

# Spontaneous intracranial hypotension associated with transdural thoracic osteophyte reversed by primary dural repair

## Case report

DEVIN K. BINDER, M.D., PH.D., VAHÉ SARKISSIAN, M.D., WILLIAM P. DILLON, M.D.,  
AND PHILIP R. WEINSTEIN, M.D.

*Departments of Neurological Surgery and Radiology, University of California at San Francisco, California*

✓ Spontaneous intracranial hypotension (SIH) is an increasingly recognized syndrome associated with a specific set of clinical and imaging findings; however, determining the site of spinal cerebrospinal fluid (CSF) leakage in these patients is often difficult, and indications for surgical intervention need to be better defined. The authors report on a 55-year-old woman who presented with posture-related headache, disorientation, and memory impairment. Imaging features were consistent with SIH. Computerized tomography myelography demonstrated a large T2–3 anterior transdural osteophyte associated with a CSF fistula. After an unsuccessful trial of conservative therapy, the patient underwent median sternotomy, T2–3 discectomy and removal of osteophyte, which allowed adequate exposure for primary dural repair. Postoperatively, there was immediate and prolonged resolution of all of her symptoms. This case of SIH was caused by transdural penetration by an anterior osteophyte and CSF leakage in the upper thoracic spine, which was treated effectively by anterior exposure and primary dural repair. Aggressive surgical intervention may be required to treat upper thoracic CSF leaks refractory to other measures.

**KEY WORDS** • cerebrospinal fluid leak • intracranial hypotension • thoracotomy • median sternotomy • osteophyte • blood patch

ORIGINALLY described by the German neurologist Schaltenbrand<sup>51,52</sup> in 1938 as “hypoliqorrhoea,” SIH is a condition of low CSF volume caused most often by a spinal CSF leak. Hallmark signs and symptoms associated with SIH include orthostatic headache, neck pain or stiffness, nausea, vomiting, horizontal diplopia, dizziness, hearing and visual changes, phonophobia, photophobia, and, in some cases, frank obtundation.<sup>6,24,32,38,57,70</sup> Conservative management and surgery have both been used to treat SIH, but their relative roles need to be better defined.

In this paper, we present a case of SIH caused by CSF leakage from a lesion in the upper thoracic spine. Conservative management proved unsuccessful, and surgical treatment by median sternotomy and osteophylectomy proved necessary to enable adequate exposure for primary dural repair.

---

*Abbreviations used in this paper:* CSF = cerebrospinal fluid; CT = computerized tomography; MR = magnetic resonance; SIH = spontaneous intracranial hypotension.

## Case Report

*Presentation and Examination.* This 55-year-old woman presented with a 6-week history of severe holocranial headache, which worsened when she was upright and improved when she was recumbent. She also experienced aural fullness, memory difficulties, and disorientation. On admission brain MR imaging demonstrated the classic imaging finding of SIH (Fig. 1A). A large-volume (30-ml) lumbar epidural blood patch was placed, but it only provided temporary symptomatic improvement. Postmyelography CT scanning demonstrated a CSF fistula centered in the anterior upper thoracic spine associated with a large ventral osteophyte (Fig. 2). An MR image of the spine was not obtained.

*Operation.* The patient was taken to the operating room where she underwent a median sternotomy and anterior T2–3 discectomy. This enabled visualization of the large ventral T2–3 osteophyte. The osteophyte was debrided using a high-speed drill. After completion of the osteophylectomy, the dural defect became apparent, although a small amount of arachnoid had herniated into the space

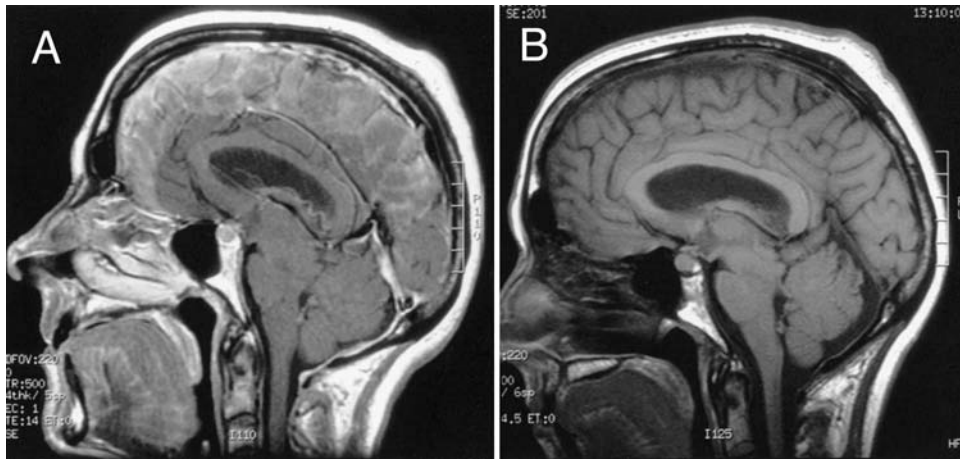


FIG. 1. Sagittal MR images. A: Preoperative T<sub>1</sub>-weighted image demonstrating brain sag, effacement of the suprasellar and basal cisterns, and diffuse dural enhancement—classic imaging findings of SIH. B: Postoperative image revealing partial reversal of brain sag and restoration of suprasellar and basal cisterns.

and had sealed off the leak. Gentle mechanical displacement of the arachnoid led to prompt egress of CSF under medium pressure. The linear dural defect resulting from the osteophyte was repaired by placing two nonabsorbable vertical mattress sutures and a small piece of interposed muscle, and fibrin glue was applied. No fusion procedure was performed.

**Postoperative Course.** Postoperatively, the patient was maintained on bed rest for 48 hours. Her headache, aural fullness, and neurological symptoms resolved completely within 24 hours of surgery. She was mobilized on postoperative Day 2 without difficulty. Repeated MR imaging on postoperative Day 4 demonstrated partial reversal of brain sag and other imaging manifestations of SIH (Fig. 1B). She was discharged on postoperative Day 7. Since discharge (> 1 year), she has suffered no recurrence of orthostatic headache or other neurological symptoms.

## Discussion

### History and Origin of the System

Schaltenbrand<sup>51,52</sup> was the first to describe a condition of spontaneously low or even negative CSF pressures with orthostatic headaches, which he termed primary spontaneous intracranial hypotension or “essential aliquorrhoea.” Subsequent investigators have further defined this syndrome of intracranial hypotension or hypoliquorrhoea.<sup>4,27,28,72</sup>

It was originally controversial whether the low CSF volume state resulted from decreased CSF production, increased CSF resorption, or CSF leakage.<sup>21,26,39,51,52,69</sup> In 1992, Rando and Fishman<sup>48</sup> hypothesized that the mechanism of CSF leakage involved spontaneous rupture of a spinal arachnoid (Tarlov) cyst. Based on this report and on subsequent series, it is now clear that spinal CSF leaks are the most common cause of SIH.<sup>53,57</sup> Most CSF leaks are spontaneous and probably result from weakness of the spinal meninges,<sup>32,40,57,59</sup> but generalized connective tissue disorders (for example, Marfan syndrome),<sup>9,14,19,54,56,57,63</sup> local trauma (for example, osteophyte piercing dura, as in our case),<sup>12,53,67</sup> so-called nude nerve root syndrome,<sup>55</sup> or iatrogenic overdrainage of CSF<sup>50</sup> may contribute in some cases.

### Clinical Manifestations

Spontaneous intracranial hypotension is nearly always<sup>41,60</sup> characterized by orthostatic headache. The onset of headache is usually gradual or subacute, but patients may present with so-called thunderclap headache.<sup>62</sup> The headache may be holocranial or localized to the frontal or occipital regions. It is probably caused by a loss of CSF volume and subsequent traction on the pain-sensitive intracranial dura due to downward brain displacement.

Associated findings are quite varied and may include neck pain or stiffness, interscapular pain, nausea, vomiting, and cranial neuropathies.<sup>4,7,37,53,57,70</sup> Distinct cranial neuropathies described in association with SIH include abducent (horizontal diplopia), oculomotor, trigeminal (facial pain/paresthesias), vestibulocochlear (dizziness and hearing changes, phonophobia), and optic (blurred vision, photophobia, and transient visual obscurations).<sup>15,24,37,41,45,57,68</sup> Occasionally SIH may present with predominantly motor manifestations.<sup>41,42</sup> In some cases, severe brain sag may lead to signs of central (transtentorial) herniation and patients may suffer stupor due to diencephalic compression.<sup>3,6,44,57</sup>

### Diagnosis of SIH

Neuroradiological evaluation is essential for diagnosis and for accurate localization of the site of the CSF leak.<sup>17,22,35,43,49</sup> The main imaging findings of SIH are brought about because the CSF volume has been reduced, which, according to the Monro–Kellie rule, induces venous engorgement;<sup>17,31</sup> the imaging characteristics thus include the following: 1) pachymeningeal enhancement; 2) enlargement of the dural venous sinuses; and 3) descent of the brain into the posterior fossa (also called brain sag or pseudo-Chiari malformation).<sup>7,17,30,34,35,37,43,49,61,65</sup> Other associated features include venous engorgement of the pituitary gland,<sup>1,33,38</sup> chiasmatic drooping on the dorsum sellae, collapse of the superior ophthalmic veins,<sup>8</sup> and spontaneous subdural hygromas. Meningeal biopsy sampling is unnecessary for establishing a diagnosis.<sup>16,18,25,36</sup>

### Localization of the Site of a CSF Fistula

Localization of the site of a CSF fistula can be difficult



FIG. 2. A: Axial CT myelogram obtained at T2–3 demonstrating a 5-mm bone osteophyte penetrating the anterior dura (arrow) and extradural contrast collection (arrowhead). B: Sagittal reconstruction of CT myelogram revealing an osteophyte arising from superior endplate of T-3 (arrow).

and requires expert neuroradiological/neuroimaging consultation. Most commonly, spontaneous CSF leaks occur in the lower cervical or upper thoracic region. The initial study of choice is fat-suppressed fast-spin echo MR imaging of the spine,<sup>10</sup> which may demonstrate an extradural collection of CSF or a prominent perineural cyst. Supportive evidence includes CSF hygroma, epidural venous engorgement and dural enhancement, and paraspinous fluid collections behind the C1–2 segment.<sup>10</sup> Spinal MR imaging, however, is often unable to reveal the actual site of CSF leakage.<sup>37,46,48,57</sup> Furthermore, the location of an epidural collection does not necessarily correlate with the site of the CSF fistula.<sup>10</sup> Postmyelography CT scanning is currently the study of choice to demonstrate extrathecal contrast accumulation or define anatomical abnormalities such as meningeal diverticula;<sup>10,11,57</sup> however, it still may not demonstrate the site of the leak. In such cases, it may be necessary to perform dynamic myelography or dynamic postmyelography CT scanning in which contrast is instilled in the scanner and repetitive CT scans are obtained.

Radionuclide cisternography has also been used to evaluate spinal CSF leaks,<sup>9,26,39,48</sup> but it is less sensitive than postmyelography CT scanning and has poorer spatial resolution.<sup>57</sup> It is primarily applied in cases of cranial CSF leaks. The newer modality of MR myelography may prove useful.<sup>29,47</sup>

#### Nonsurgical Treatment

In cases of SIH the patient's headache usually resolves spontaneously after bed rest and provision of fluids. Pharmacological management is largely ineffective.<sup>18,23</sup> In cases involving intractable persistent headache or other signs and symptoms of SIH, the initial treatment of choice is a large-volume (> 20-ml) epidural blood patch,<sup>5,11,20,37,57</sup> following which the patient should be placed in a head-down reverse Trendelenberg position.<sup>2,66</sup> Relief of symptoms is often immediate, secondary to thecal compression and increased CSF pressure, but symptoms may recur if leakage persists. Occasionally, several large-volume blood patches are necessary for permanent benefit.<sup>11,64</sup> Accurate local-

ization of the leakage by CT myelography can allow an epidural blood patch to be placed at the site of the leak. If the patient suffers mental status deterioration due to brain sag,<sup>3,6,44,57</sup> lumbar intrathecal infusion with Elliott B solution (artificial CSF) may be required to arrest or reverse impending central (transtentorial) herniation.<sup>6</sup>

#### Surgical Management of Spinal CSF Leaks

Surgical exploration and repair have been successful in cases refractory to conservative management.<sup>13,44,55,58,59,67</sup> In a retrospective analysis of 10 patients treated surgically for spontaneous spinal CSF leaks between 1992 and 1997, the authors found that although symptomatic relief occurred postoperatively in all cases, preoperative diagnostic imaging findings did not always correlate with intraoperative findings.<sup>58</sup> During their mean follow-up period of 19 months, there was no recurrence of symptoms in any case.

Only a few previous cases of osteophyte-related SIH have been reported.<sup>13,58,67,71</sup> For example, CSF leakage associated with cervical bone spurs has been reported.<sup>13,58,67</sup> In one case, CT myelography demonstrated a high-flow CSF leak anterior to C5–6; this was confirmed on radionuclide cisternography. A midline bone spur protruding through the posterior longitudinal ligament into the thecal sac was successfully extracted via an anterior approach, and primary dural closure was then performed.<sup>67</sup> Postoperatively, MR imaging demonstrated resolution of SIH.<sup>67</sup>

Eross, et al.,<sup>13</sup> reported on three patients with SIH caused by osseous pathological entities of the cervical spine. Their first patient had midline anterior bone spurs adjoining the C5–6 interface and CT myelography evidence of a leak starting at C-6 with contrast pooling to T-11. Efforts at conservative management had failed, and the patient underwent C-5 discectomy and partial C5–6 corpectomy. Intraoperatively, the C-5 bone spur was mobilized, which provided exposure but also led to enlargement of a dural tear.<sup>13,67</sup> Multiple distinct procedures were performed to repair the dural defect, including further spur

## Thoracic dural cerebrospinal fluid leak repair

debridement, C6–7 corpectomy, and placement of a lumbo-peritoneal shunt.<sup>13</sup> Because primary dural closure was not successful, this patient continued to be incapacitated by orthostatic headaches 24 months after onset.

Unlike the variety of case reports of cervical disease associated with CSF leakage and SIH, to our knowledge there is only one documented case of SIH secondary to a thoracic bone spur.<sup>71</sup> In that case a calcified T7–8 disc indented the thecal sac, and myelography demonstrated pooling of extrathecal contrast at the same level. Primary surgical repair of the CSF fistula and removal of the herniated disc were considered, but instead the authors opted for localized T7–8 epidural blood patch. Despite clinical improvement, recurrent or increased size of a right subdural collection prompted burr hole drainage, which was repeated 1 week later following recurrence of headache. The authors report that ultimately the patient became asymptomatic despite the fact that a direct surgical effort at primary spinal dural CSF leak repair was not performed.

### Conclusions

In summary, we have detailed a case of symptomatic SIH due to an upper thoracic CSF leak resulting from a large transdural anterior osteophyte. An appropriate trial of conservative management was ineffective. Median sternotomy, anterior T2–3 discectomy, and osteophyte removal exposed a high-flow CSF fistula, and primary dural repair led to rapid reversal of symptoms.

To our knowledge, this is the first case report of median sternotomy for operative repair of a thoracic CSF leak causing SIH. The results of this case, together with our review of the literature, demonstrate that aggressive operative exposure may be necessary for primary dural repair in cases of SIH refractory to conservative therapy. Because most identified sites of spontaneous CSF leakage are in the cervical or thoracic region, at times extensive operative approaches may be necessary. We encourage all neurosurgeons to become familiar with the diagnosis and treatment of SIH as well as the potential for operative intervention to effect a cure.

### References

1. Alvarez-Linera J, Escribano J, Benito-León J, Porta-Etessam J, Rovira A: Pituitary enlargement in patients with intracranial hypotension syndrome. **Neurology** **55**:1895–1897, 2000
2. Beards SC, Jackson A, Griffiths AG, Horsman EL: Magnetic resonance imaging of extradural blood patches: appearances from 30 min to 18 h. **Br J Anaesth** **71**:182–188, 1993
3. Beck CE, Rizk NW, Kiger LT, Spencer D, Hill L, Adler JR: Intracranial hypotension presenting with severe encephalopathy. Case report. **J Neurosurg** **89**:470–473, 1998
4. Bell WE, Joynt RJ, Sahs AL: Low spinal fluid pressure syndromes. **Neurology** **10**:512–521, 1960
5. Benzon HT, Nemickas R, Molloy RE, Ahmad S, Melen O, Cohen B: Lumbar and thoracic epidural blood injections to treat spontaneous intracranial hypotension. **Anesthesiology** **85**:920–922, 1996
6. Binder DK, Dillon WP, Fishman RA, Schmidt MH: Intrathecal saline infusion in the treatment of obtundation associated with spontaneous intracranial hypotension: technical case report. **Neurosurgery** **51**:830–837, 2002
7. Blank SC, Shakir RA, Bindoff LA, Bradey N: Spontaneous intracranial hypotension: clinical and magnetic resonance imaging characteristics. **Clin Neurol Neurosurg** **99**:199–204, 1997
8. Chen WT, Fuh JL, Limg JF, Lu SR, Wu ZA, Wang SJ: Collapsed superior ophthalmic veins in patients with spontaneous intracranial hypotension. **Neurology** **61**:1265–1267, 2003
9. Davenport RJ, Chataway SJ, Warlow CP: Spontaneous intracranial hypotension from a CSF leak in a patient with Marfan's syndrome. **J Neurol Neurosurg Psychiatry** **59**:516–519, 1995
10. Dillon WP: Spinal manifestations of intracranial hypotension. **AJNR** **22**:1233–1234, 2001
11. Dillon WP, Fishman RA: Some lessons learned about the diagnosis and treatment of spontaneous intracranial hypotension. **AJNR** **19**:1001–1002, 1998
12. Dodick DW, Bosch EP, Lyons MK: Orthostatic headache syndrome with CSF leak secondary to bony pathology of the cervical spine. **Neurology** **54** (Suppl 3):A129, 2000 (Abstract)
13. Eross EJ, Dodick DW, Nelson KD, Bosch P, Lyons M: Orthostatic headache syndrome with CSF leak secondary to bony pathology of the cervical spine. **Cephalalgia** **22**:439–443, 2002
14. Fattori R, Nienaber CA, Descovich B, Ambrosetto P, Reggiani LB, Pepe G, et al: Importance of dural ectasia in phenotypic assessment of Marfan's syndrome. **Lancet** **354**:910–913, 1999
15. Ferrante E, Savino A, Brioschi A, Marazzi R, Donato MF, Riva M: Transient oculomotor cranial nerves palsy in spontaneous intracranial hypotension. **J Neurosurg Sci** **42**:177–180, 1998
16. Fishman RA: Intracranial hypotension. **Neurology** **44**:1981–1982, 1994
17. Fishman RA, Dillon WP: Dural enhancement and cerebral displacement secondary to intracranial hypotension. **Neurology** **43**:609–611, 1993
18. Fishman RA, Dillon WP: Spontaneous intracranial hypotension causing reversible frontotemporal dementia. **Neurology** **59**:787, 2002
19. Fukutake T, Sakakibara R, Mori M, Araki M, Hattori T: Chronic intractable headache in a patient with Marfan's syndrome. **Headache** **37**:291–295, 1997
20. Gaukroger PB, Brownridge P: Epidural blood patch in the treatment of spontaneous low CSF pressure headache. **Pain** **29**:119–122, 1987
21. Gibson BE, Wedel DJ, Faust RJ, Petersen RC: Continuous epidural saline infusion for the treatment of low CSF pressure headache. **Anesthesiology** **68**:789–791, 1988
22. Hochman MS, Naidich TP, Kobetz SA, Fernandez-Maitin A: Spontaneous intracranial hypotension with pachymeningeal enhancement on MRI. **Neurology** **42**:1628–1630, 1992
23. Hong M, Shah GV, Adams KM, Turner RS, Foster NL: Spontaneous intracranial hypotension causing reversible frontotemporal dementia. **Neurology** **58**:1285–1287, 2002
24. Horton JC, Fishman RA: Neurovisual findings in the syndrome of spontaneous intracranial hypotension from dural cerebrospinal fluid leak. **Ophthalmology** **101**:244–251, 1994
25. Ishihara S, Fukui S, Otani N, Miyazawa T, Ohnuki A, Kato H, et al: Evaluation of spontaneous intracranial hypotension: assessment on ICP monitoring and radiological imaging. **Br J Neurosurg** **15**:239–241, 2001
26. Labadie EL, van Antwerp J, Bamford CR: Abnormal lumbar isotope cisternography in an unusual case of spontaneous hypotensive headache. **Neurology** **26**:135–139, 1976
27. Lasater GM: Primary intracranial hypotension. The low spinal fluid pressure syndrome. **Headache** **10**:63–66, 1970
28. Marcellis J, Silberstein SD: Spontaneous low cerebrospinal fluid pressure headache. **Headache** **30**:192–196, 1990
29. Matsumura A, Anno I, Kimura H, Ishikawa E, Nose T: Diagnosis of spontaneous intracranial hypotension by using magnetic resonance myelography. Case report. **J Neurosurg** **92**:873–876, 2000
30. Messori A, Simonetti BF, Regnicolo L, Di Bella P, Logullo F, Salvolini U: Spontaneous intracranial hypotension: the value of

- BRI measurements in diagnosis by MRI. **Neuroradiology** **43**:453–461, 2001
31. Mokri B: The Monro-Kellie hypothesis: applications in CSF volume depletion. **Neurology** **56**:1746–1748, 2001
  32. Mokri B: Spontaneous cerebrospinal fluid leaks: from intracranial hypotension to cerebrospinal fluid hypovolemia—evolution of a concept. **Mayo Clin Proc** **74**:1113–1123, 1999
  33. Mokri B, Atkinson JL: False pituitary tumor in CSF leaks. **Neurology** **55**:573–575, 2000
  34. Mokri B, Atkinson JL, Dodick DW, Miller GM, Piepgras DG: Absent pachymeningeal gadolinium enhancement on cranial MRI despite symptomatic CSF leak. **Neurology** **53**:402–404, 1999
  35. Mokri B, Krueger BR, Miller GM, Piepgras DG: Meningeal gadolinium enhancement in low-pressure headaches. **Ann Neurol** **30**:294–295, 1991 (Abstract)
  36. Mokri B, Parisi JE, Scheithauer BW, Piepgras DG, Miller GM: Meningeal biopsy in intracranial hypotension: meningeal enhancement on MRI. **Neurology** **45**:1801–1807, 1995
  37. Mokri B, Piepgras DG, Miller GM: Syndrome of orthostatic headaches and diffuse pachymeningeal gadolinium enhancement. **Mayo Clin Proc** **72**:400–413, 1997
  38. Mokri B, Posner JB: Spontaneous intracranial hypotension: the broadening clinical and imaging spectrum of CSF leaks. **Neurology** **55**:1771–1772, 2000
  39. Molins A, Alvarez J, Sumalla J, Titus F, Codina A: Cisternographic pattern of spontaneous liquoral hypotension. **Cephalalgia** **10**:59–65, 1990
  40. Nosik WA: Intracranial hypotension secondary to lumbar nerve sleeve tear. **JAMA** **157**:1110–1111, 1955
  41. Nowak DA, Rodiek SO, Zinner J, Guhlmann A, Topka H: Broadening the clinical spectrum: unusual presentation of spontaneous cerebrospinal fluid hypovolemia. Case report. **J Neurosurg** **98**:903–907, 2003
  42. Pakiam AS, Lee C, Lang AE: Intracranial hypotension with parkinsonism, ataxia, and bulbar weakness. **Arch Neurol** **56**:869–872, 1999
  43. Pannullo SC, Reich JB, Krol G, Deck MD, Posner JB: MRI changes in intracranial hypotension. **Neurology** **43**:919–926, 1993
  44. Pleasure SJ, Abosch A, Friedman J, Ko NU, Barbaro N, Dillon W, et al: Spontaneous intracranial hypotension resulting in stupor caused by diencephalic compression. **Neurology** **50**:1854–1857, 1998
  45. Portier F, de Minteguiaga C, Racy E, Huy PT, Herman P: Spontaneous intracranial hypotension: a rare cause of labyrinthine hydrops. **Ann Otol Rhinol Laryngol** **111**:817–820, 2002
  46. Rabin B, Roychowdhury J, Meyer JR, Cohen BA, LaPat KD, Russell EJ: Spontaneous intracranial hypotension: spinal MR findings. **AJNR** **19**:1034–1049, 1998
  47. Ramsbacher J, Schilling AM, Wolf KJ, Brock M: Magnetic resonance myelography (MRM) as a spinal examination technique. **Acta Neurochir** **139**:1080–1084, 1997
  48. Rando TA, Fishman RA: Spontaneous intracranial hypotension: report of two cases and review of the literature. **Neurology** **42**:481–487, 1992
  49. Sable SG, Ramadan NM: Meningeal enhancement and low CSF pressure headache. An MRI study. **Cephalalgia** **11**:275–276, 1991
  50. Samadani U, Huang JH, Baranov D, Zager EL, Grady MS: Intracranial hypotension after intraoperative lumbar cerebrospinal fluid drainage. **Neurosurgery** **52**:148–152, 2003
  51. Schaltenbrand G: Neuere Anschauungen zur Pathophysiologie der Liquorzirkulation. **Zentralbl Neurochir** **3**:290–300, 1938
  52. Schaltenbrand G: Normal and pathological physiology of the cerebrospinal fluid circulation. **Lancet** **1**:805–808, 1953
  53. Schievink WI: Spontaneous spinal cerebrospinal fluid leaks: a review. **Neurosurg Focus** **9**(1):E8, 2000
  54. Schievink WI, Gordon OK, Tourje J: Connective tissue disorders with spontaneous spinal cerebrospinal fluid leaks and intracranial hypotension: a prospective study. **Neurosurgery** **54**:65–71, 2004
  55. Schievink WI, Jacques L: Recurrent spontaneous spinal cerebrospinal fluid leak associated with “nude nerve root” syndrome: case report. **Neurosurgery** **53**:1216–1219, 2003
  56. Schievink WI, Meyer F, Schrijver I, Francke U: A syndrome of spontaneous spinal cerebrospinal fluid leaks and skeletal features of Marfan syndrome. **Ann Neurol** **44**:458, 1998
  57. Schievink WI, Meyer FB, Atkinson JL, Mokri B: Spontaneous spinal cerebrospinal fluid leaks and intracranial hypotension. **J Neurosurg** **84**:598–605, 1996
  58. Schievink WI, Morreale VM, Atkinson JL, Meyer FB, Piepgras DG, Ebersold MJ: Surgical treatment of spontaneous spinal cerebrospinal fluid leaks. **J Neurosurg** **88**:243–246, 1998
  59. Schievink WI, Reimer R, Folger WN: Surgical treatment of spontaneous intracranial hypotension associated with a spinal arachnoid diverticulum. Case report. **J Neurosurg** **80**:736–739, 1994
  60. Schievink WI, Smith KA: Nonpositional headache caused by spontaneous intracranial hypotension. **Neurology** **51**:1768–1769, 1998
  61. Schievink WI, Tourje J: Intracranial hypotension without meningeal enhancement on magnetic resonance imaging. Case report. **J Neurosurg** **92**:475–477, 2000
  62. Schievink WI, Wijdicks EF, Meyer FB, Sonntag VK: Spontaneous intracranial hypotension mimicking aneurysmal subarachnoid hemorrhage. **Neurosurgery** **48**:513–517, 2001
  63. Schrijver I, Schievink WI, Godfrey M, Meyer FB, Francke U: Spontaneous spinal cerebrospinal fluid leaks and minor skeletal features of Marfan syndrome: a microfibrilopathy. **J Neurosurg** **96**:483–489, 2002
  64. Sencakova D, Mokri B, McClelland RL: The efficacy of epidural blood patch in spontaneous CSF leaks. **Neurology** **57**:1921–1923, 2001
  65. Spelle L, Boulin A, Tainturier C, Visot A, Graveleau P, Pierot L: Neuroimaging features of spontaneous intracranial hypotension. **Neuroradiology** **43**:622–627, 2001
  66. Szeinfeld M, Ihmeidan IH, Moser MM, Machado R, Klose KJ, Serafini AN: Epidural blood patch: evaluation of the volume and spread of blood injected into the epidural space. **Anesthesiology** **64**:820–822, 1986
  67. Vishteh AG, Schievink WI, Baskin JJ, Sonntag VK: Cervical bone spur presenting with spontaneous intracranial hypotension. Case report. **J Neurosurg** **89**:483–484, 1998
  68. Warner GT: Spontaneous intracranial hypotension causing a partial third cranial nerve palsy: a novel observation. **Cephalalgia** **22**:822–823, 2002
  69. Weber WE, Heidendal GA, de Krom MC: Primary intracranial hypotension and abnormal radionuclide cisternography. Report of a case and review of the literature. **Clin Neurol Neurosurg** **93**:55–60, 1991
  70. Weitz SR, Drasner K: Spontaneous intracranial hypotension: a series. **Anesthesiology** **85**:923–925, 1996
  71. Winter SC, Maartens NF, Anslow P, Teddy PJ: Spontaneous intracranial hypotension due to thoracic disc herniation. Case report. **J Neurosurg (Spine)** **96**:343–345, 2002
  72. Woltman HW: Headache: a consideration of some of the more common types. **Med Clin North Am** **24**:1159–1170, 1940

Manuscript received July 19, 2004.

Accepted in final form February 9, 2005.

Address reprint requests to: Devin K. Binder, M.D., Ph.D., Department of Neurological Surgery, University of California at San Francisco, M779 Moffitt Hospital, Box 0112, San Francisco, California 94143-0112. email: dbinder@itsa.ucsf.edu.