

Fourth Annual Cedars-Sinai
Intracranial Hypotension Symposium

October 2, 2021



Current surgical treatment of spinal CSF leaks



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No disclosures



CSF leak program, Cedars-Sinai Medical Center, Los Angeles, CA, USA

- Neurosurgery

Wouter I. Schievink, M.D.

Rachelle B. Tache, M.S.N., A.P.R.N., N.P.-C.



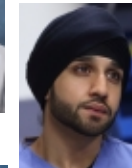
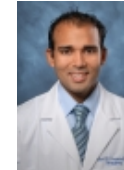
- Neuroradiology

M. Marcel Maya, M.D.

Franklin G. Moser, M.D., M.M.M.

Ravi S. Prasad, M.D.

Vikram Wadhwa, M.D.



- Headache Medicine

Ronald Andiman, M.D.



- Anesthesiology

Charles Louy, M.D., Ph.D.

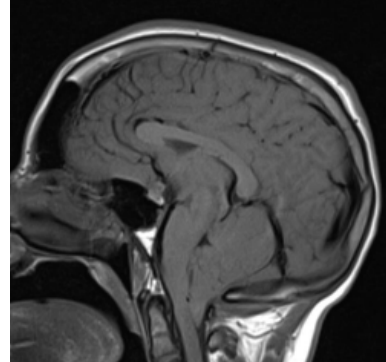
Howard Rosner, M.D.

Mary Alice Vijjeswarapu, M.D.

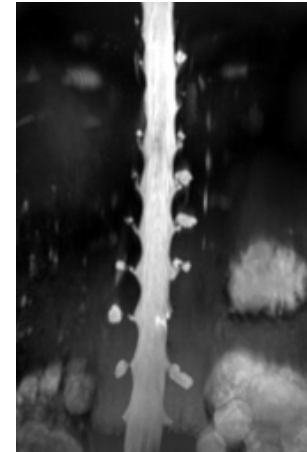


Diagnostic evaluation of SIH – A practical approach

MRI brain



MR-Myelography



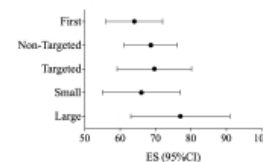
Epidural blood patching

=

Curative for majority of patients with SIH



Figure 21. Epidural Blood Patches (EBPs) outcomes. Pooled estimates of proportions (95% CI) of successful EBP treatment stratified by EBP technique (non-targeted/targeted, small/large)



Diagnostic evaluation of SIH – A practical approach

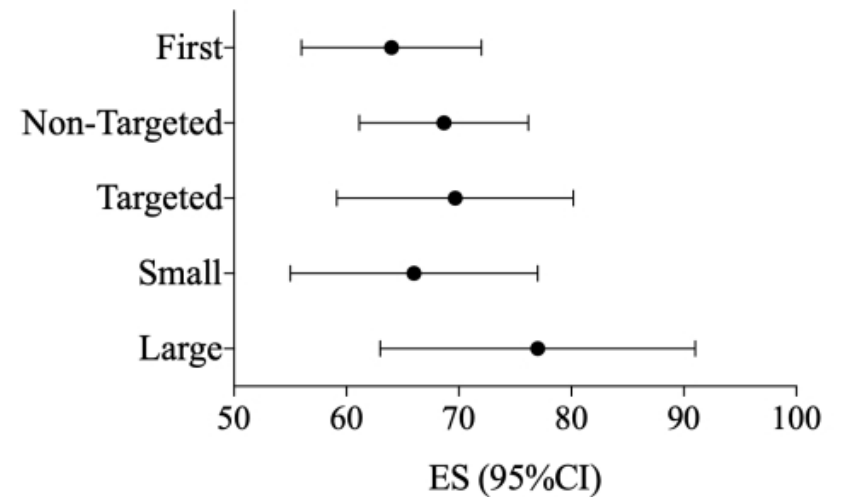
Epidural blood patching is curative for majority of patients with SIH

JAMA Neurology | **Original Investigation**

Clinical Presentation, Investigation Findings, and Treatment Outcomes of Spontaneous Intracranial Hypotension Syndrome A Systematic Review and Meta-analysis

Linda D'Antona, MD, MBBS; Melida Andrea Jaime Merchan, MD; Anna Vassiliou, iBSc; Laurence Dale Watkins, MD;
Indran Davagnanam, MD; Ahmed Kassem Toma, MD; Manjit Singh Matharu, MD, PhD

eFigure 21. Epidural Blood Patches (EBPs) outcomes. Pooled estimates of proportions (95% CI) of successful EBP treatment stratified by EBP technique (non-targeted/targeted, small/large)



A classification system of spontaneous spinal CSF leaks

Surgery – referral bias

Table 3 Data for 568 patients with spontaneous intracranial hypotension

	Leak classification							p Value
	All patients	1A	1B	2A	2B	3	4	
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.

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

Wouter I Schievink¹, M Marcel Maya², Franklin G Moser², Paul Simon³ and Miriam Nuño⁴


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.

Cephalalgia
0(0) 1–5
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DOI: 10.1177/03331024211048510
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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

J Neurosurg 88:756-759, 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

1991 – 1998

Learning about CSF leaks

Clipping of meningeal diverticula and exploratory surgeries

1999 – 2009

Establishing a CSF leak center (FGI & hvEBP)

Clipping of meningeal diverticula and exploratory surgeries

Occasional targeting of osteophytes

2009-2011

DSM -> Targeting ventral leak site extradural approach

2011-2021

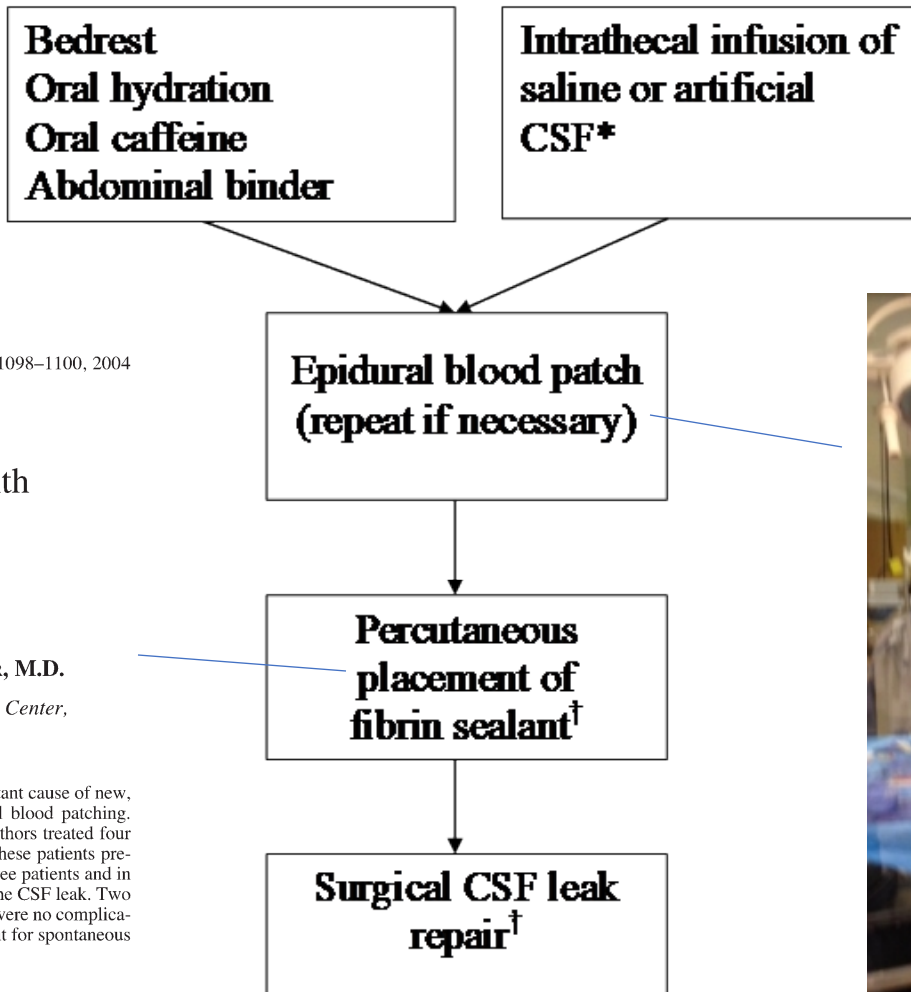
Targeting ventral leak sites intradural approach

2014

Discovery of CSF-venous fistulas

2016

Understanding anatomy of diverticulum vs lateral tear related CSF leak



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

✓ Spontaneous intracranial hypotension due to a cerebrospinal fluid (CSF) leak in the spine is an important cause of new, daily persistent headaches. Most patients respond well to conservative treatments including epidural blood patching. Limited options for effective treatment are available for patients in whom these treatments fail. The authors treated four patients (mean age 38 years; range 26–43 years) with percutaneous placement of a fibrin sealant. All these patients presented with intractable positional headaches. The CSF leak was located in the lower cervical spine in three patients and in the lower thoracic spine in one patient. Four to 20 milliliters of fibrin sealant was injected at the site of the CSF leak. Two of the four patients became asymptomatic within days of the procedure and thus avoided surgery. There were no complications of this procedure. Percutaneous placement of a fibrin sealant is a safe, minimally invasive treatment for spontaneous spinal CSF leaks and should be considered in patients in whom conservative treatment has failed.

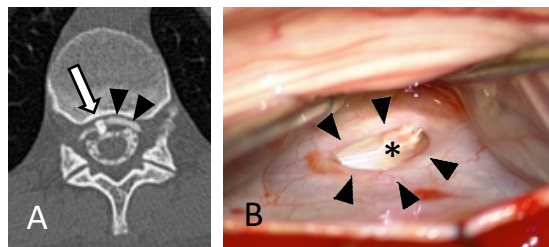
KEY WORDS • cerebrospinal fluid leak • headache • intracranial hypotension



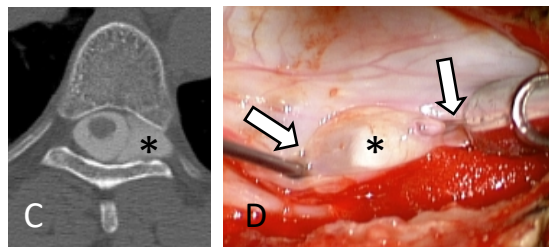
• When urgent treatment is required such as with coma†

Knowledge of exact site of CSF leak required

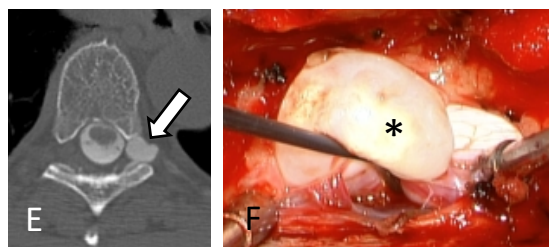
Ventral CSF leak



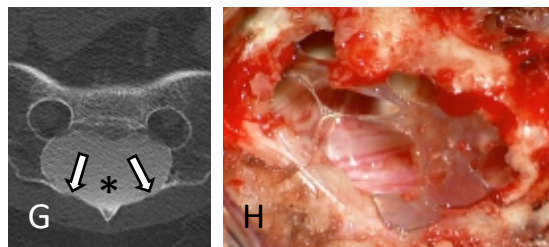
Lateral CSF leak



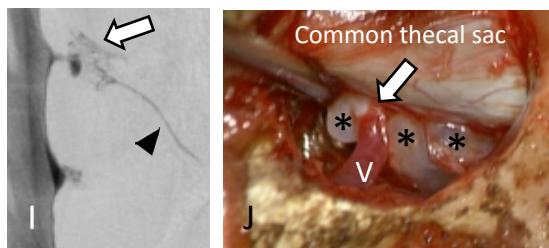
Meningeal diverticulum



Dural ectasia



CSF-venous fistula



Treatment recommendations depend on CSF leak type

A classification system of spontaneous spinal CSF leaks

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 M. Marcel Maya, MD
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ABSTRACT

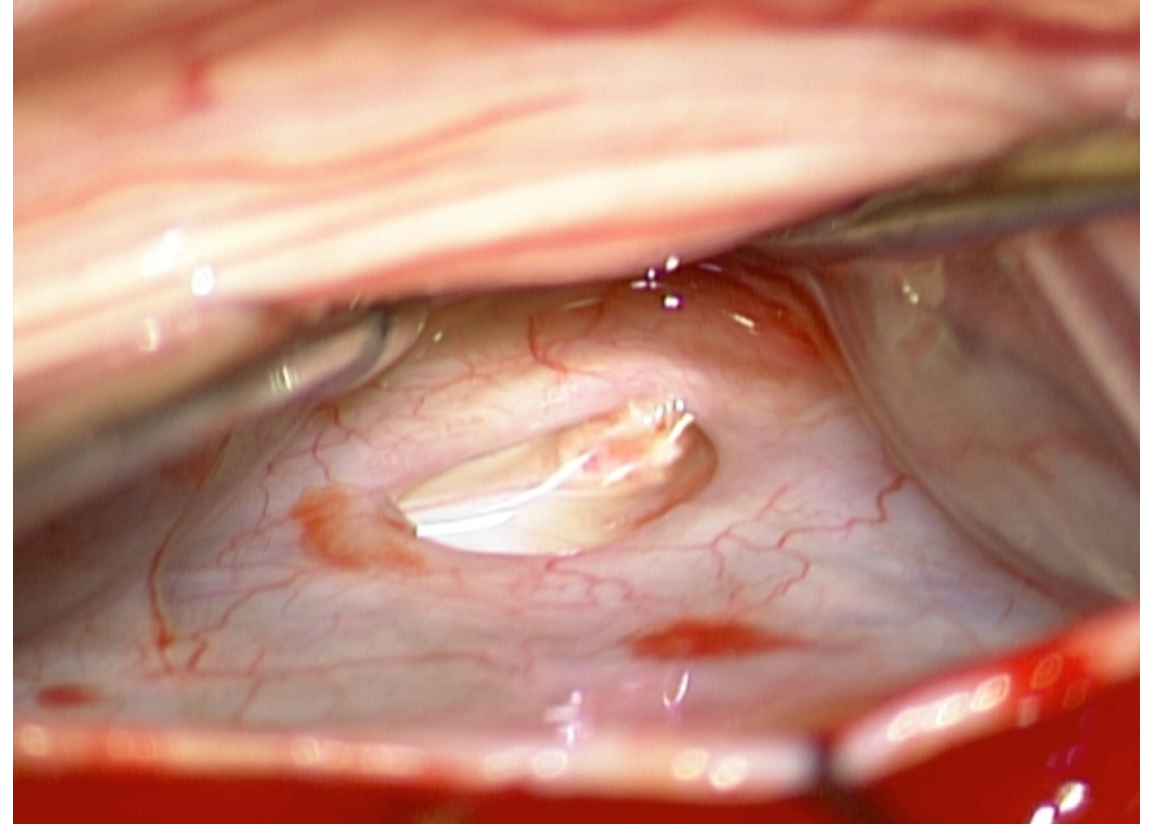
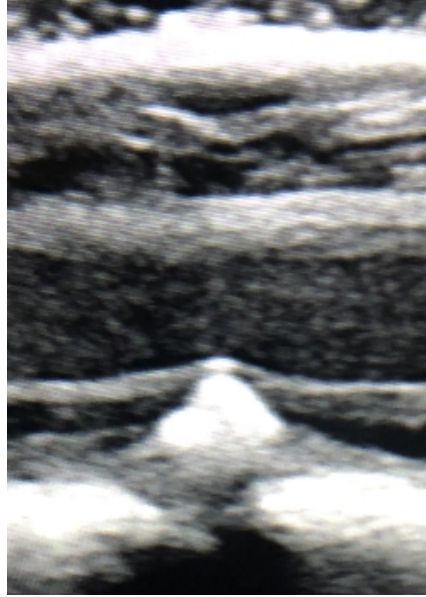
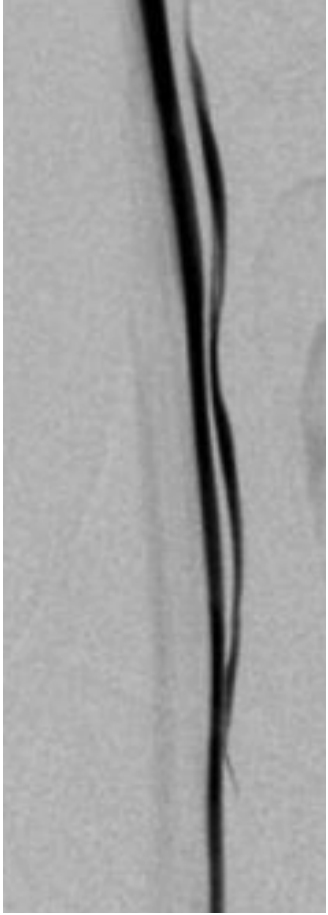
Objective: Spontaneous spinal CSF leaks cause spontaneous intracranial hypotension but no systematic study of the different types of these CSF leaks has been reported. Based on our experience with spontaneous intracranial hypotension, we propose a classification system of spontaneous spinal CSF leaks.

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



Type 1a – Ventral leak

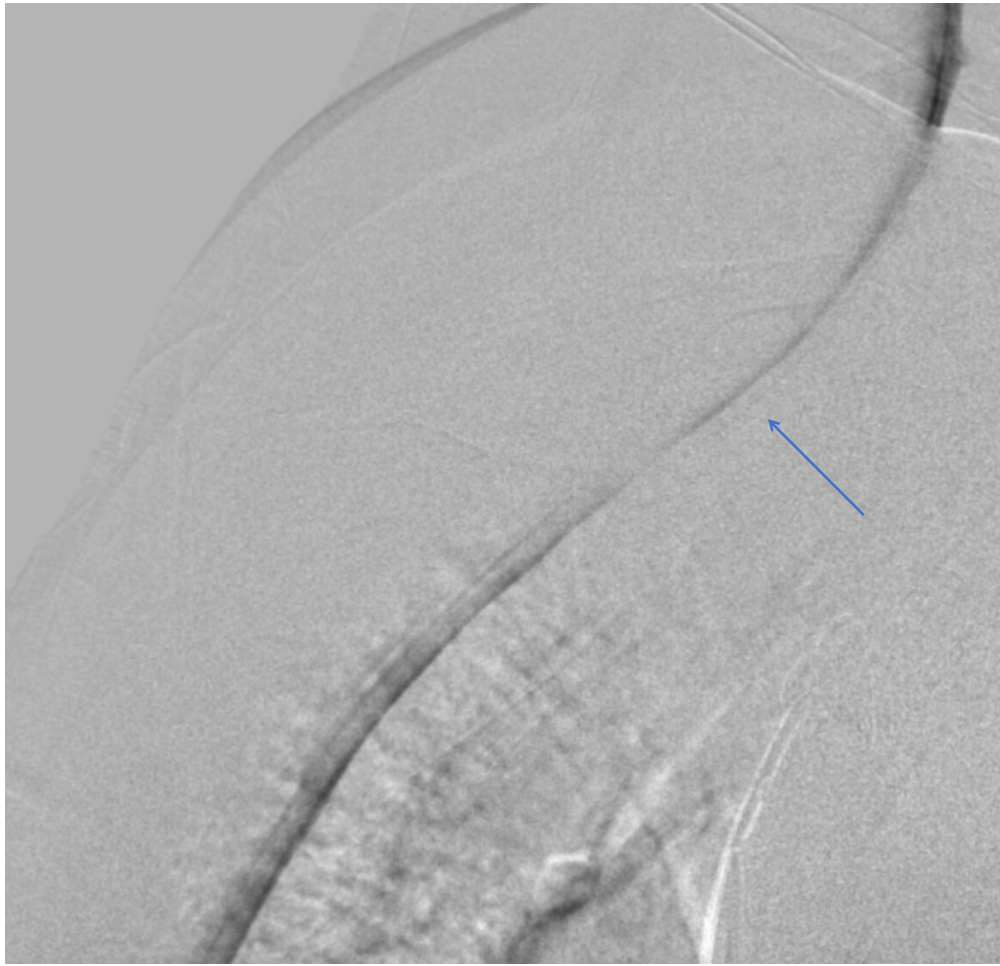
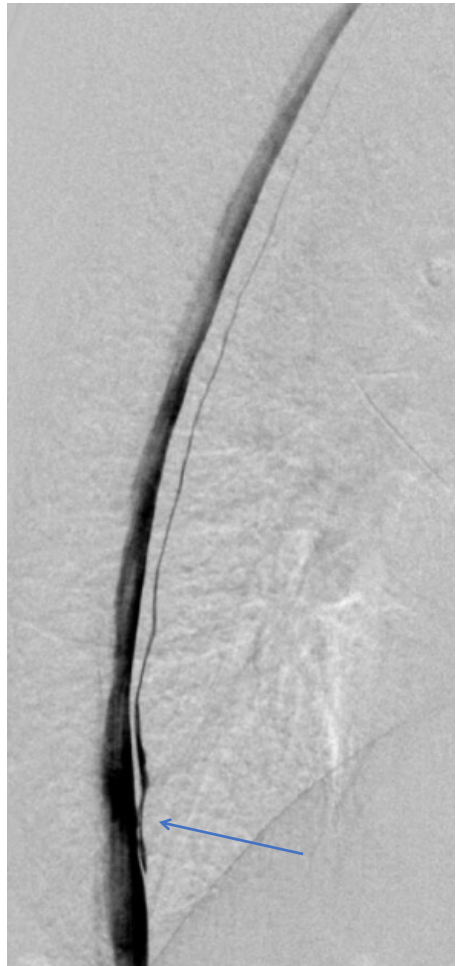
Ventral spinal CSF leak

- 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

Looking for a ventral CSF leak

- **DSM** (Fast CSF leaks)
- Dynamic CT-myelogram (Fast but also not so fast CSF leaks)
- MRI? (Static image for dural defect)
- Bony spicule (Indirect localization device)

Ventral spinal CSF leaks – Digital subtraction myelography



Bone spur as cause of type 1a ventral CSF leak

J Neurosurg 89:483–484, 1998

Cervical bone spur presenting with spontaneous intracranial hypotension

Case report

**A. GIANCARLO VISITTEH, 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.

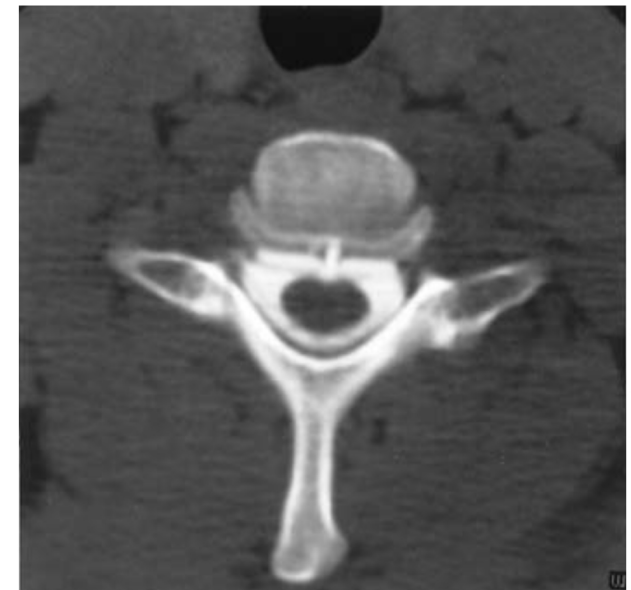
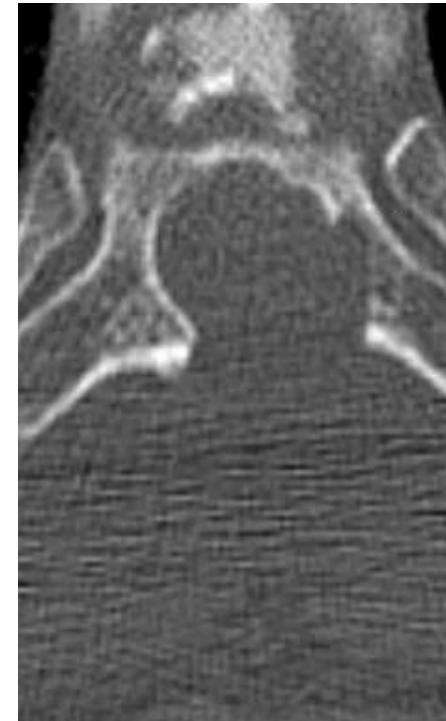


FIG. 1. Postmyelography axial CT obtained at the C5–6 level, showing the bone spur protruding into the thecal sac and associated extrathecal contrast.

Bony spicules in SIH



Pre-op



Post-op

Caveats in identification of bony spicule as source of ventral type 1a CSF leak

- Present in approximately 90% of patients with type 1a CSF leak
- Multiple spicules – not always the largest
- Absorption of spicule over time

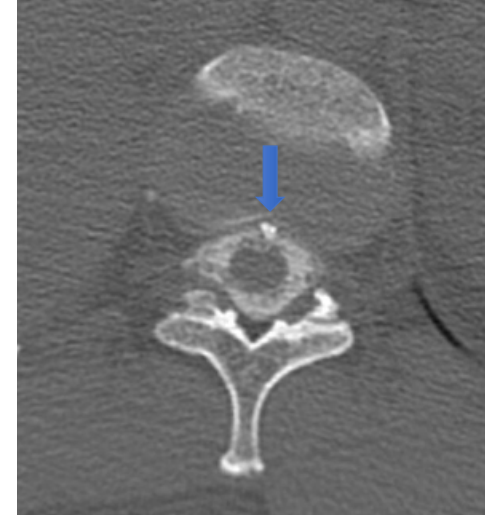
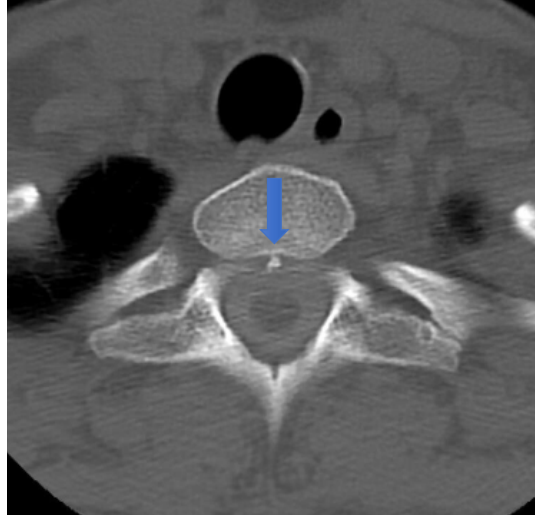
Not always the largest osteophyte

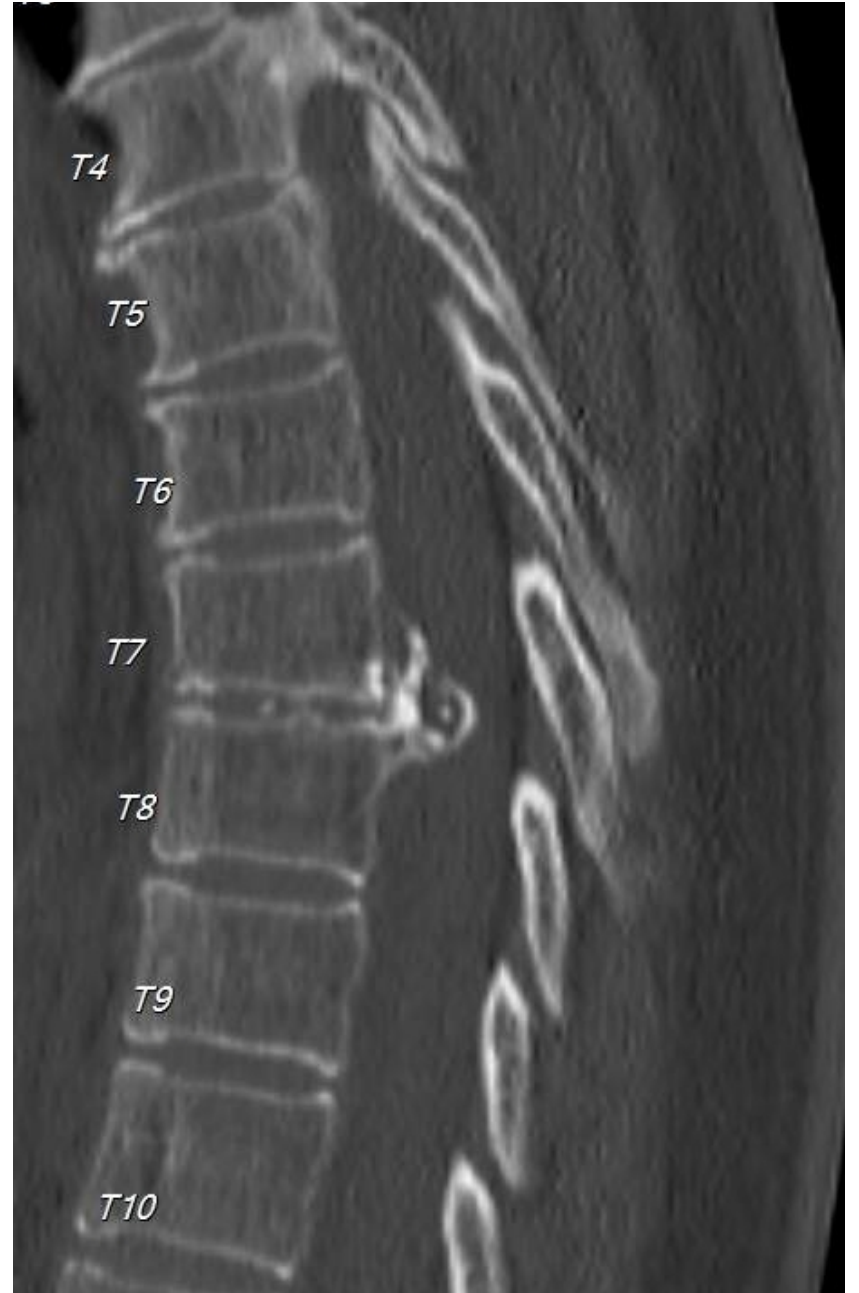


Absorption of osteophyte over time

8 months

14 months





Surgical approaches to ventral thoracic dural tears

Sternotomy

Thoracotomy

VATS

Posterolateral extradural

Posterior intradural

Surgical approaches to ventral dural tears

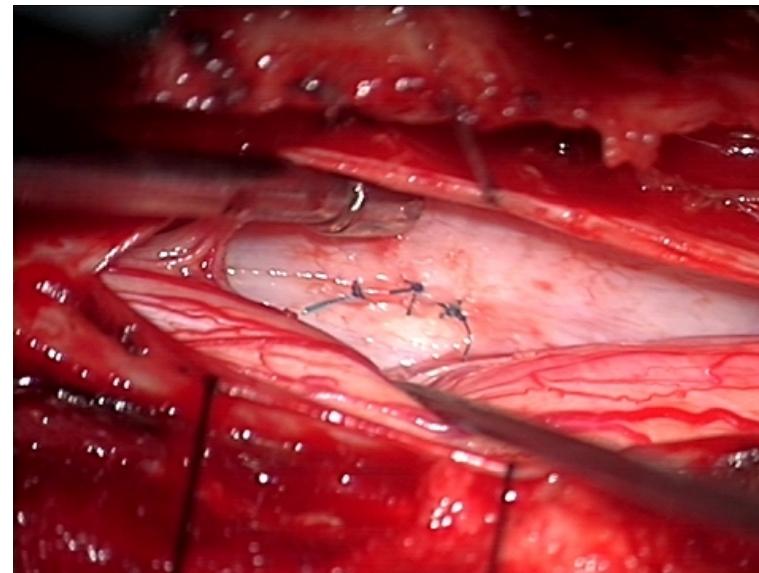
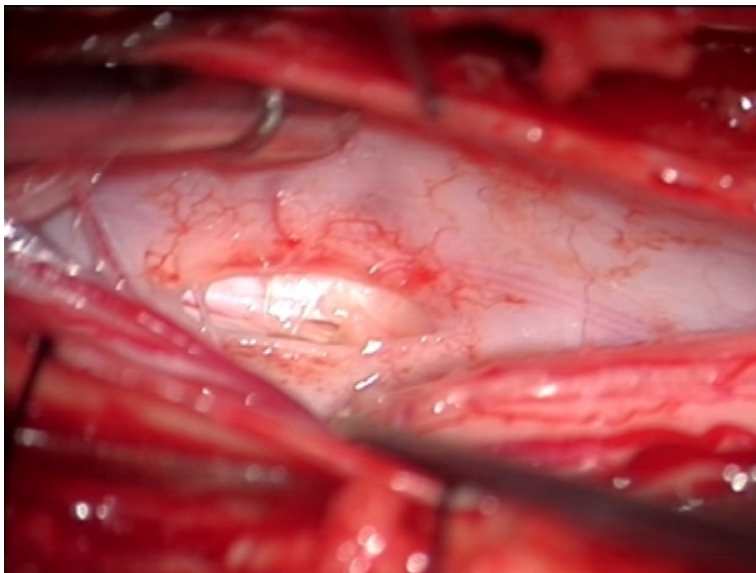
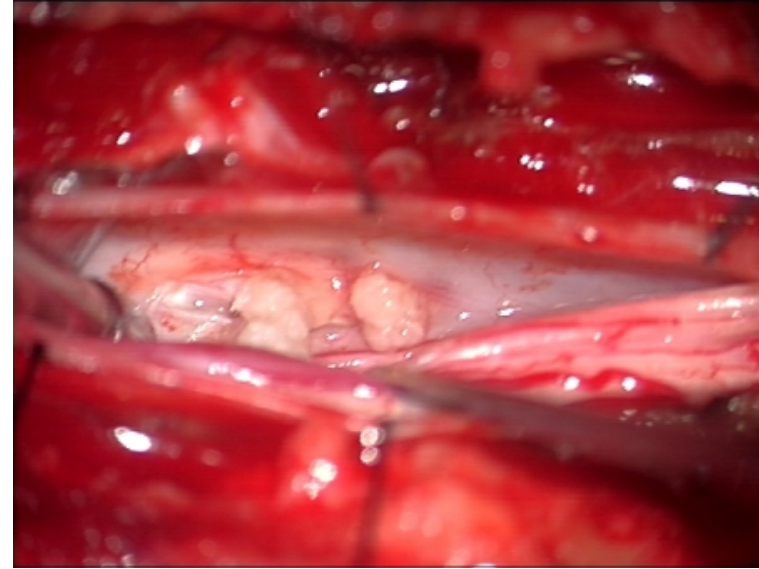
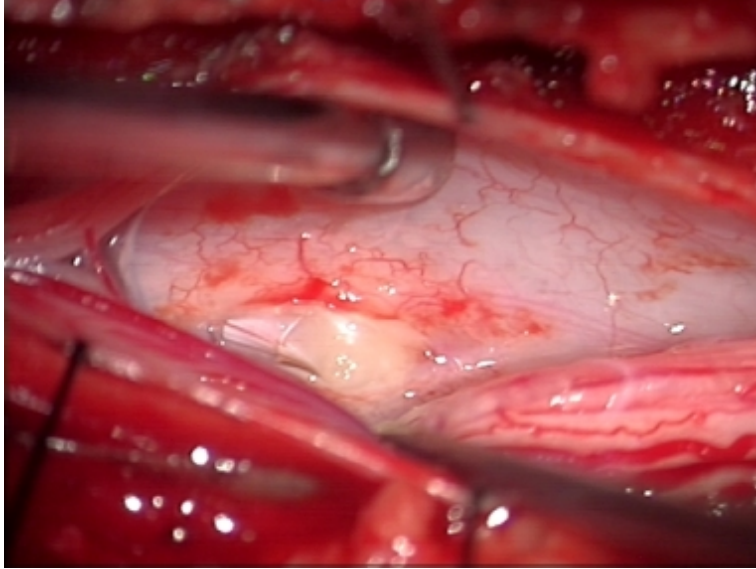
Pre-DSM: 2000-2009: Fenestration/surgical glue or foam placement/shunt/VATS/thoracotomy

Post-DSM: 2009-2011: Posterolateral extradural approach

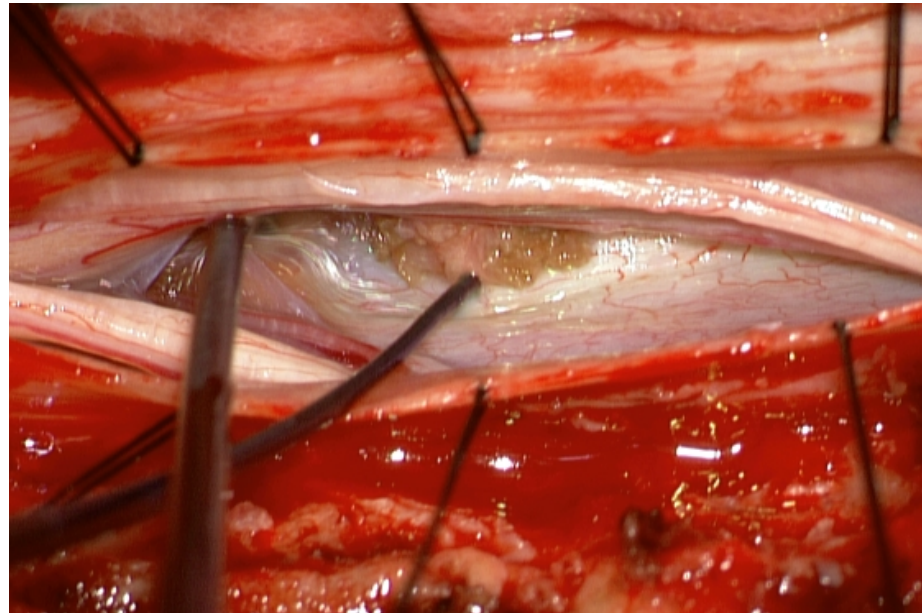
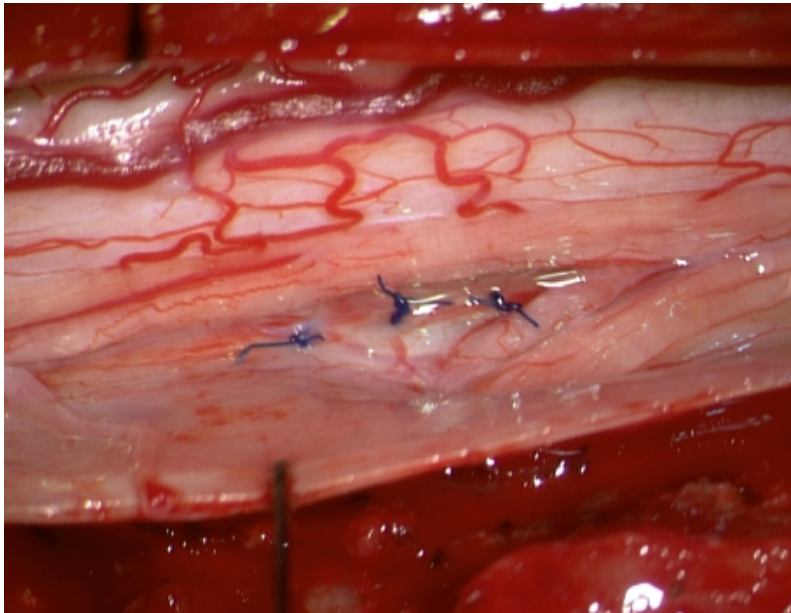
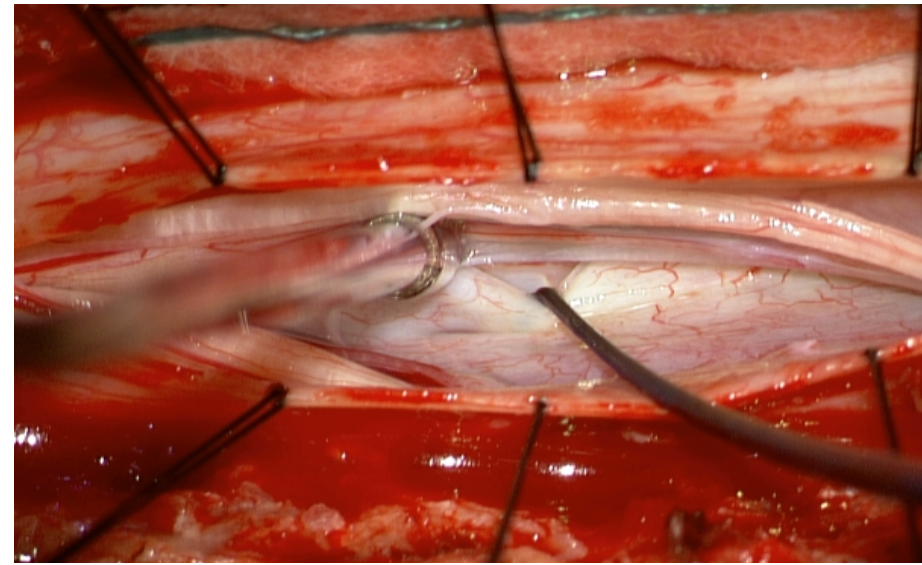
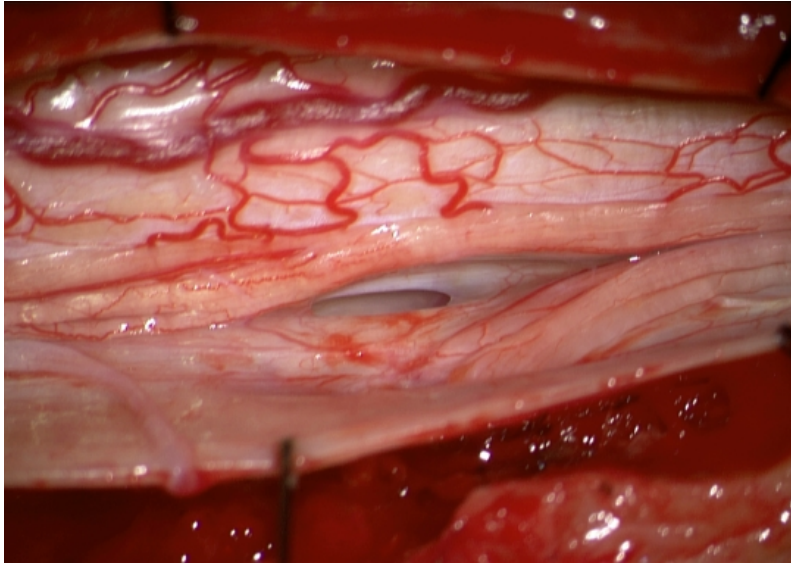
2011-2021: Posterior intradural for thoracolumbar leak

Anterior approach for cervical leak

Resection of transdural disc herniation and repair ventral tear



Ventral dural tear: sutures vs muscle repair



Ventral spinal CSF leak repair- Thoracic

Full or hemi-laminectomy

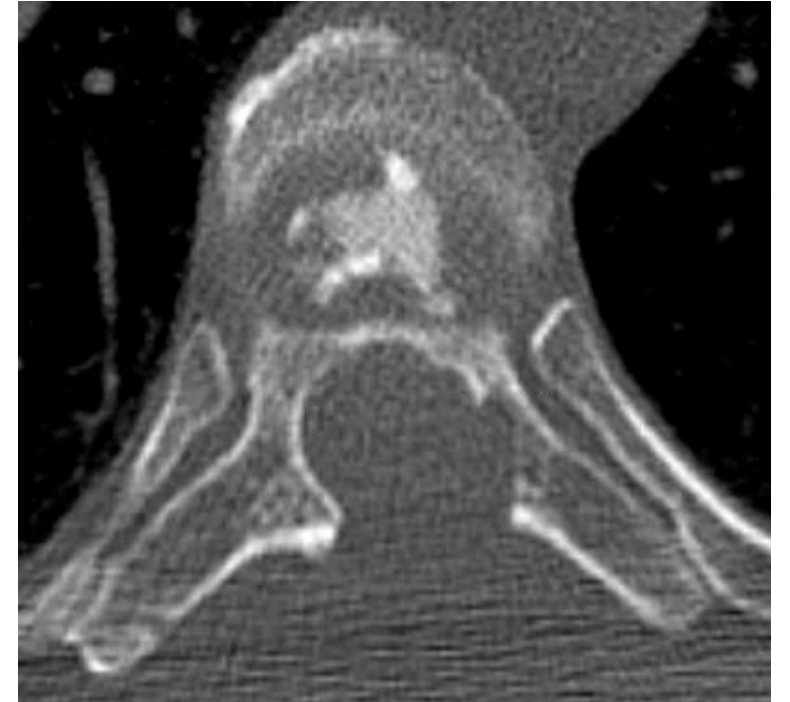
Partial resection pedicle

Midline or paramedian dural incision

Divide dentate ligament

Localize and repair dural tear

Intraoperative monitoring



- ! Consider anterior approach if prior posterior intradural approach
- Consider placement of ventral dural graft if defect cannot be found
- Consider acetazolamide for patients with friable dura

Size of laminectomy for ventral CSF leak repair

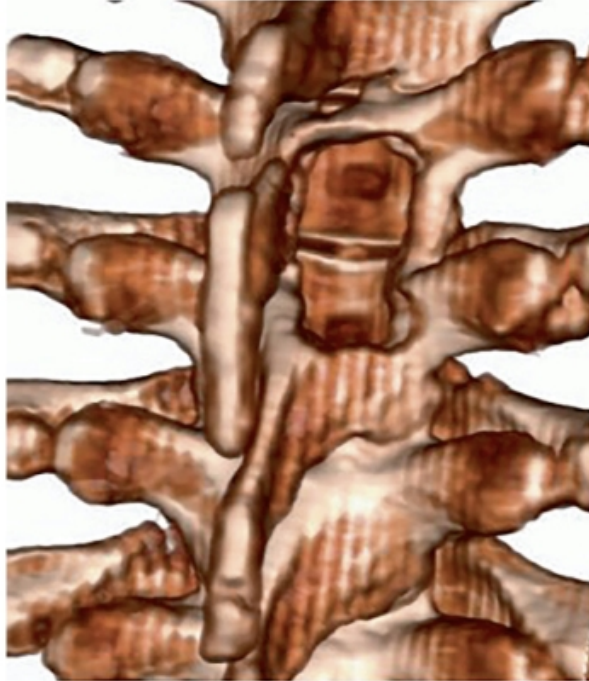
Posterior Approach and Spinal Cord Release for 360° Repair of Dural Defects in Spontaneous Intracranial Hypotension

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.



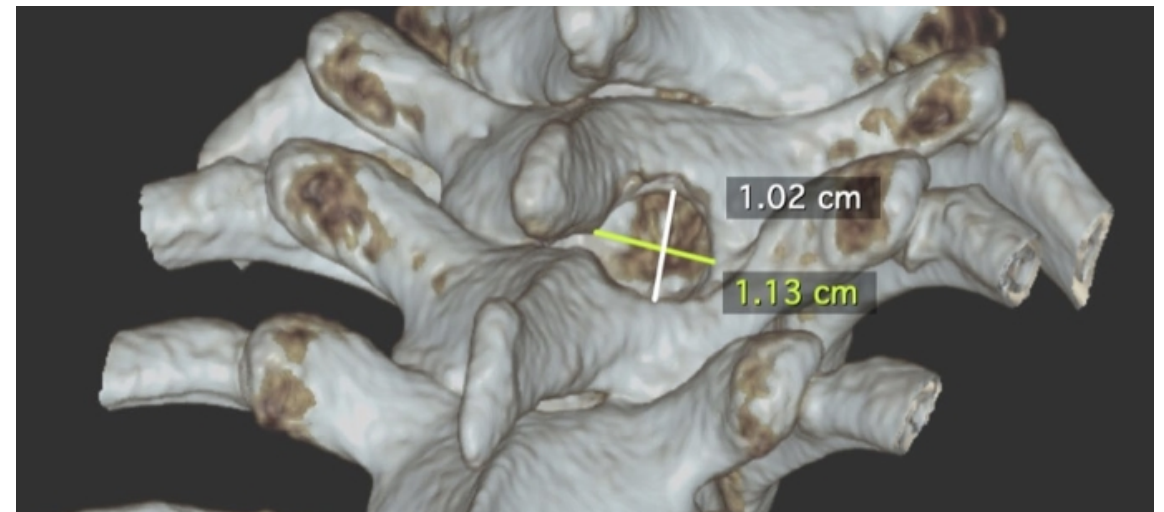
Acta Neurochirurgica
<https://doi.org/10.1007/s00701-021-04987-w>

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
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Ventral spinal CSF leak repair- Cervical

Full corpectomy

Discectomies

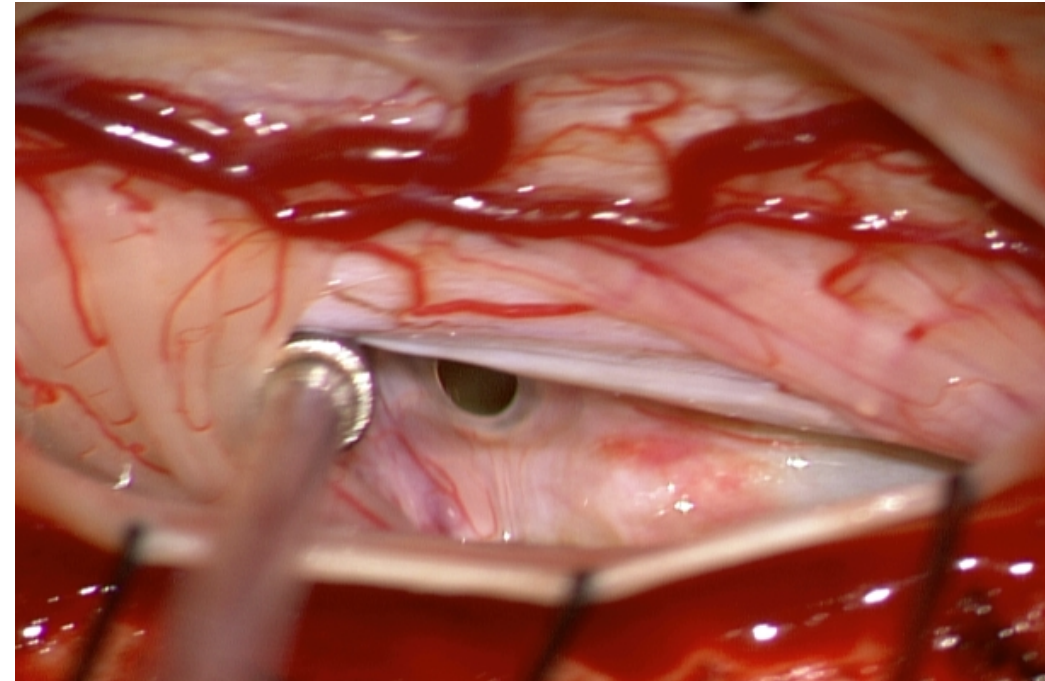
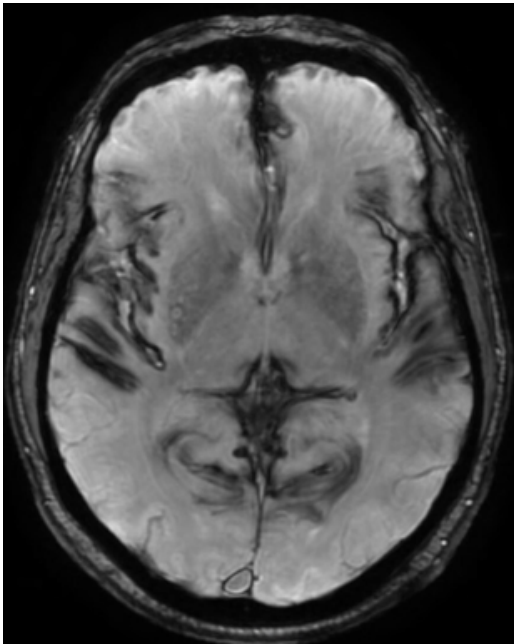
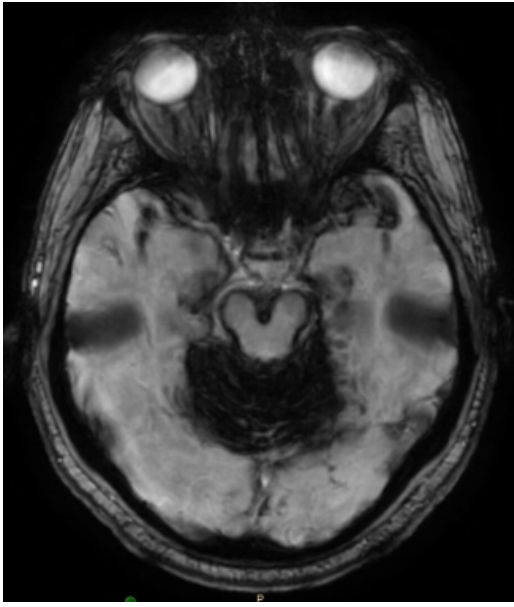
Localize and repair dural tear

Fusion



- ! Consider posterior approach if prior anterior approach
- Consider placement of ventral dural graft if defect cannot be found
- Consider acetazolamide for patients with friable dura

71 year-old man with iSS, S/P attempt at ventral CSF leak repair elsewhere



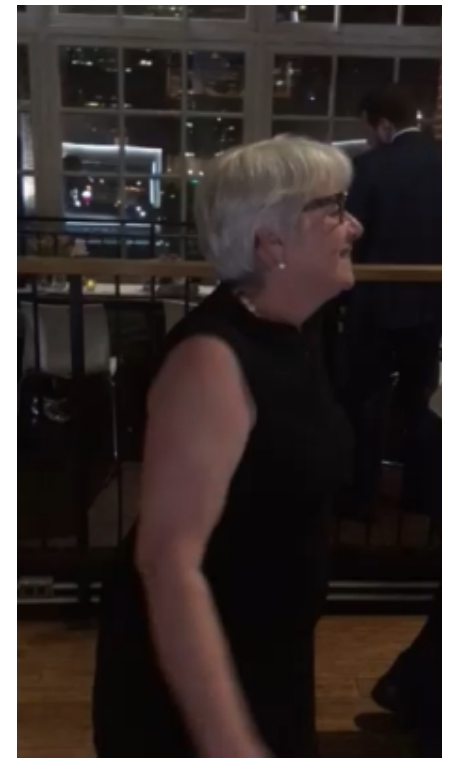
Ventral spinal CSF leak repair (n=250) – With identification and repair of ventral dural tear initial experience

- Successful repair (radiographic): 242 (96.8%)

Complications

- Infection: 3 (1.2%)
 - Neurologic deficit (transient): 6 (2.4%)
 - Pseudomeningocele: 10 (4.0%)
 - Pre-syrinx/cicatrix 4 (1.6%)
 - Epidural hematoma: 0
 - Mortality: 0
-
- Residual symptoms in spite of 100% CSF leak resolution: 10-15%

Post-op recovery

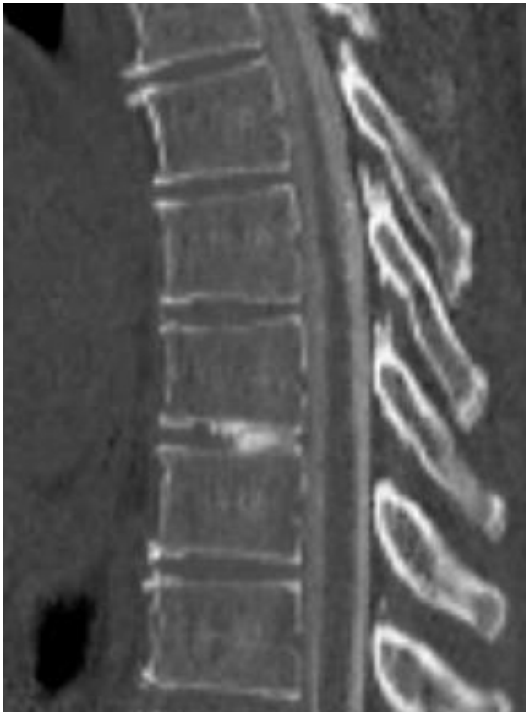
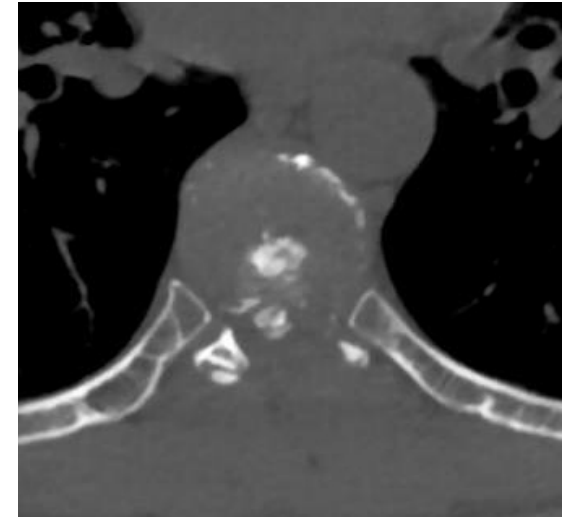


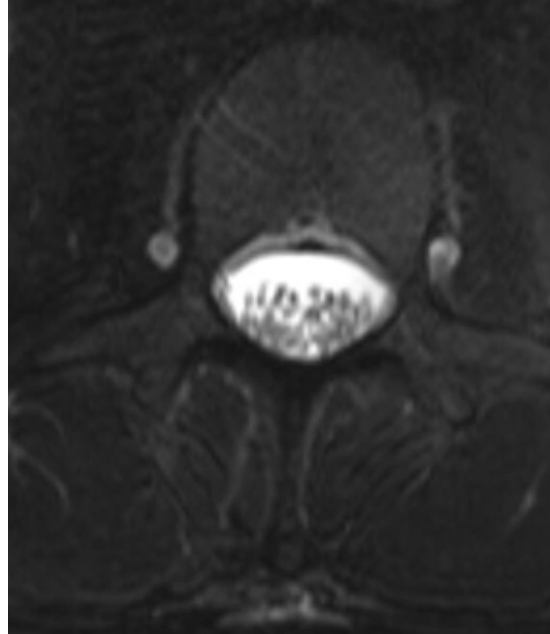
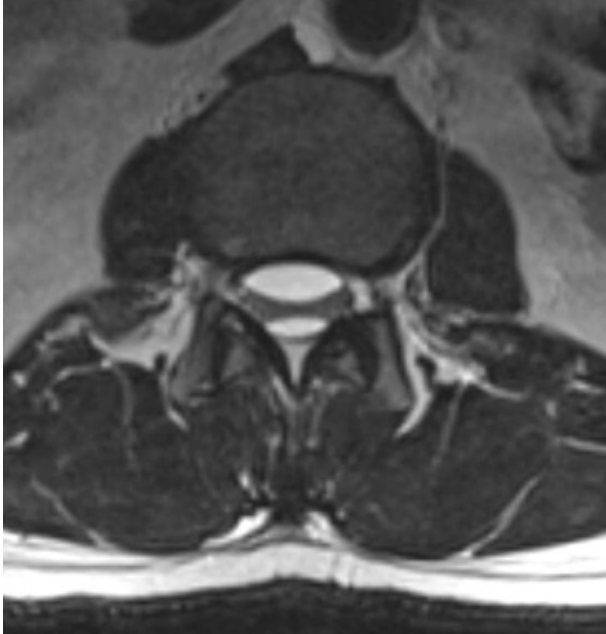
Some unusual post-operative complications

- Iatrogenic calcified disc herniation
- Reversible spinal subdural hygromas
- Adhesive arachnoiditis



Iatrogenic calcified disc herniation



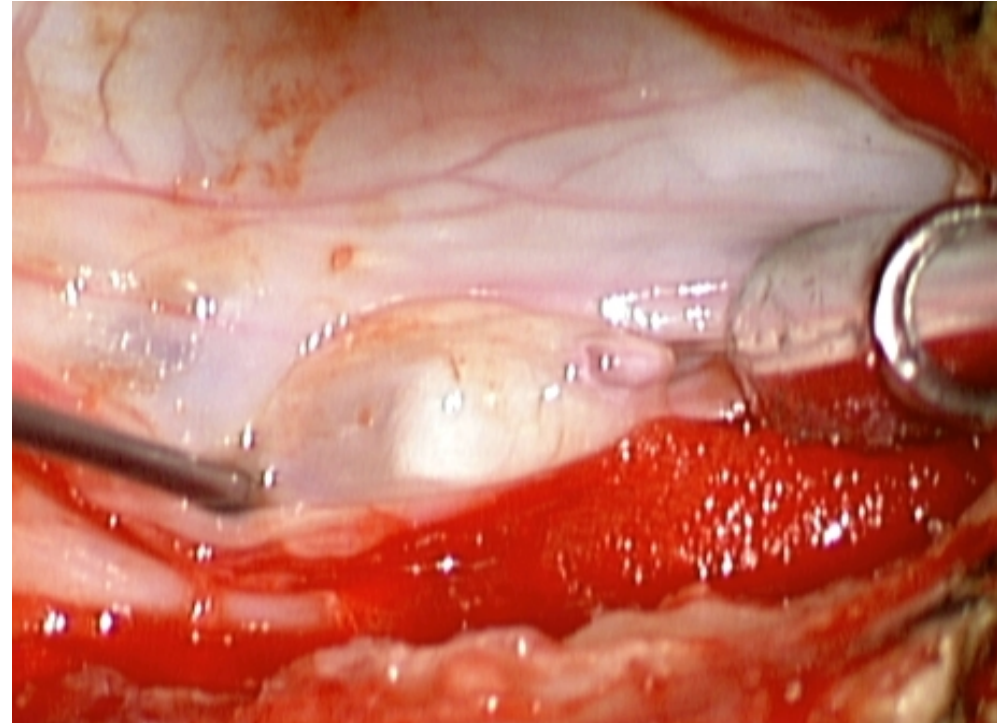
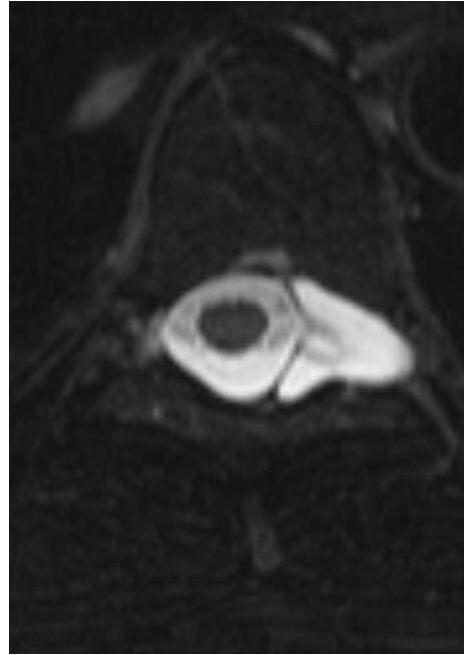
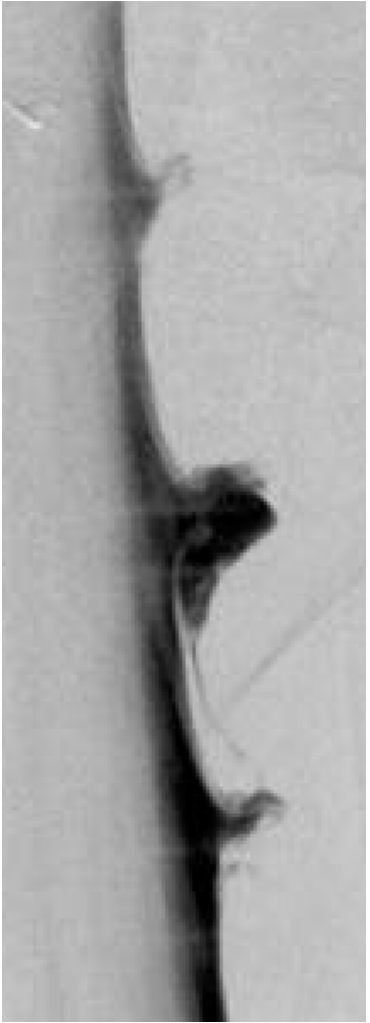


Iatrogenic reversible spinal subdural hygromas



Iatrogenic adhesive arachnoiditis

That's permanent, sometimes progressive



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

Type 1 b postero-lateral CSF leaks

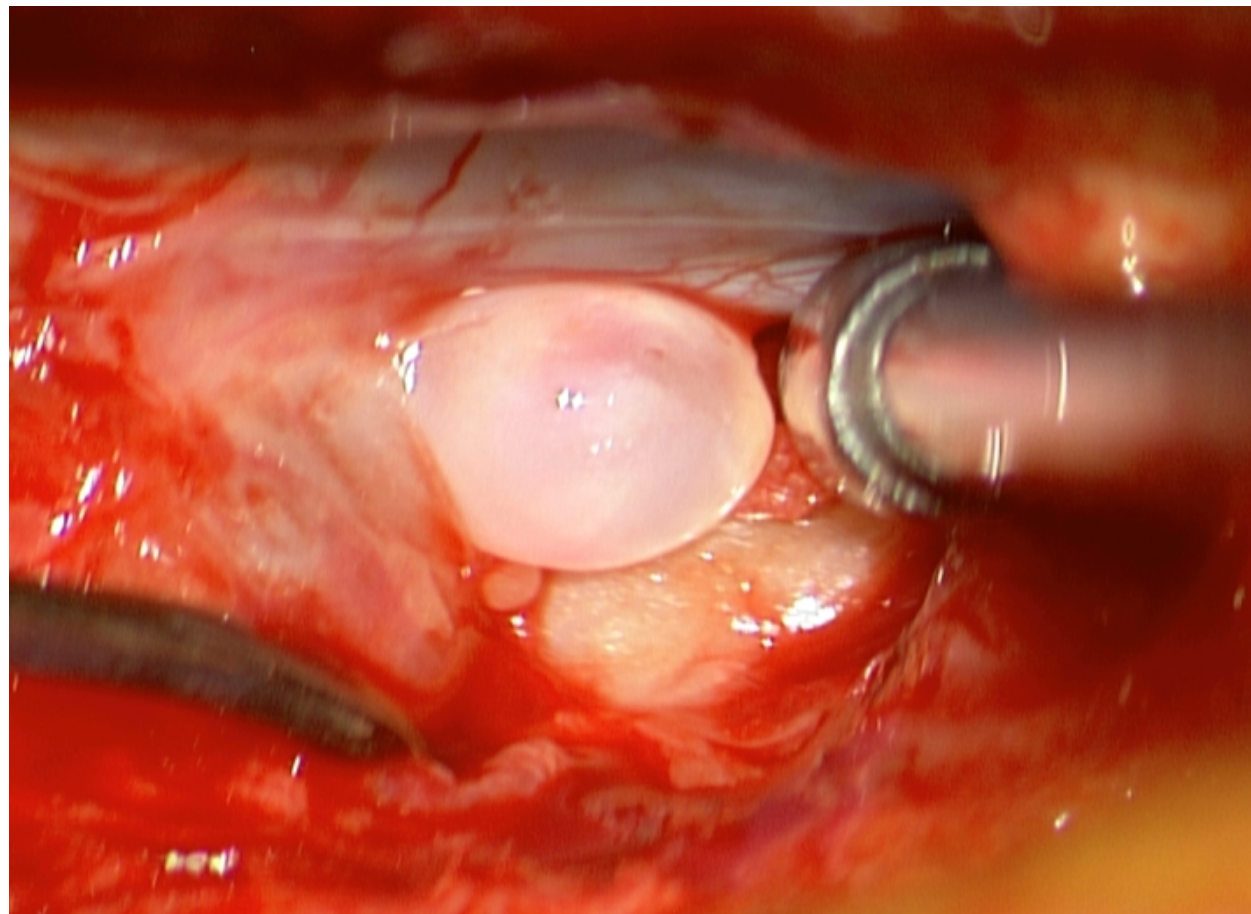
Consider percutaneous fibrin glue injection for cure,
regardless of duration of symptoms

Extradural surgical approach

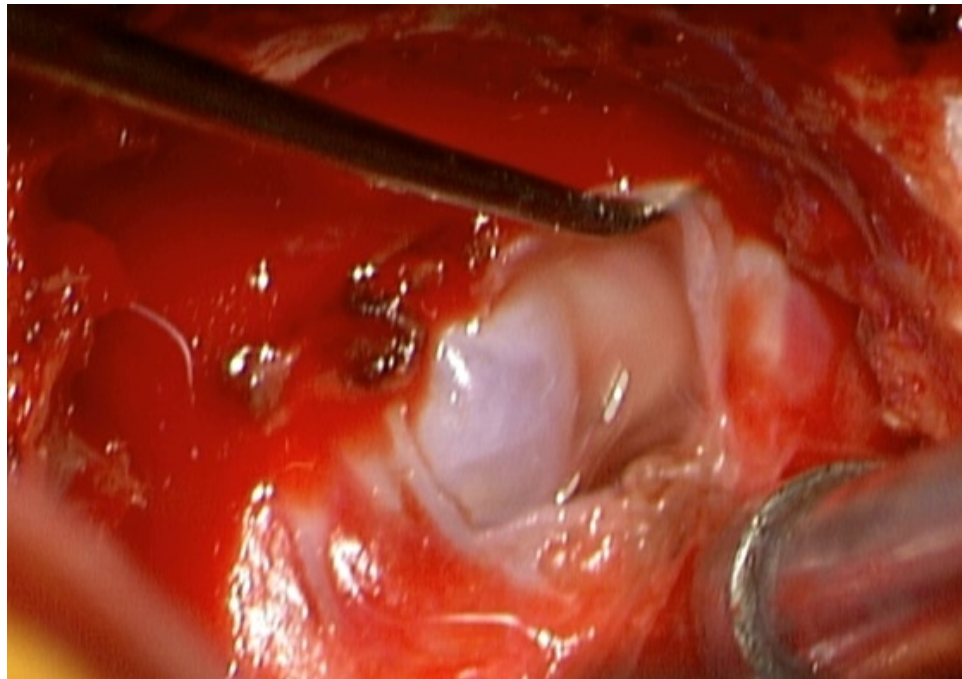
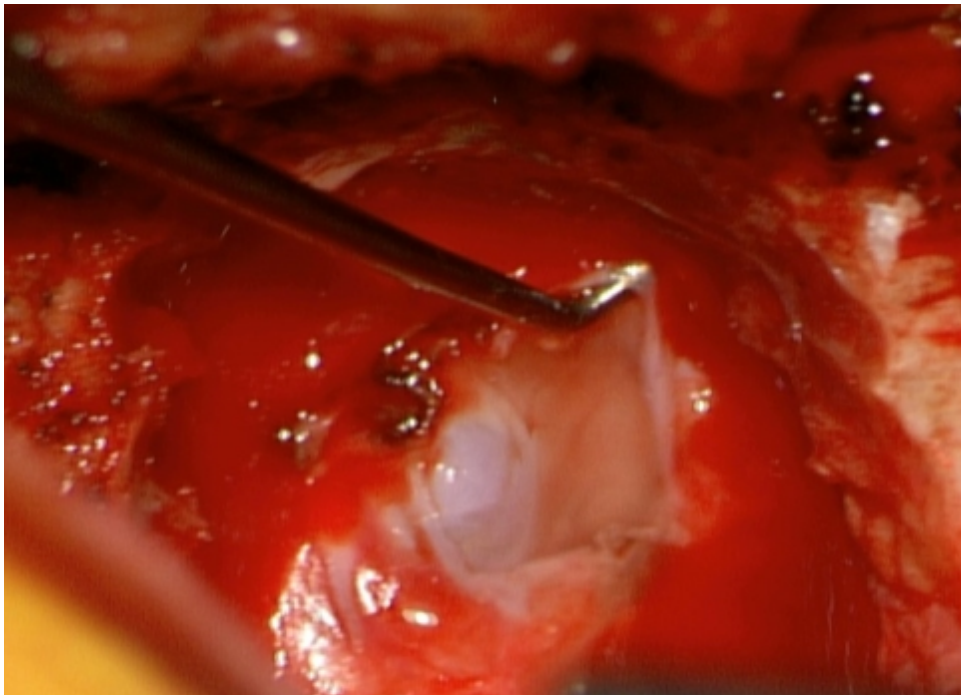
Successful repair (radiographic): 94% (62/66)

Neurologic deficit: 0

Epidural hematoma: 0



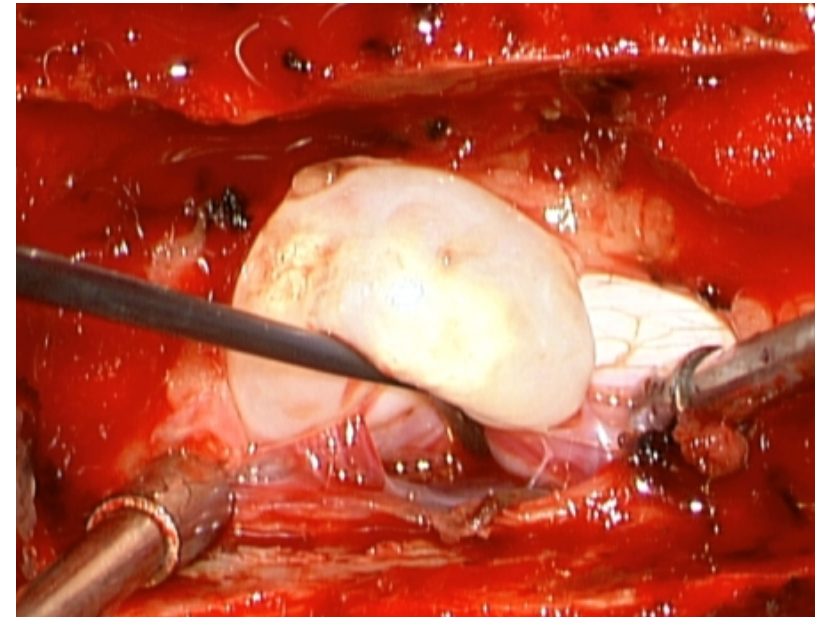
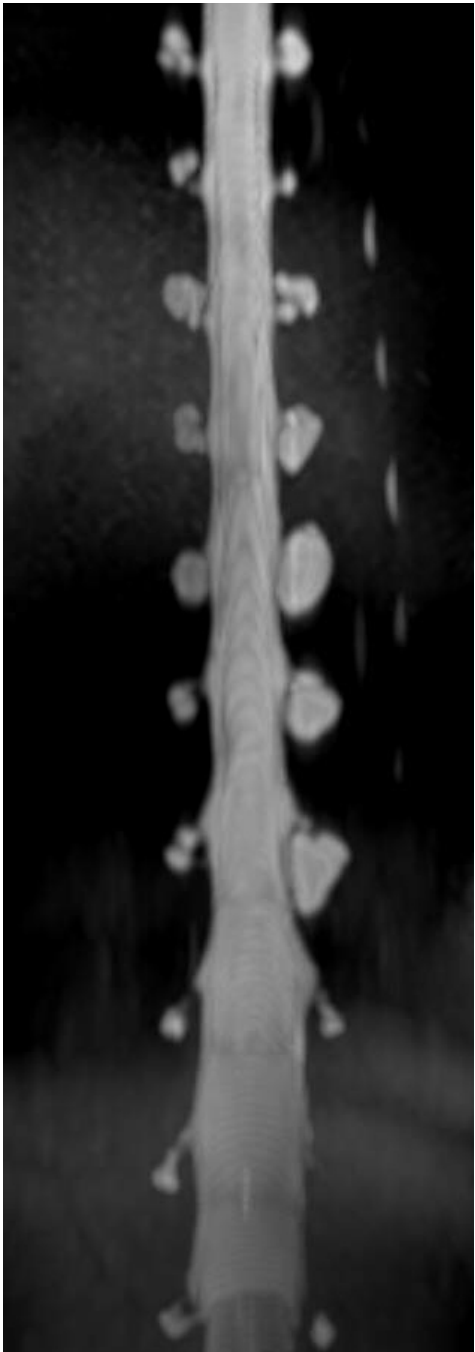
Type 1 b lateral CSF leaks with peri-lesional membrane formation



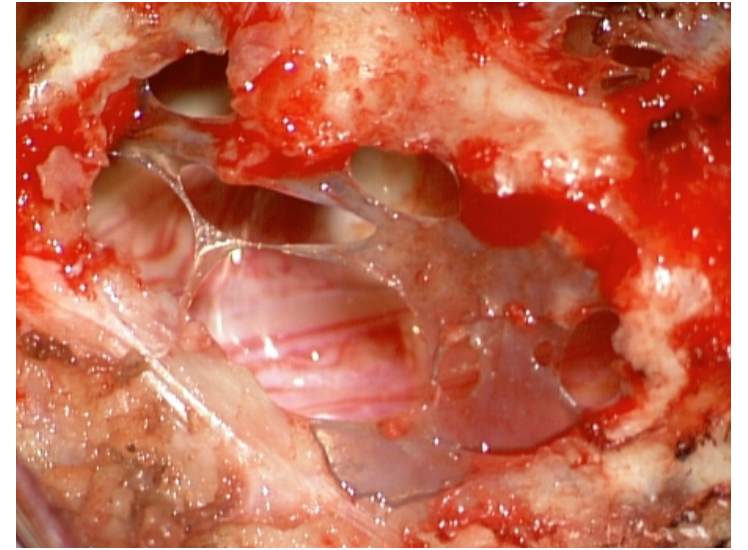
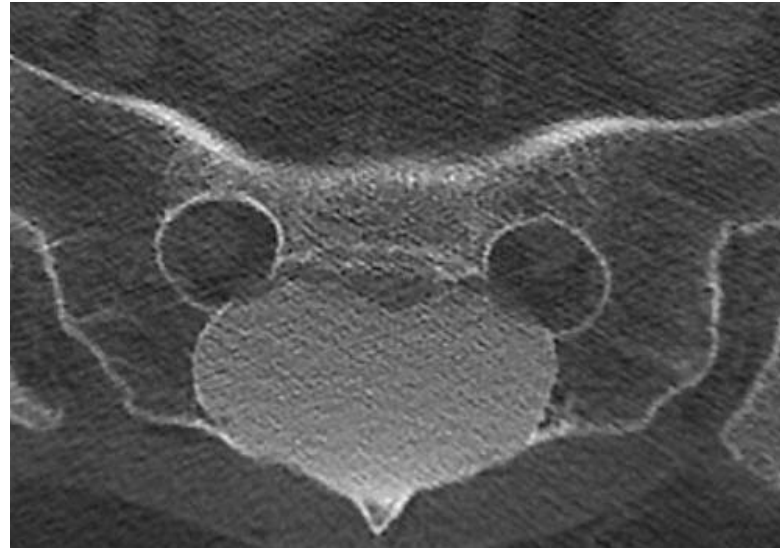
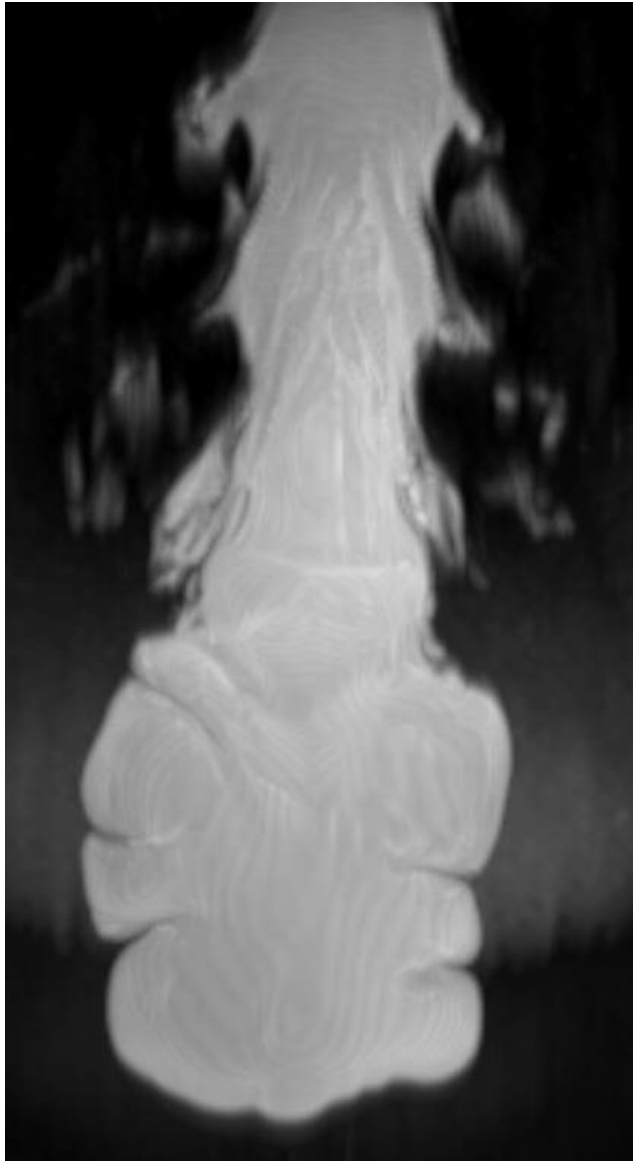
Type 1 b postero-lateral CSF leaks

Extradural repair with aneurysm clipping or suturing

Intradural approach only recommended for associated spinal cord herniation – exceedingly rare



Type 2a – simple meningeal diverticulum

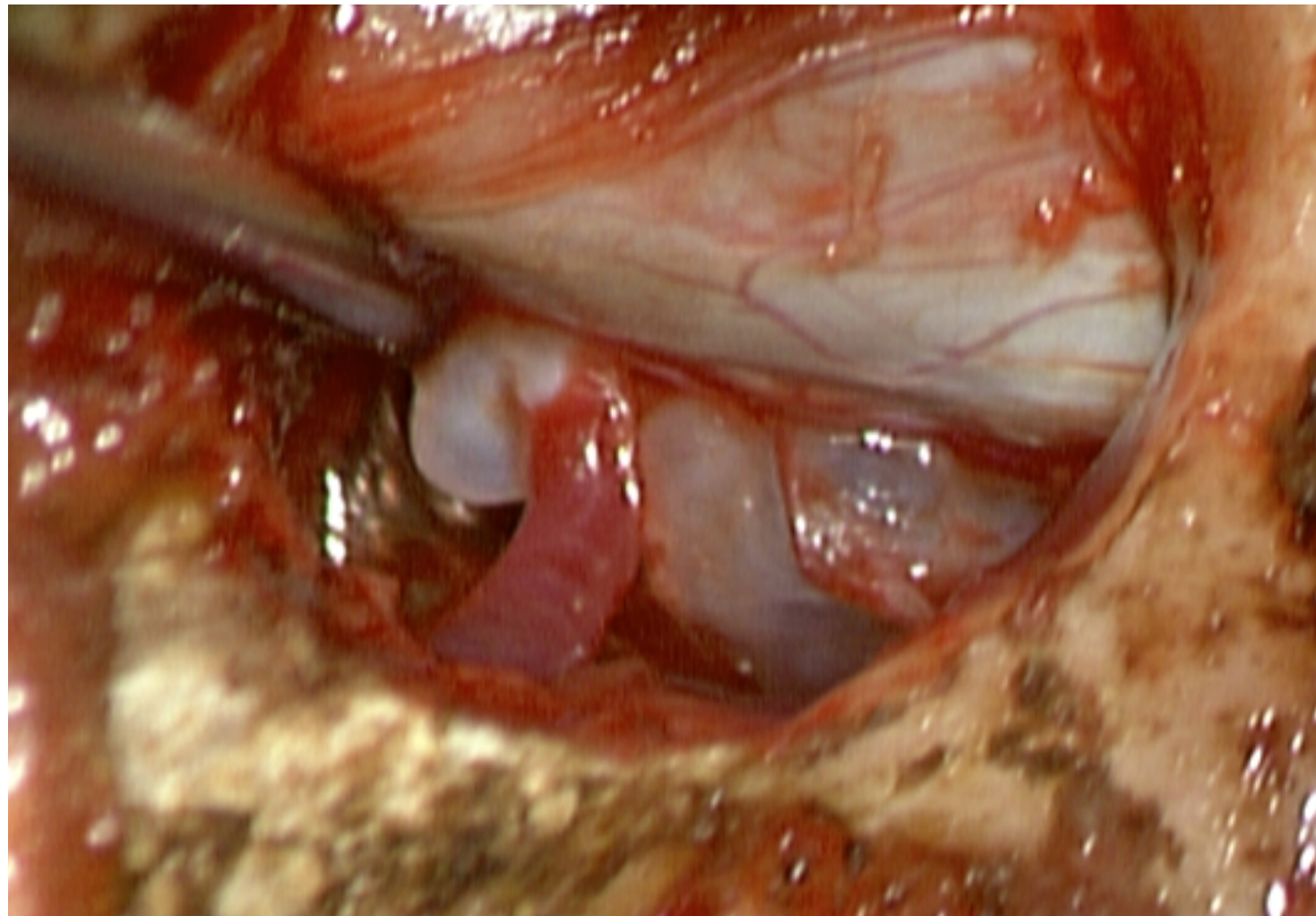
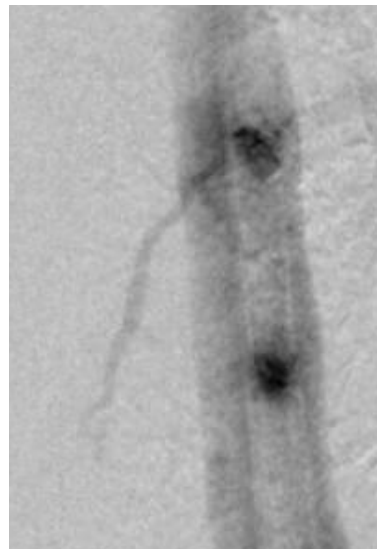


Type 2b – complex meningeal diverticula/dural ectasia

Meningeal diverticula: Simple vs complex refers to.....

Meningeal diverticula: Simple vs complex refers to.....





Type 3 – CSF-venous fistula

CSF-venous fistulas – 3 options for treatment

Epidural blood patching less effective

1 Percutaneous fibrin glue injection

2 Endovascular glue embolization

3 Surgical ligation

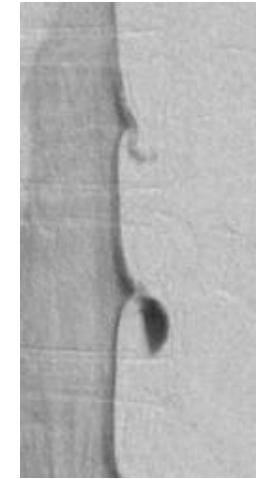
Pros and cons of CSF-venous fistula treatments

1 Percutaneous fibrin glue injection (outpatient)

2014

local/MAC

80%



FGI

2 Endovascular glue embolization (outpatient)

2021

General anesthesia

80%

Endo onyx

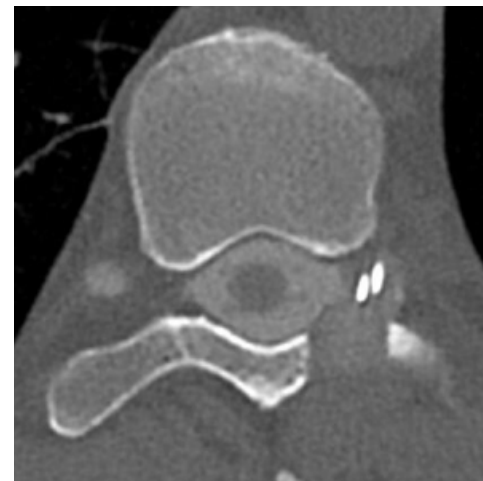


3 Surgical ligation (inpatient)

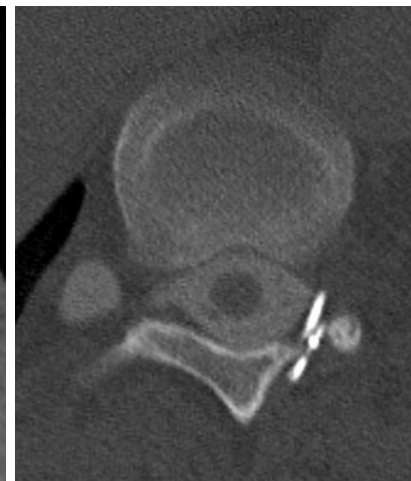
2014

General anesthesia

>95%



hemoclips



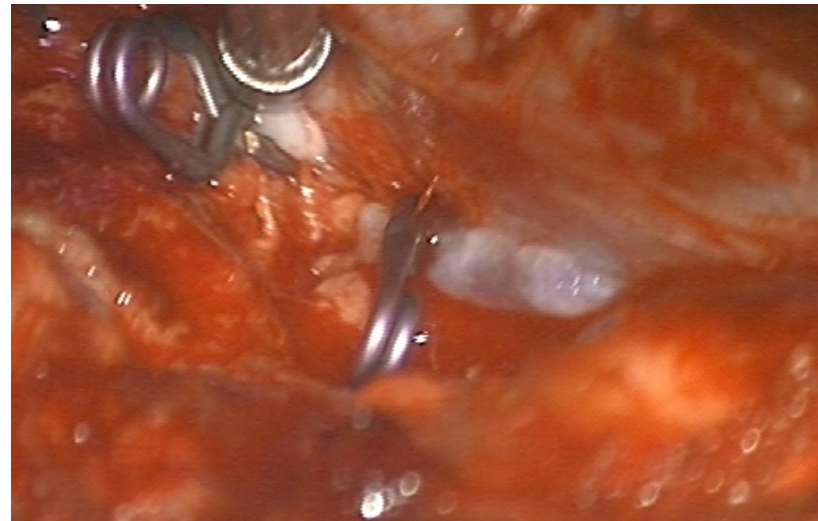
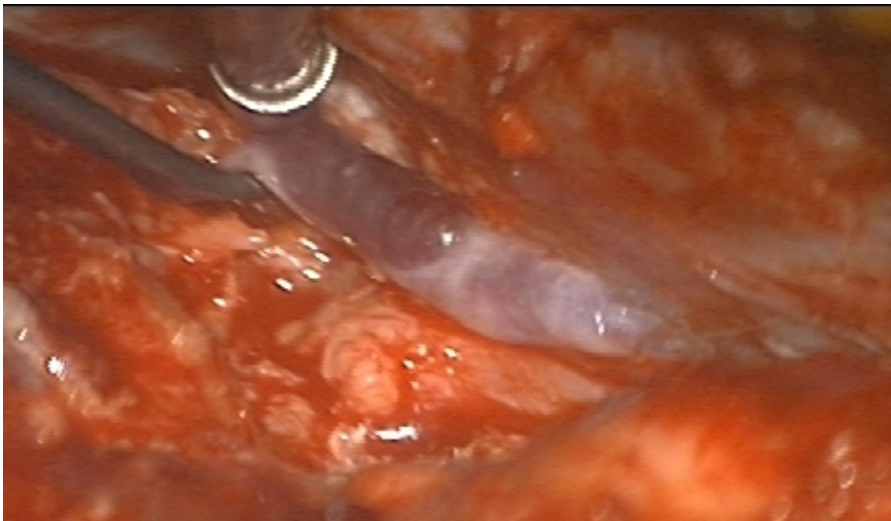
aneurysm clips

Type 3 CSF leak - CSF-venous fistulas

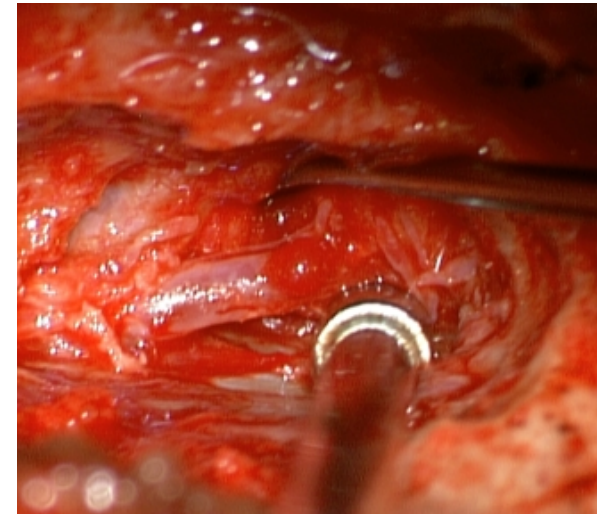
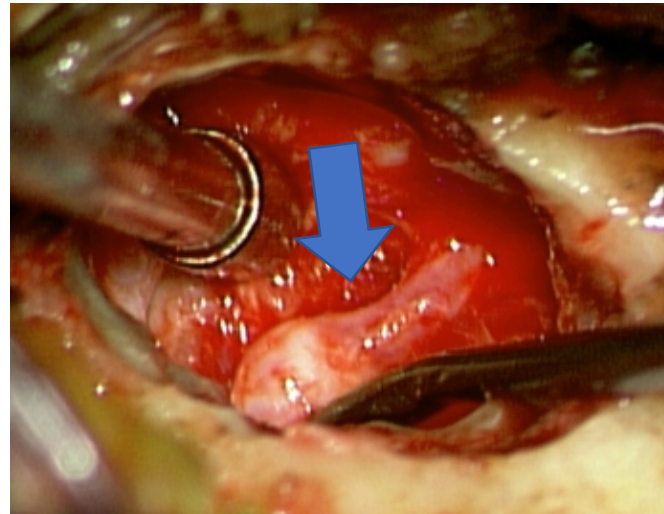
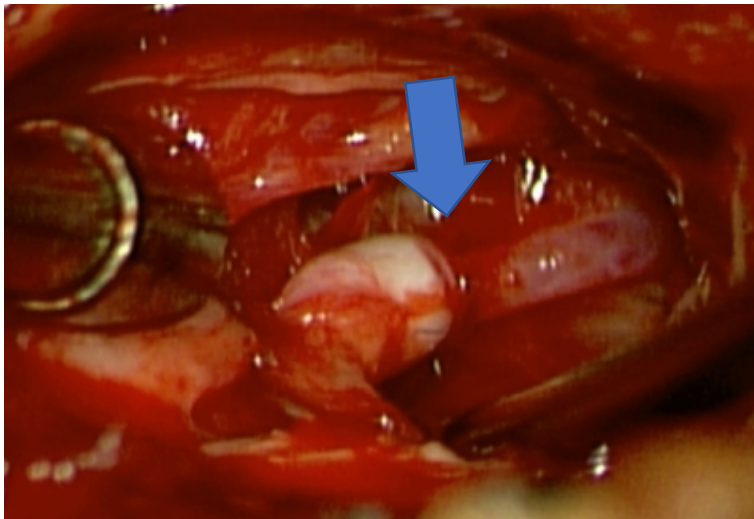
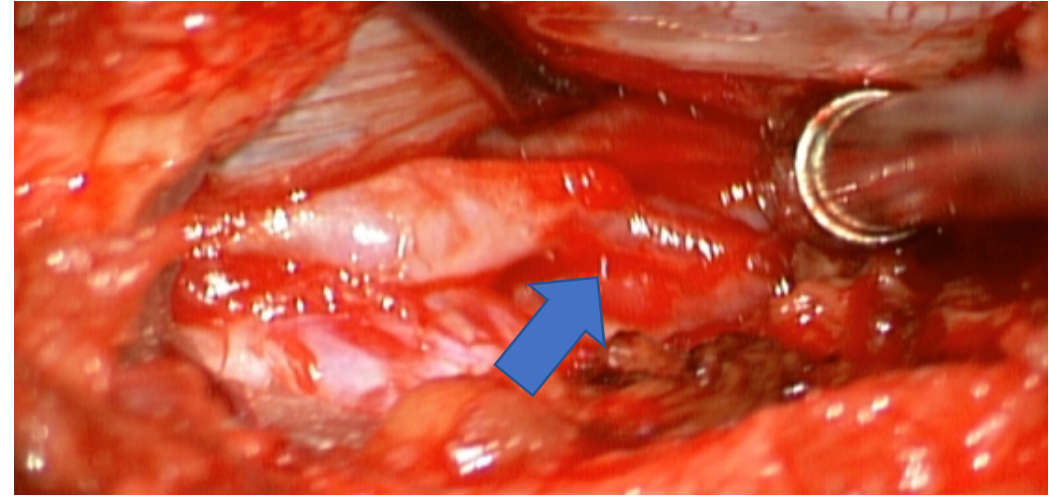
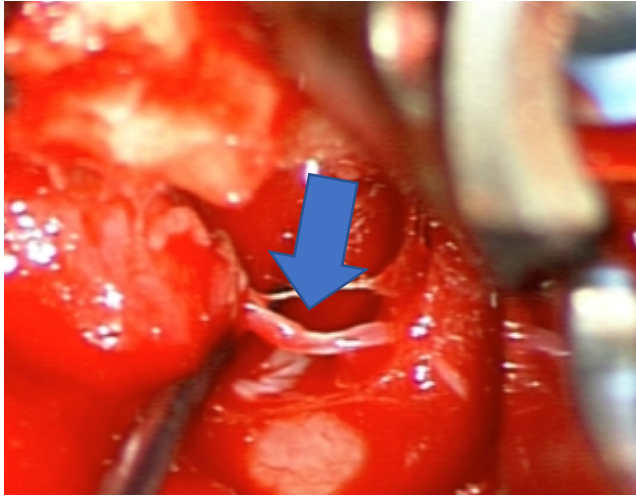
Surgical options

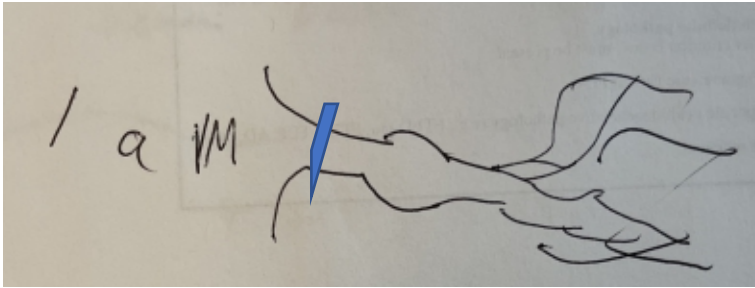
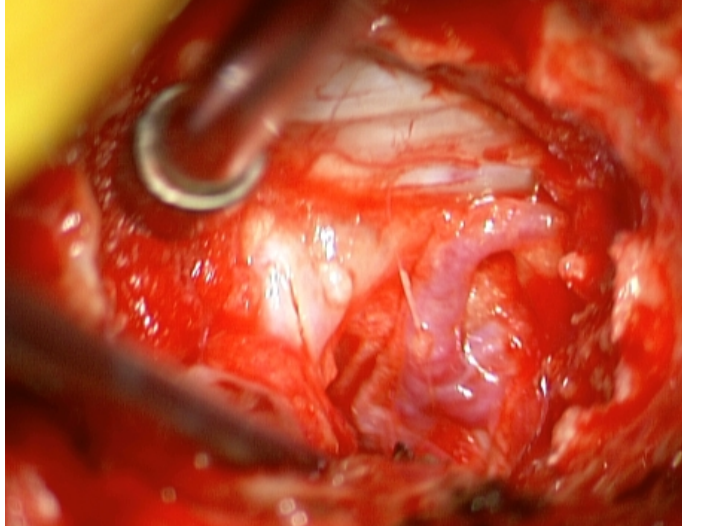
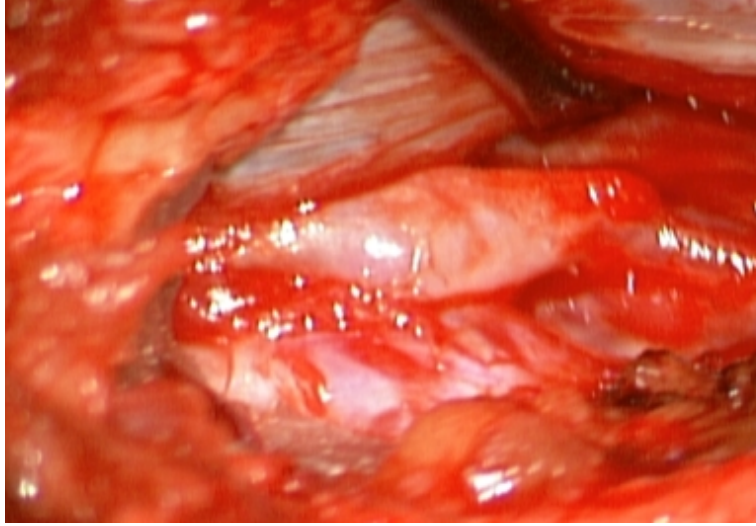
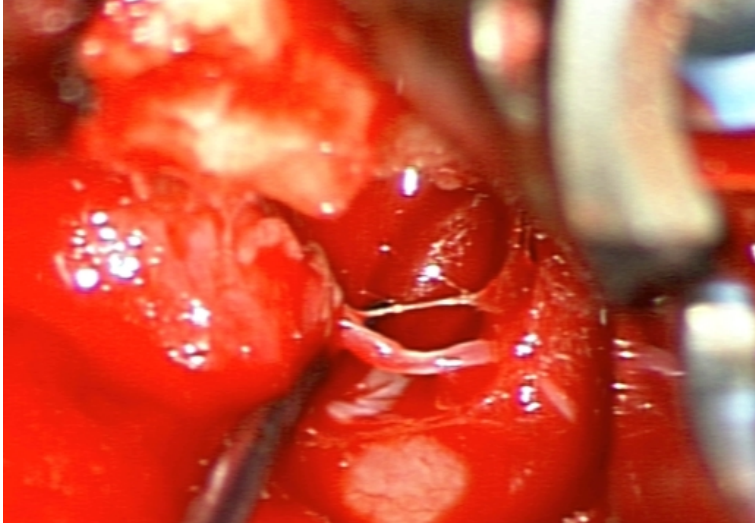
Option A: Clip/cauterize fistulous connection

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

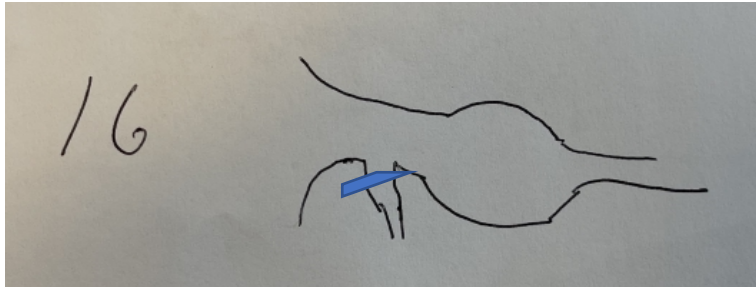


Type 3 CSF leak - CSF-venous fistulas

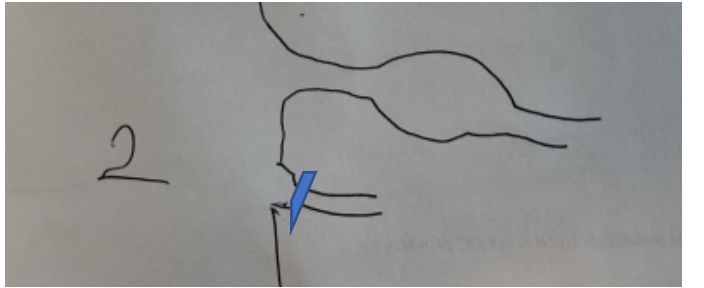




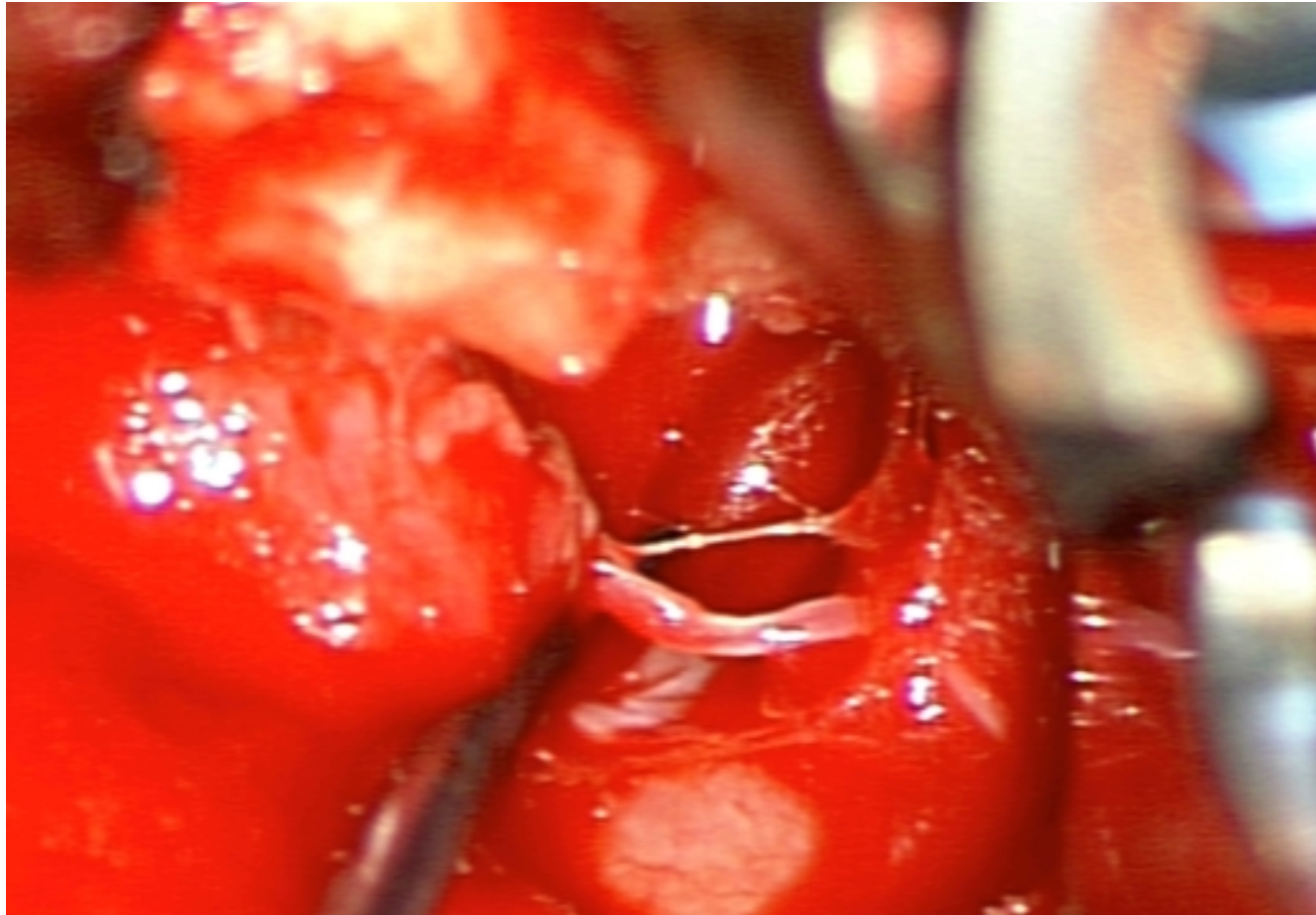
75%



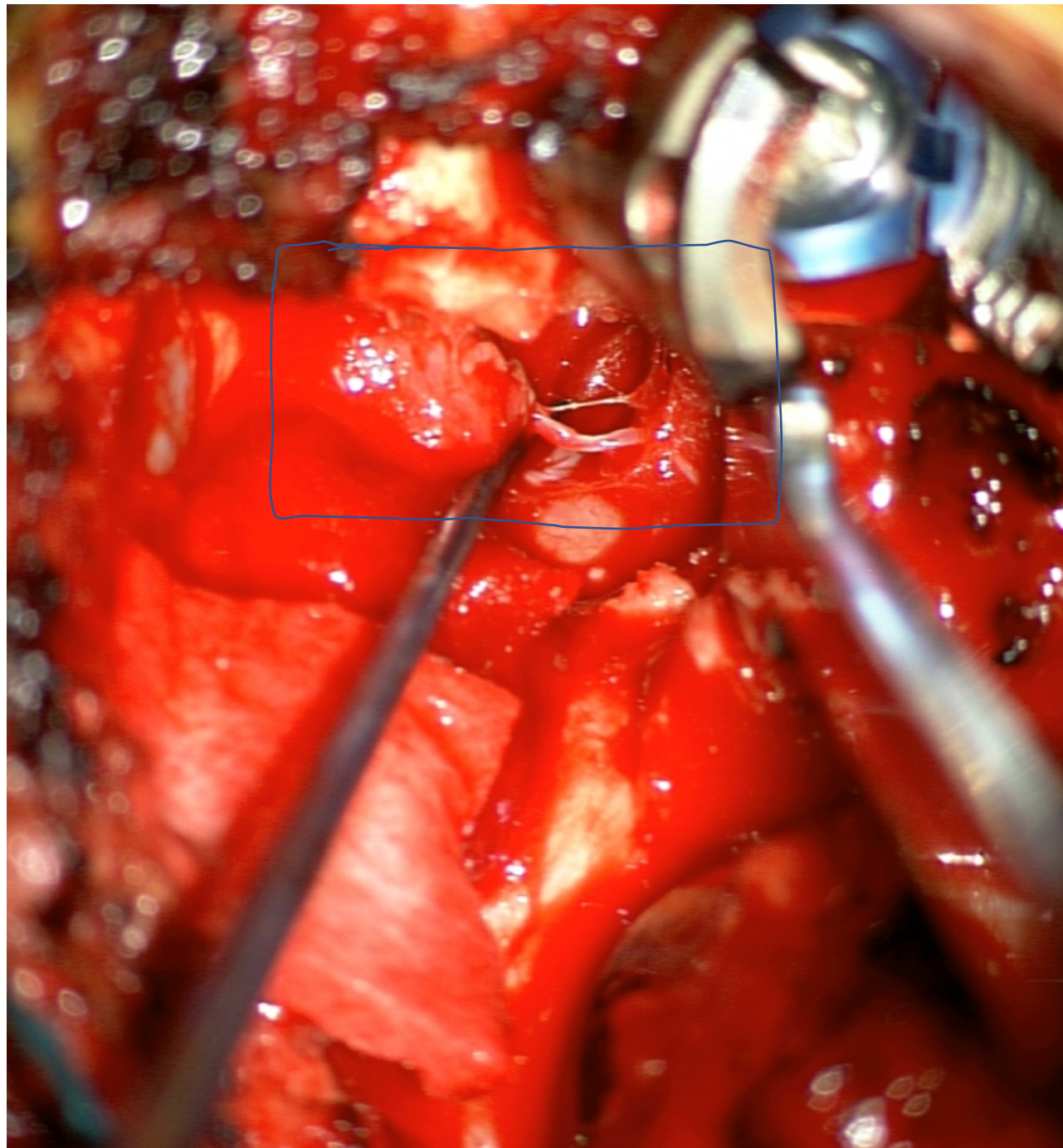
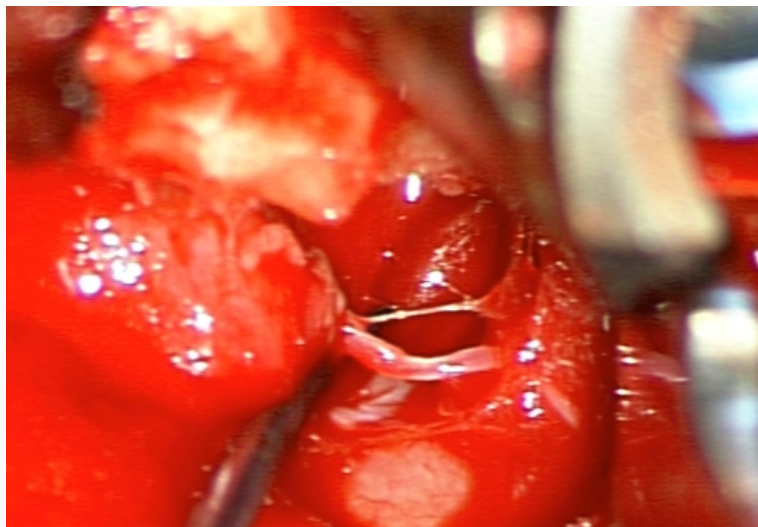
15%



10%

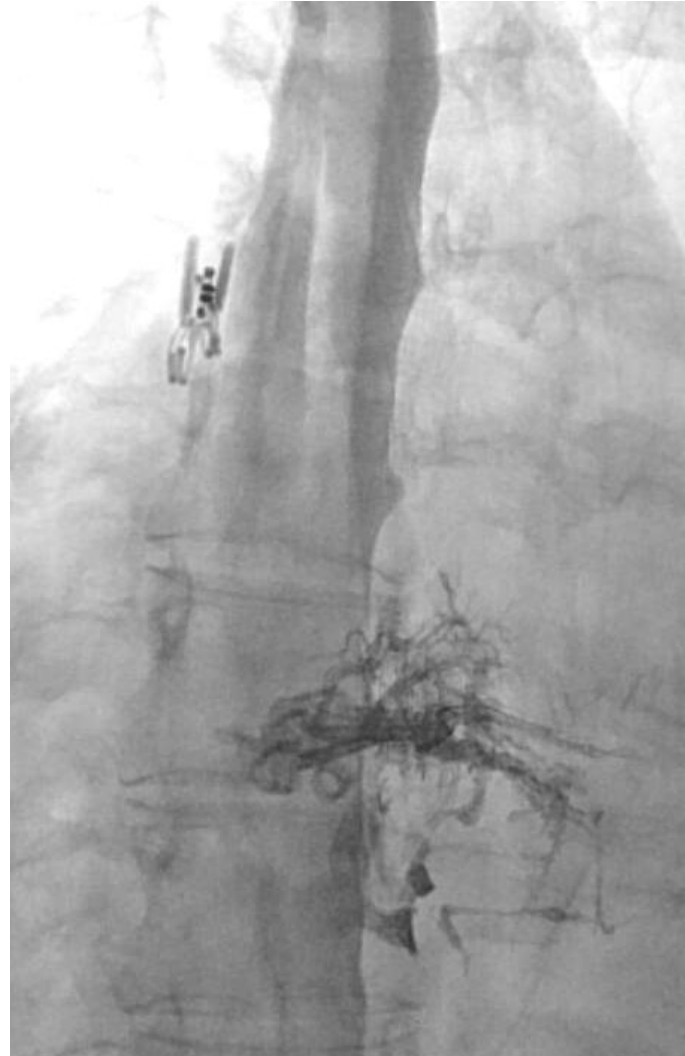


For type 1a fistula and “eloquent” nerve root: endovascular treatment best



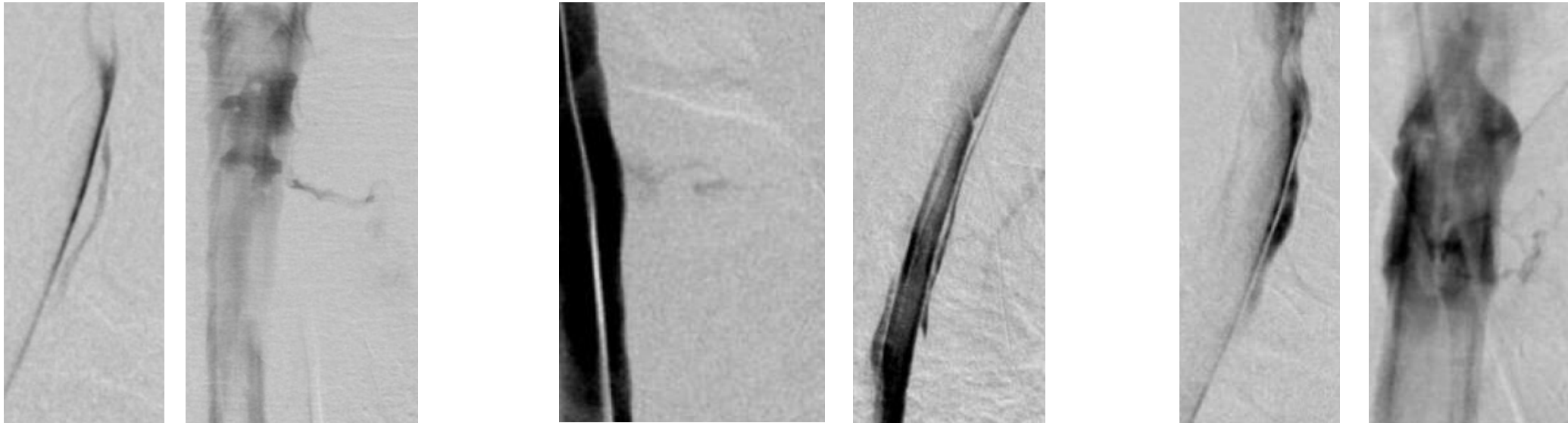
Combination treatment for complex CSF-venous fistulas

- Surgical clipping
- Endovascular onyx embolization
- Percutaneous fibrin sealant injection
- Percutaneous onyx injection



Type 3 CSF leaks – CSF-venous fistulas

Intradural approach only when coexists with type 1a ventral dural tear



Thank you!



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