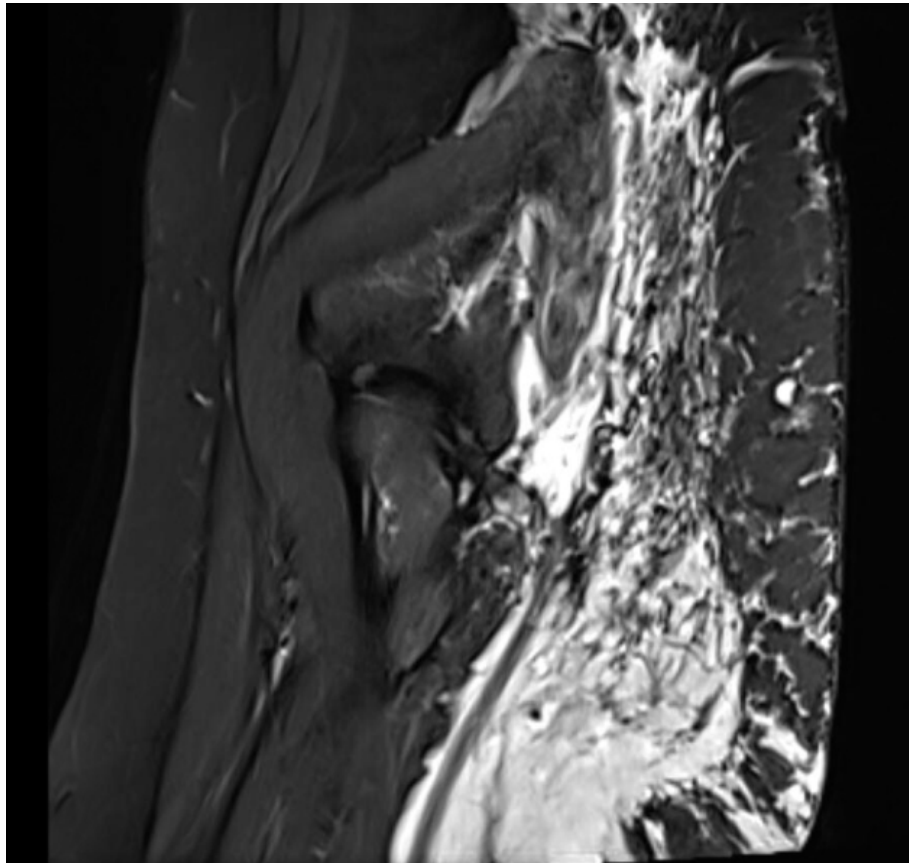
KEYWORDS CSF–venous fistulas; venous vascular malformations; intracranial hypotension; vascular disorders; congenital

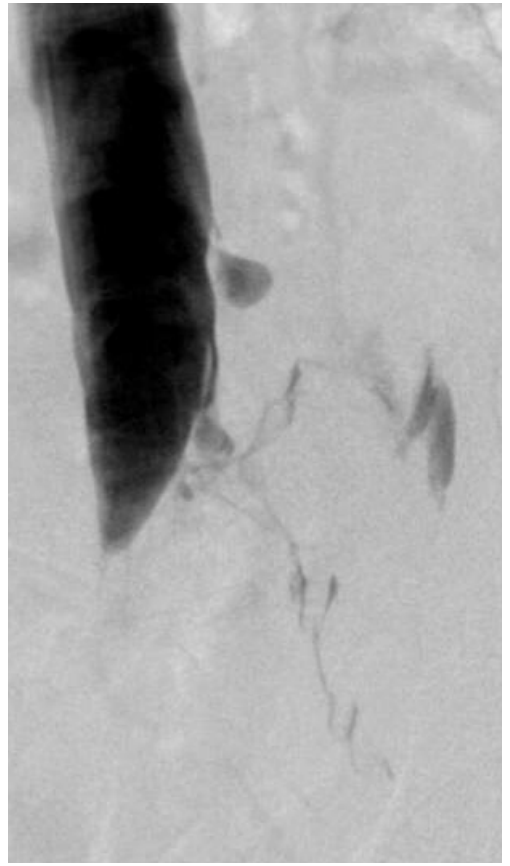


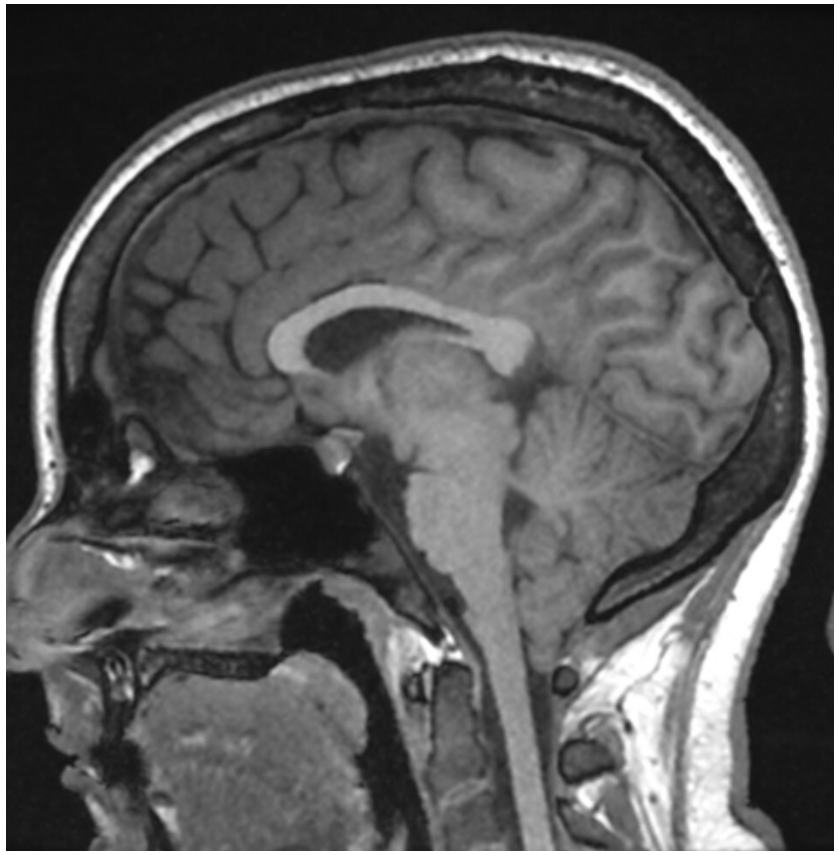


MV: 17-year-old girl with one month history of progressive orthostatic headaches







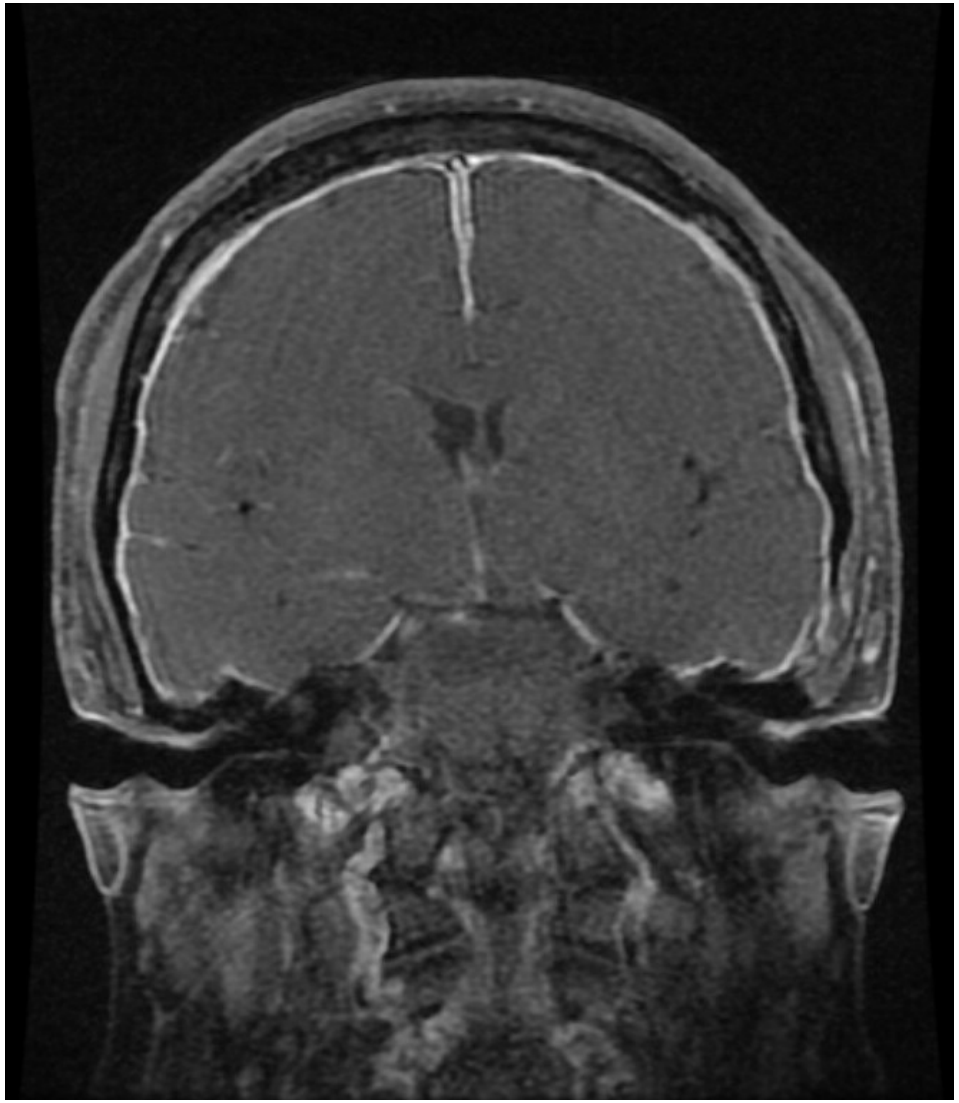


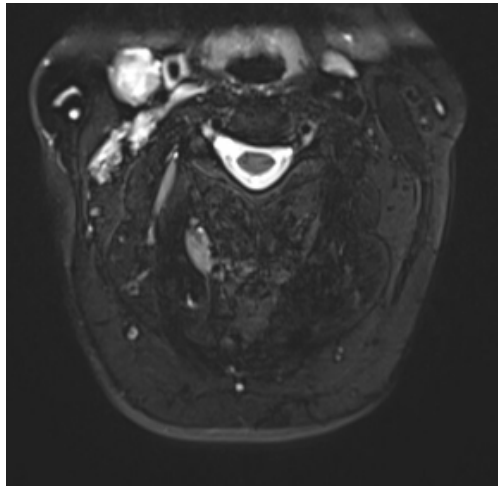
pre-procedure

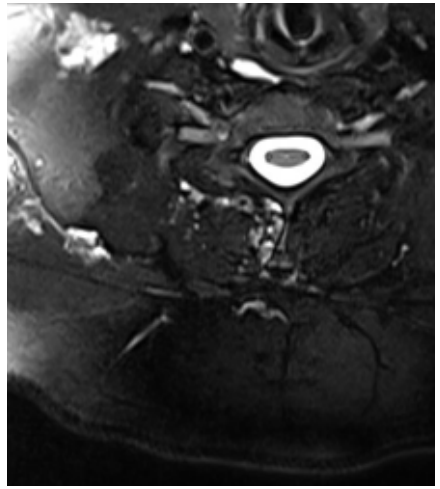
post-procedure

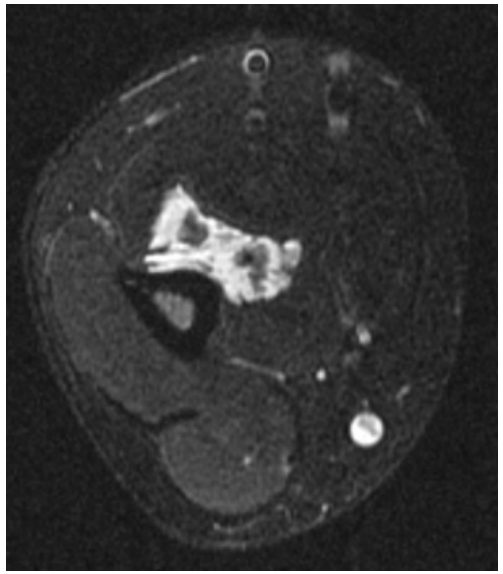


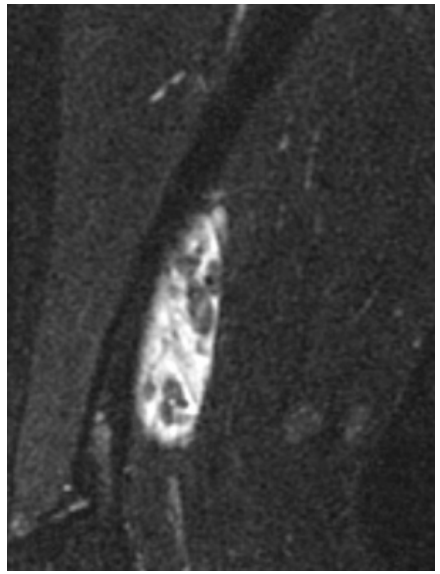
AT: 54-year-old man with 13-year history of orthostatic headaches

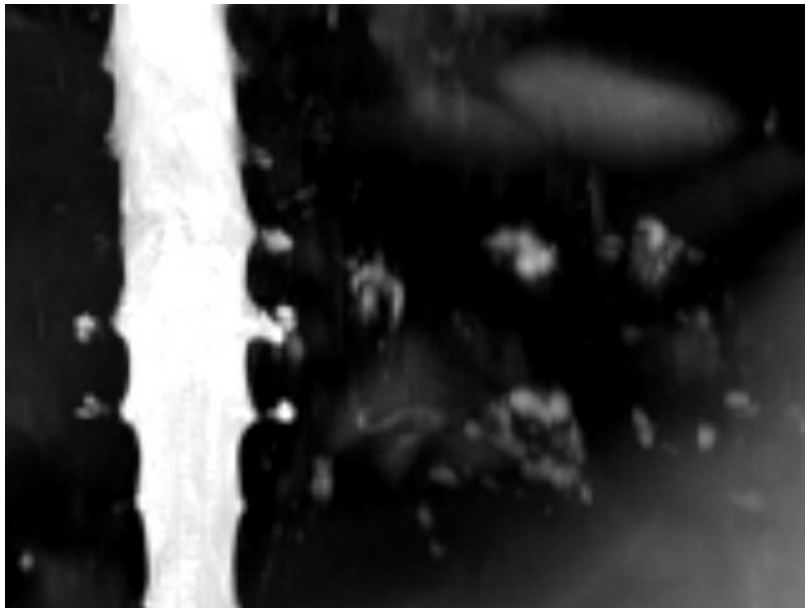


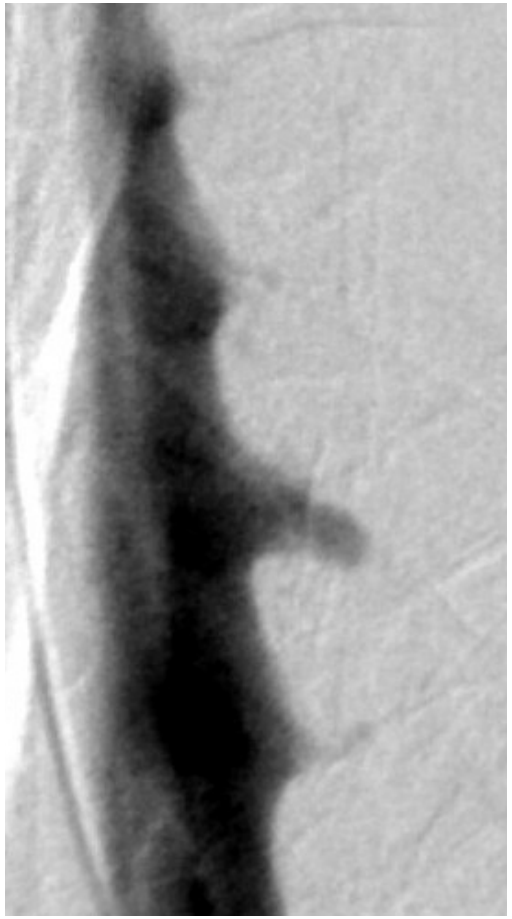


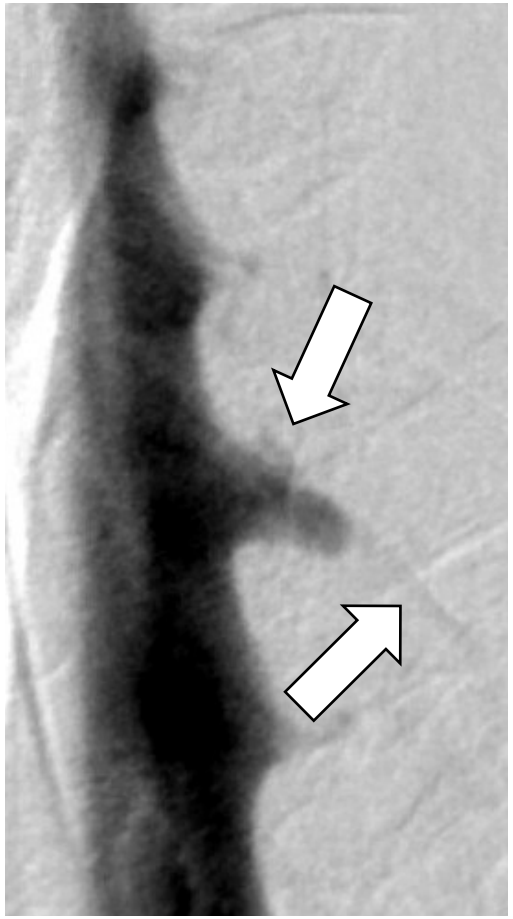


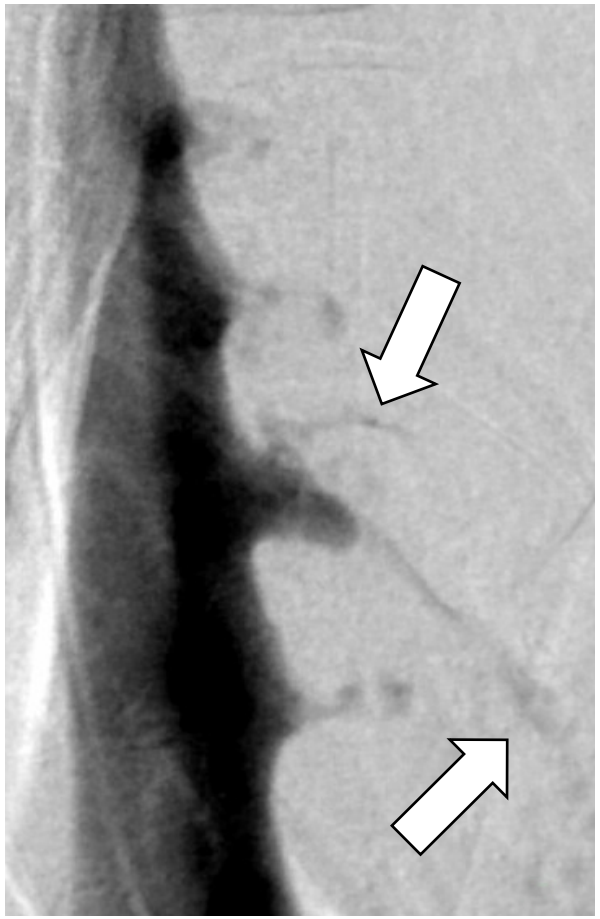


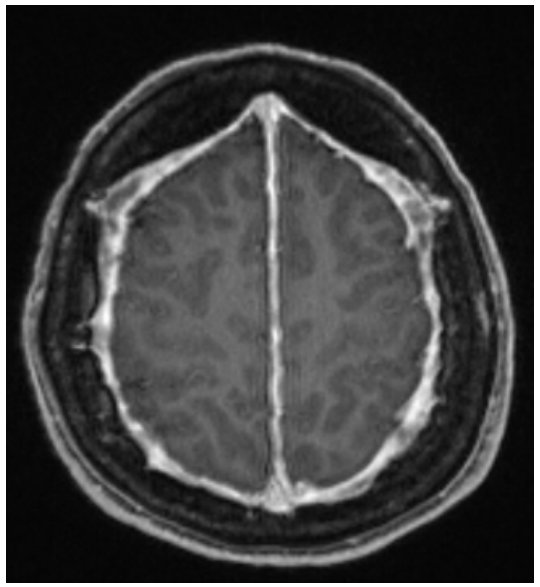


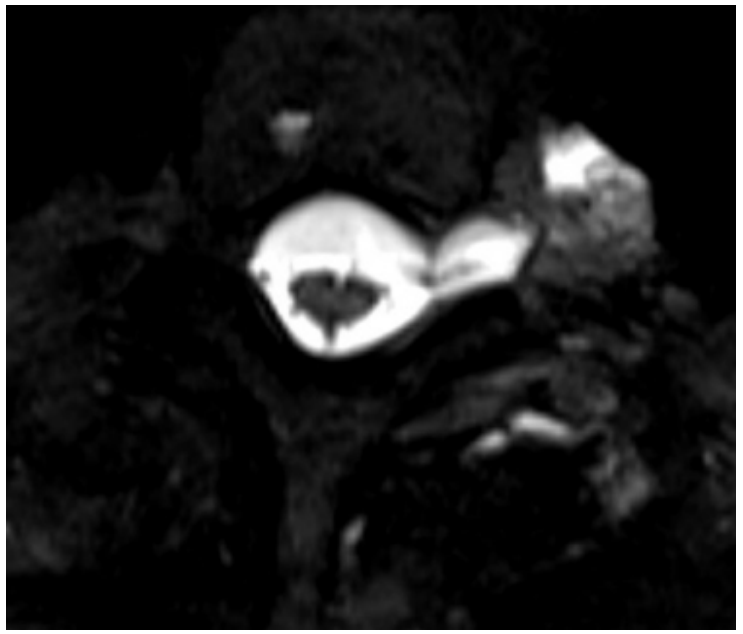


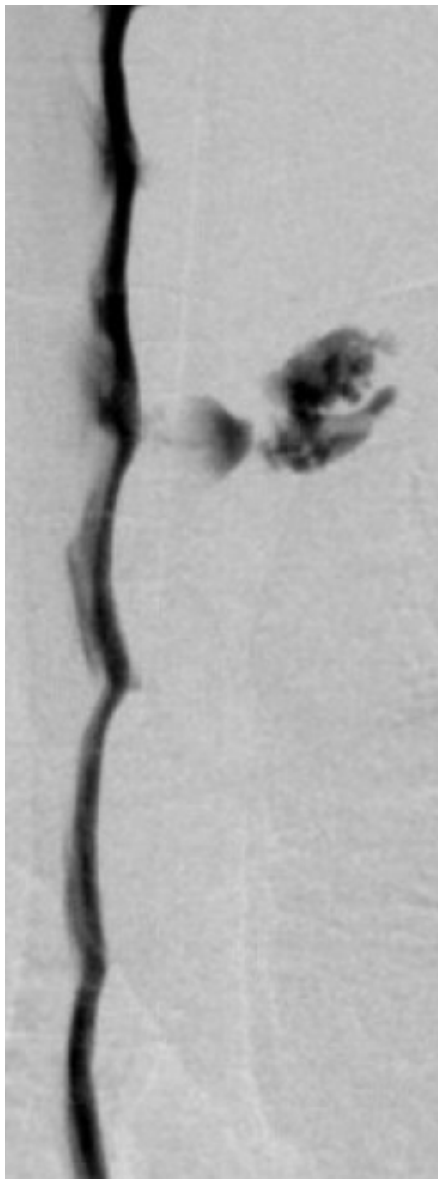


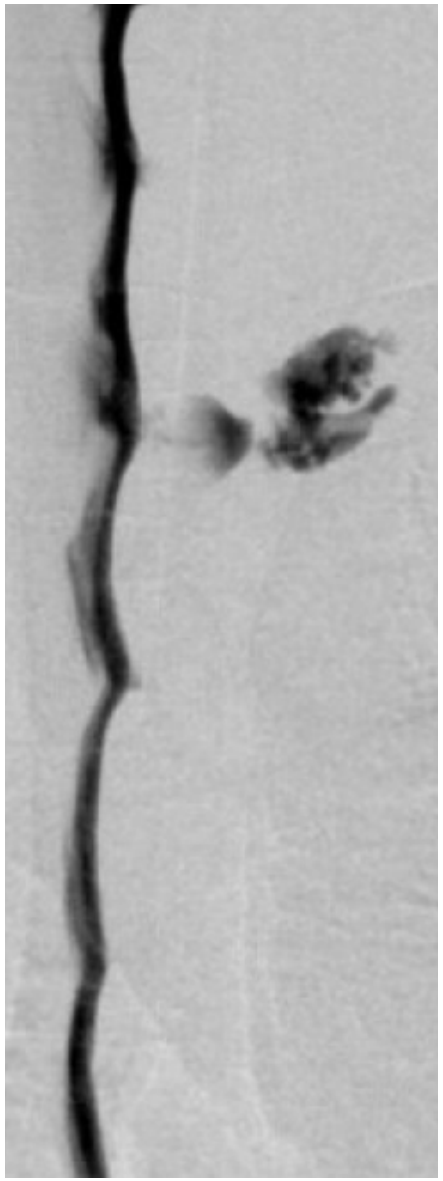




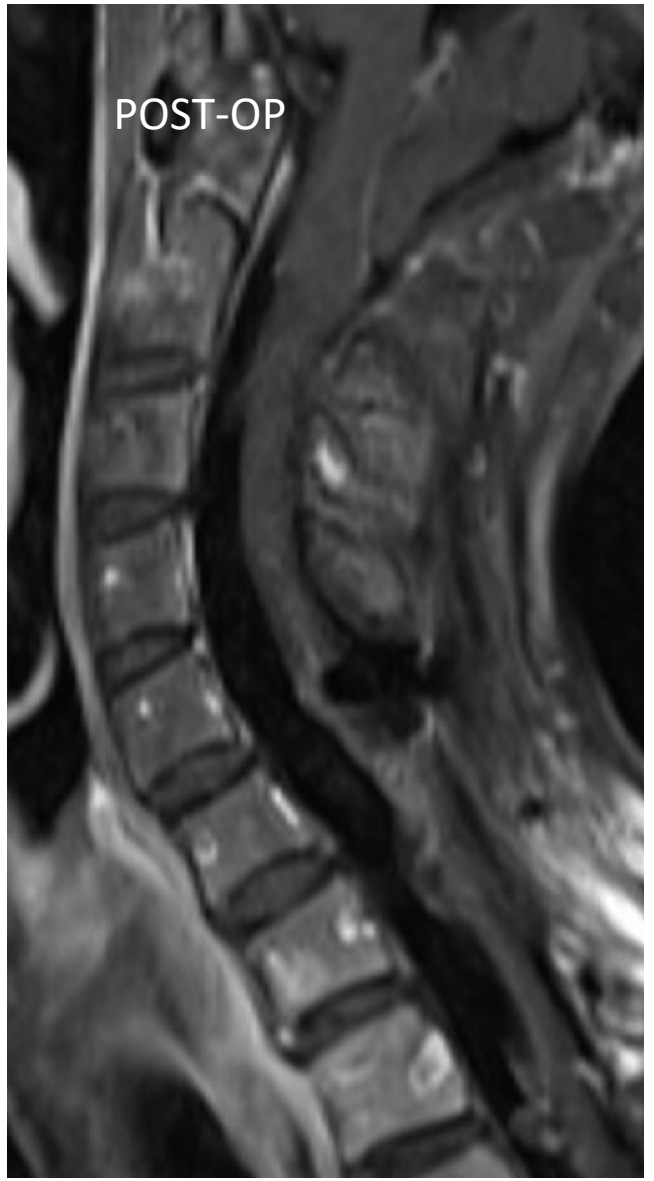









PRE-OP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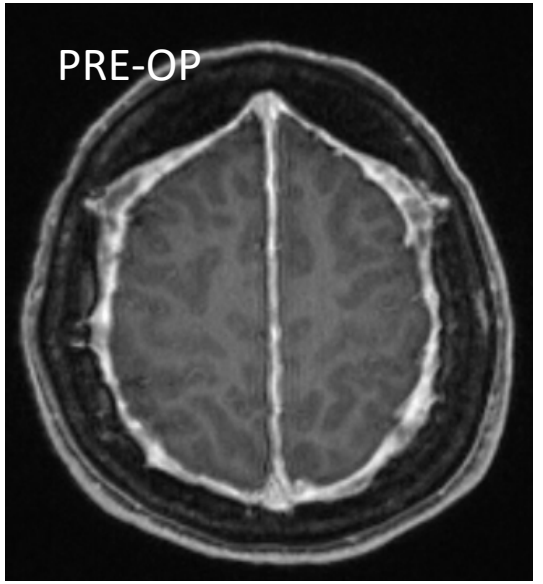
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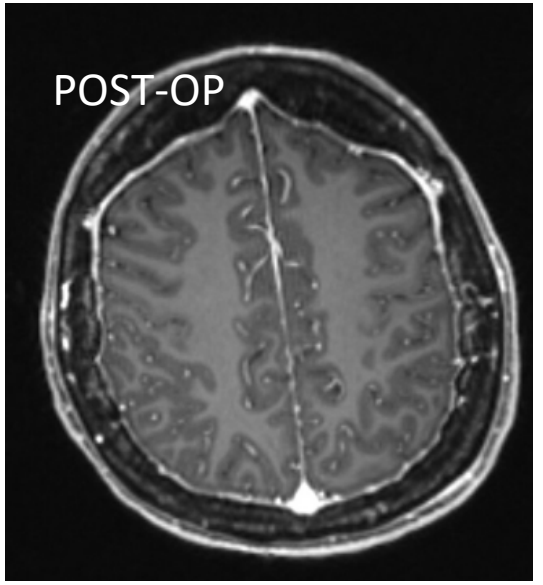
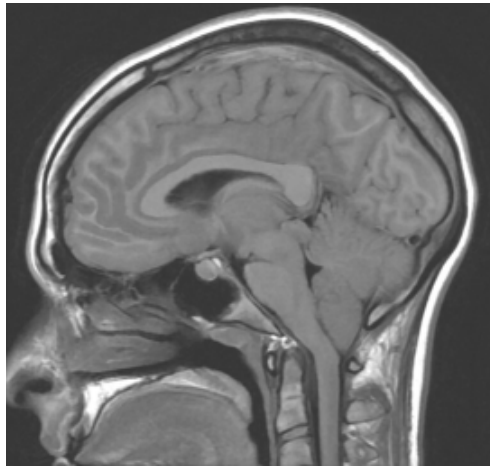
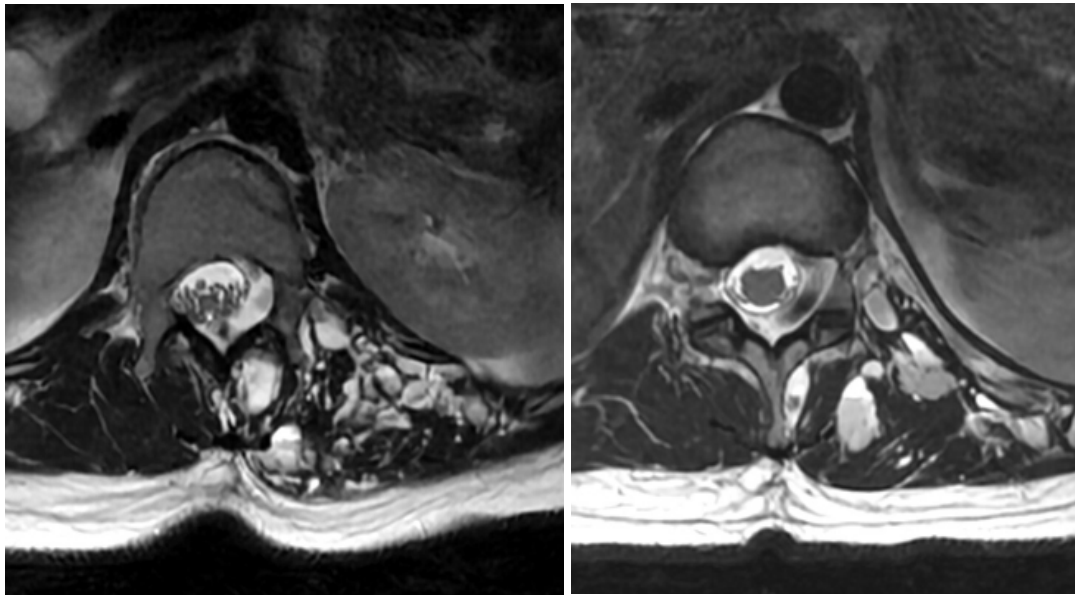
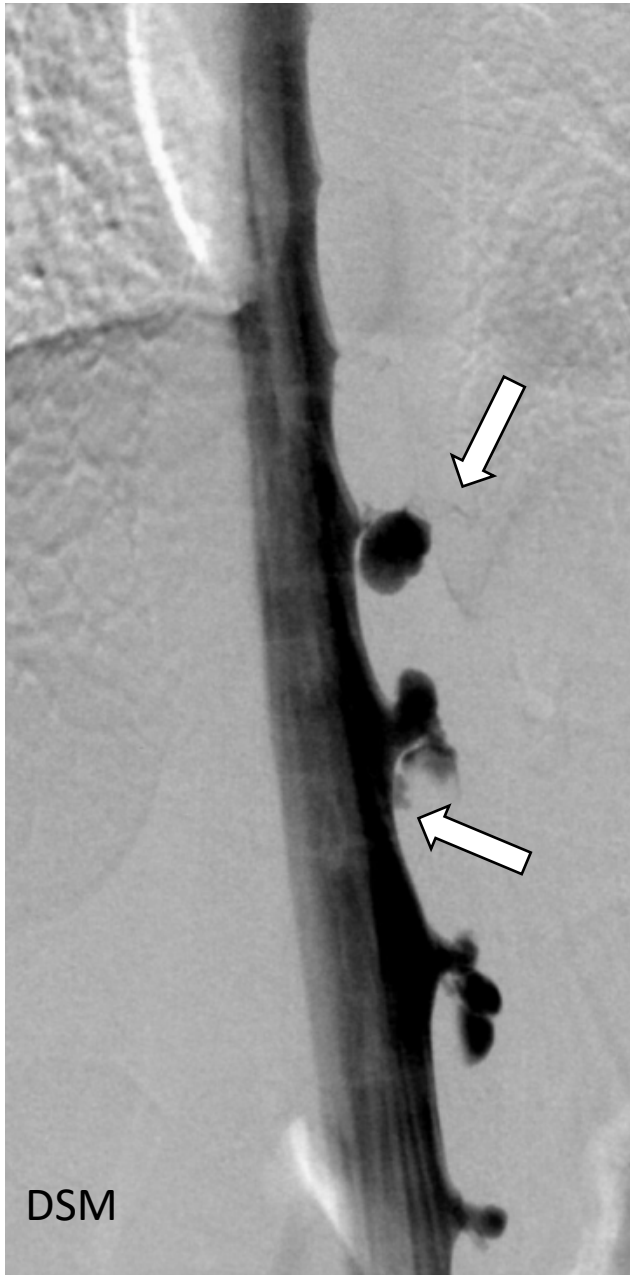

POST-OP



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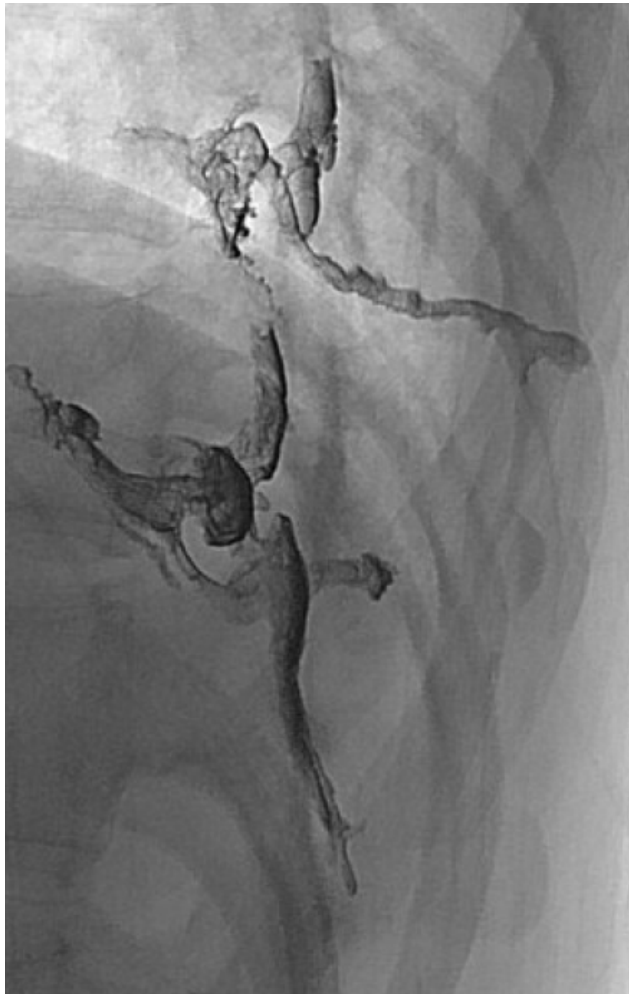


CSF-venous fistulas – 3 or 4 options for treatment

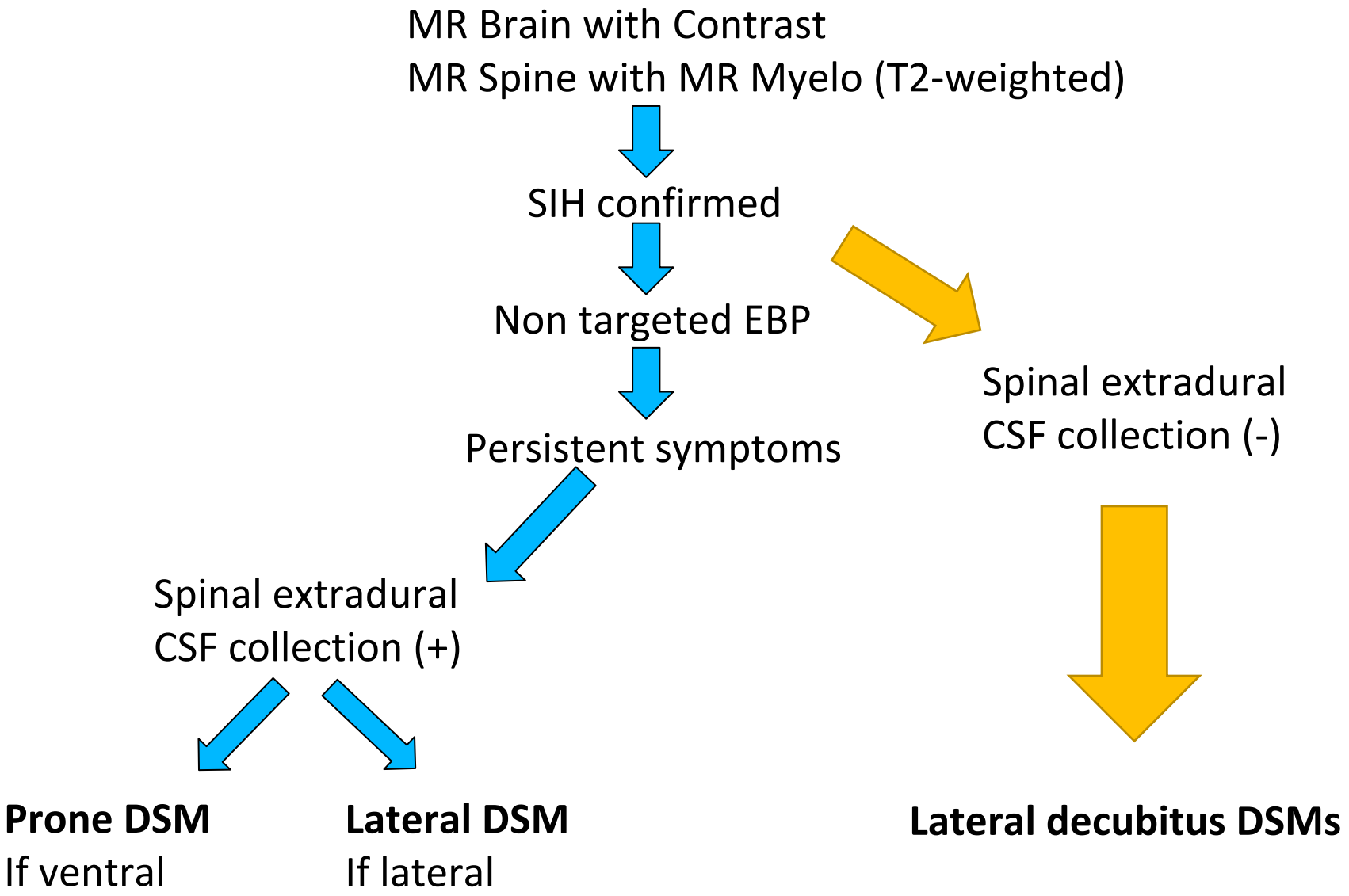
Epidural blood patching less effective?

1Percutaneous fibrin glue injection

2Endovascular Onyx embolization

3Surgical ligation

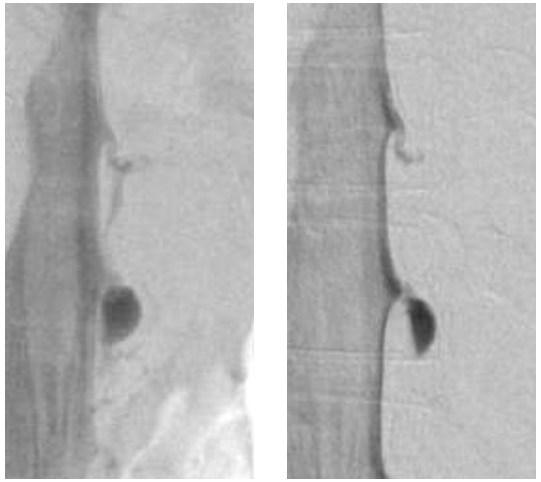
Cedars-Sinai approach to suspected SIH



Pros and cons of CSF-venous fistula treatments

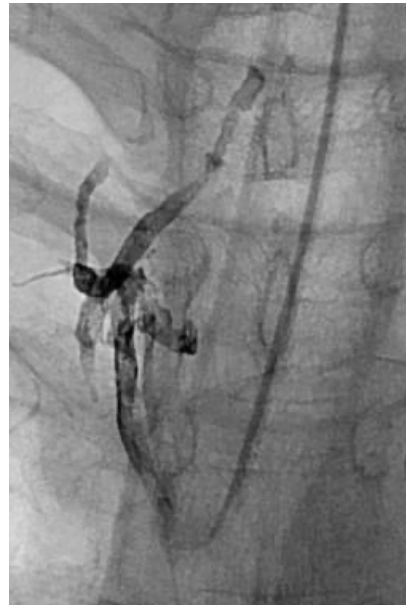
1 Percutaneous fibrin glue injection (outpatient)

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



FGI

Endo onyx

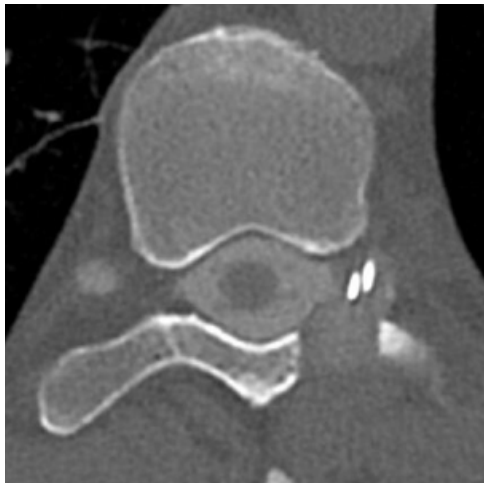


2 Endovascular Onyx embolization (outpatient)

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

3 Surgical ligation (inpatient)

- Since 2013
- General anesthesia
- >99% cure rate

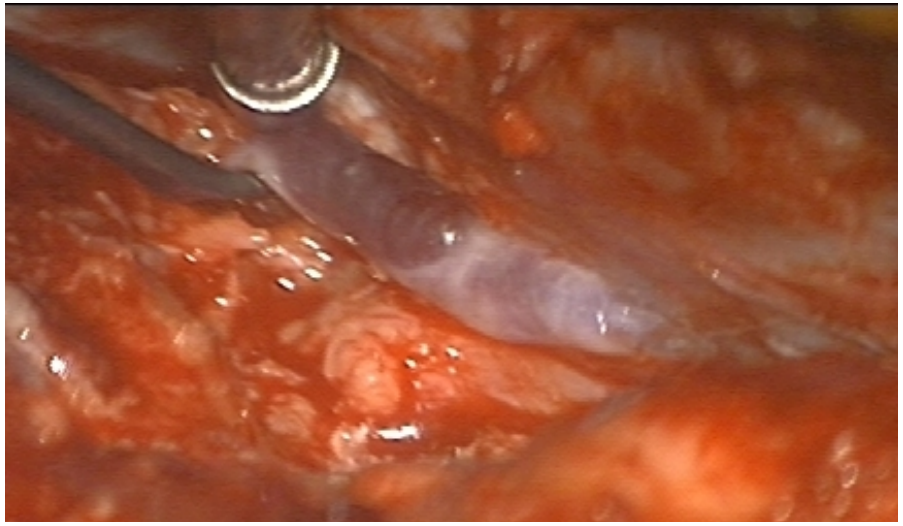


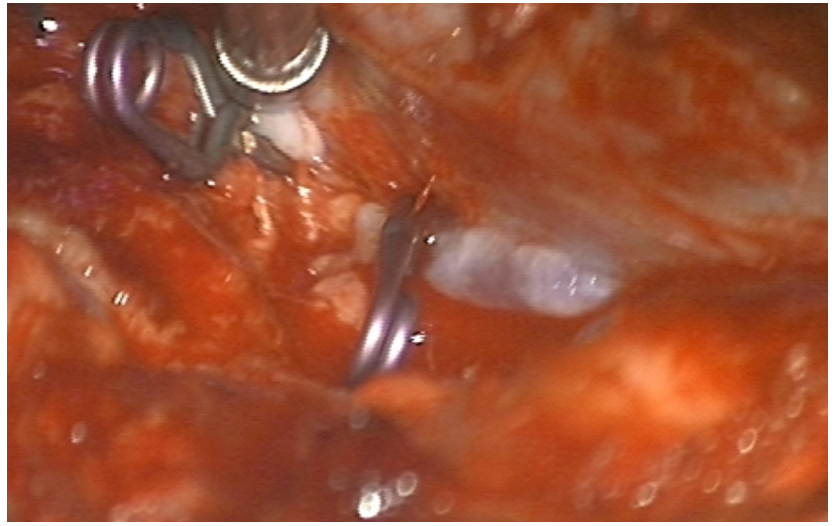
hemoclips

aneurysm clips

Type 3 CSF leak - CSF-venous fistulas
Surgical options

Option A: Clip/cauterize fistulous connection





Option B: Clip non-eloquent/functional nerve root if A not possible

Preferred treatment for spinal CSF-venous fistula

- **Patient preference**

Individualized treatment

- Spinal level “functional” nerve root
- Subtyping of CSF-venous fistula
- Associated vascular malformation

Preferred treatment for spinal CSF-venous fistula

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[redacted] has reported the first case series of transvenous embolization of paraspinal veins to treat cerebral spinal fluid (CSF)-venous fistulas. The innovative therapy resulted in clinical and radiographic improvement and no permanent complications in all participants in the small case series.

"It's a significant advance in the treatment of CSF-venous fistulas," says [redacted], a neurointerventionalist at [redacted] Rochester, [redacted]. We are able to fix these fistulas and send patients home the same day, without worrying about the complications that can occur with spinal surgery."

CSF-venous fistulas, first described in 2014, are increasingly recognized as a cause of spontaneous intracranial hypotension. "We are finding that, in at least a quarter of people with a CSF leak, it's due to a fistula. That is a major subgroup, and we expect it to grow as our diagnostic techniques advance," says [redacted], a neurologist who leads the CSF dynamics clinic at [redacted] campus in [redacted].

The most effective treatment for a CSF-venous fistula has been surgical intervention that includes laminectomy, facetectomy and ligation of the nerve root and associated veins. Although the procedure can ease the severe headaches associated with intracranial hypotension, it requires a hospital stay and lengthy recovery. Existing minimally invasive treatment options, such as epidural blood patch and fibrin glue injection, have been effective in only a tiny minority of patients with fistulas.

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Preferred treatment for spinal CSF-venous fistula

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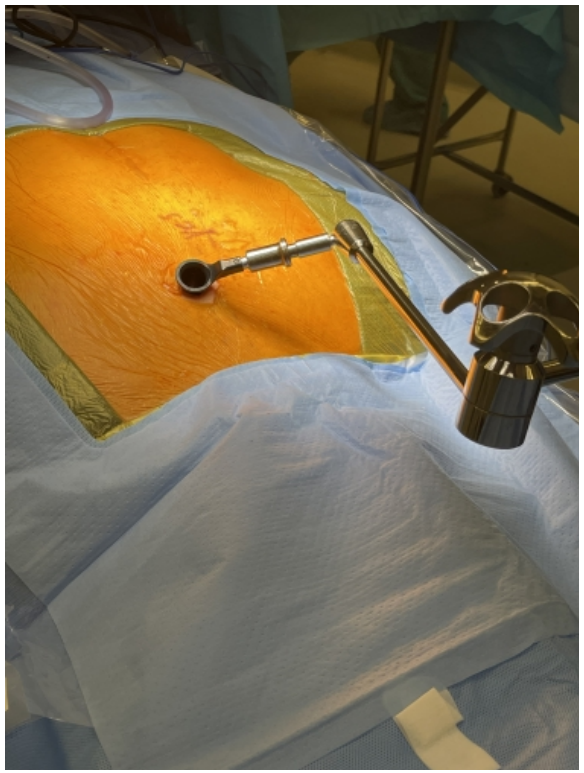

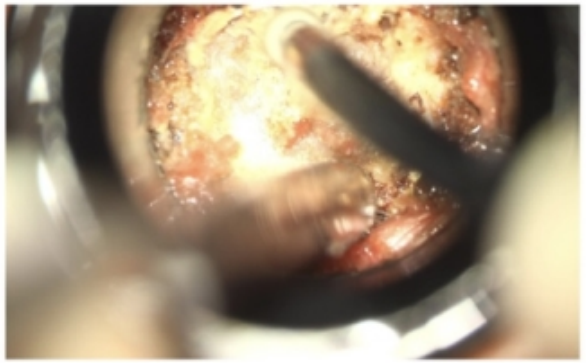

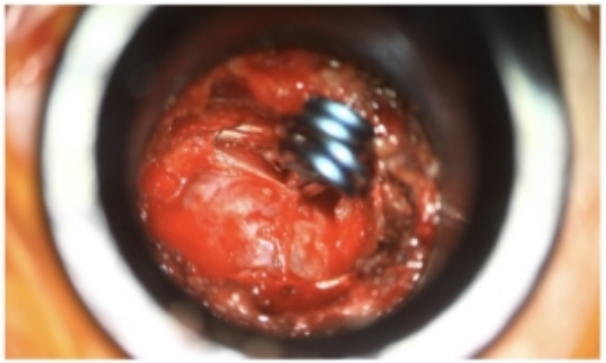

13 mm

Preferred treatment for spinal CSF-venous fistula

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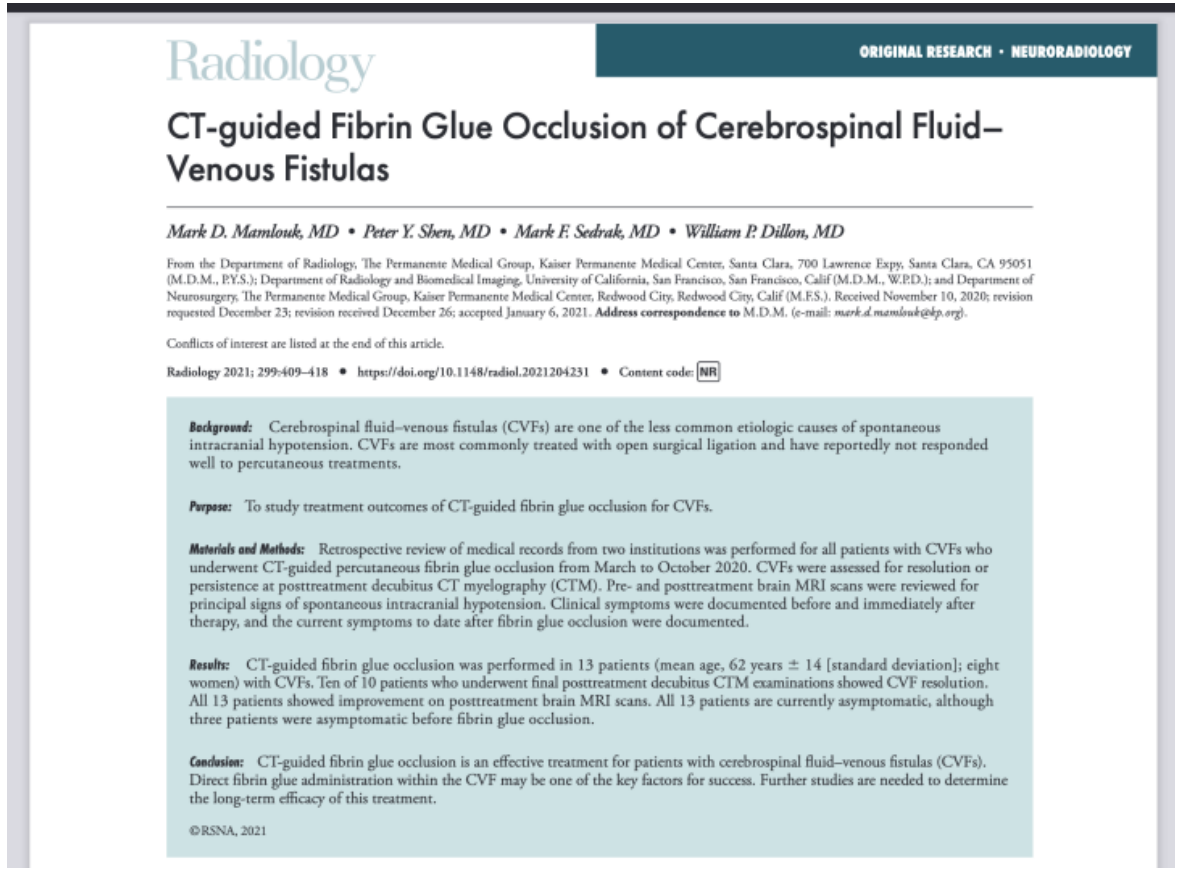

Radiology

ORIGINAL RESEARCH • NEURORADIOLOGY

CT-guided Fibrin Glue Occlusion of Cerebrospinal Fluid–Venous Fistulas

Mark D. Mamlouk, MD • Peter Y. Shen, MD • Mark F. Sedrak, MD • William P. Dillon, MD

From the Department of Radiology, The Permanente Medical Group, Kaiser Permanente Medical Center, Santa Clara, 700 Lawrence Expy, Santa Clara, CA 95051 (M.D.M., P.Y.S.); Department of Radiology and Biomedical Imaging, University of California, San Francisco, San Francisco, Calif (M.D.M., W.P.D.); and Department of Neurosurgery, The Permanente Medical Group, Kaiser Permanente Medical Center, Redwood City, Redwood City, Calif (M.F.S.). Received November 10, 2020; revision requested December 23; revision received December 26; accepted January 6, 2021. **Address correspondence to** M.D.M. (e-mail: *mark.d.mamlouk@kp.org*).

Conflicts of interest are listed at the end of this article.

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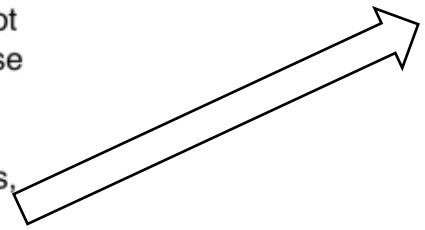
Background: Cerebrospinal fluid–venous fistulas (CVFs) are one of the less common etiologic causes of spontaneous intracranial hypotension. CVFs are most commonly treated with open surgical ligation and have reportedly not responded well to percutaneous treatments.

Purpose: To study treatment outcomes of CT-guided fibrin glue occlusion for CVFs.

Materials and Methods: Retrospective review of medical records from two institutions was performed for all patients with CVFs who underwent CT-guided percutaneous fibrin glue occlusion from March to October 2020. CVFs were assessed for resolution or persistence at posttreatment decubitus CT myelography (CTM). Pre- and posttreatment brain MRI scans were reviewed for principal signs of spontaneous intracranial hypotension. Clinical symptoms were documented before and immediately after therapy, and the current symptoms to date after fibrin glue occlusion were documented.

Results: CT-guided fibrin glue occlusion was performed in 13 patients (mean age, 62 years ± 14 [standard deviation]; eight women) with CVFs. Ten of 10 patients who underwent final posttreatment decubitus CTM examinations showed CVF resolution. All 13 patients showed improvement on posttreatment brain MRI scans. All 13 patients are currently asymptomatic, although three patients were asymptomatic before fibrin glue occlusion.

Conclusion: CT-guided fibrin glue occlusion is an effective treatment for patients with cerebrospinal fluid–venous fistulas (CVFs). Direct fibrin glue administration within the CVF may be one of the key factors for success. Further studies are needed to determine the long-term efficacy of this treatment.

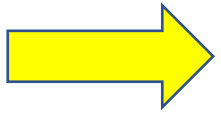


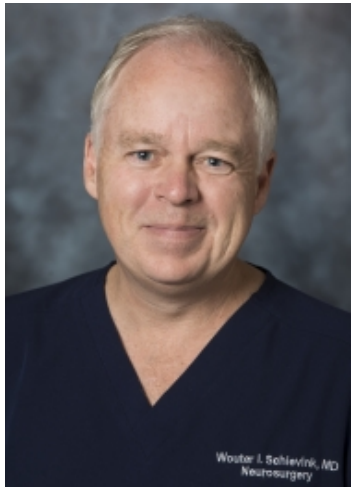
SPINE

Same-Day Bilateral Decubitus CT Myelography for Detecting CSF-Venous Fistulas in Spontaneous Intracranial Hypotension

L. Carlton Jones and P.J. Goadsby

CSF-venous fistula treatment





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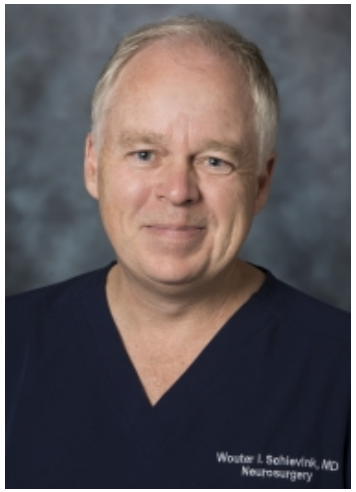
CSF-venous fistula treatment



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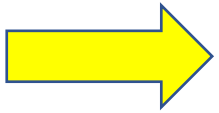
CSF-venous fistula treatment



VS

VS

Preferred treatment for spinal CSF-venous fistula

- **Patient preference**

<u>Individualized treatment</u>

- Spinal level “functional” nerve root
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Thank you!

schievinkw@cshs.org