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T El Gammal, W Sobol, V R Wadlington, M J Sillers, C Crews, W S Fisher, 3rd and J Y Lee

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Cerebrospinal Fluid Fistula: Detection with MR Cisternography

Taher El Gammal, Wlad Sobol, Van R. Wadlington, Michael J. Sillers, Cleve Crews,
Winfield S. Fisher III, and Jeannette Y. Lee

PURPOSE: **Our goal was to assess the role of MR cisternography in the examination of patients with suspected CSF rhinorrhea.**

METHODS: **MR cisternography was performed as a heavily T2-weighted fast spin-echo study with fat suppression and video reversal of the images in 37 patients over a 3-year interval. Twenty-four of the patients subsequently had exploratory surgery for fistula. Statistical analysis of the surgical results was compared with the findings at MR cisternography.**

RESULTS: **MR cisternography showed significant correlation with surgical findings, with sensitivity, specificity, and accuracy of 0.87, 0.57, and 0.78, respectively.**

CONCLUSION: **MR cisternography proved to be an accurate diagnostic imaging technique in the evaluation of suspected CSF rhinorrhea.**

Radiologic localization of a cranial CSF fistula can be difficult, but it is essential for successful surgical repair. Numerous diagnostic studies have been used; however, at present, water-soluble contrast CT cisternography is generally considered the procedure of choice (1–7). Coronal unenhanced thin-section CT is also a valuable, noninvasive adjunctive technique that depicts bony defects associated with CSF leak in some patients (4, 5). Conventional MR imaging has been suggested for the localization of CSF leaks in the petrous bone (8), and, more recently, conventional and fast spin-echo T2-weighted MR sequences have been shown to have an accuracy of 100% in depicting CSF fistulas (9, 10).

The first MR cisternogram was reported in 1986 by DiChiro et al (11), who successfully detected CSF leaks in two dogs by using intrathecal injection of contrast material to enhance CSF. We recently used MR cisternography in the diagnosis of a variety of intracranial lesions, including CSF fistulas (12, 13). This technique, which does not involve the use of contrast material or spinal puncture, is noninvasive and emphasizes and enhances the CSF signal with suppression and subtraction of adjacent background tissue signal by means of a fast spin-echo protocol with fat suppression that was first reported by Krudy in 1992 (14) for evaluation of the spine. During a period of 3 years we used MR cisternography to examine 37 consecutive patients with suspected CSF rhinorrhea.

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From the Departments of Radiology (T.E.G., W.S., V.R.W., C.C.), Otolaryngology (M.J.S.), Neurosurgery (W.S.F.), and Biostatistics Unit, Comprehensive Cancer Center (J.Y.L.), University of Alabama at Birmingham.

Address reprint requests to Taher El Gammal, MD, Department of Radiology, University of Alabama at Birmingham, 619 S 19th St, Birmingham, AL 35233.

Methods

A total of 45 MR cisternographic studies were performed in 37 patients with suspected CSF rhinorrhea during the period from April 1993 to June 1996. The patients ranged in age from 16 to 69 years (mean age, 44 years) and included 19 men and 18 women. A fistula was suspected after craniotomy in 10 patients, after endoscopic sinus surgery in 10, and after trauma in 14; in three patients, there was no history of antecedent surgery or trauma. One of these latter three patients had a history of meningitis and the other two had primary intracranial hypotension.

All patients were examined with a 1.5-T Signa 5.4 MR system (General Electric Medical Systems, Milwaukee, Wis) with 5X Advantage software and a standard head coil. A fast spin-echo sequence with fat suppression was used with parameters of 10 000/200/4 (TR/TEeff/excitations), an echo train length of 16, a 512 × 192 matrix, no phase wrap option, 3-mm-thick interleaved contiguous sections, and a 16-cm field of view. Sixteen sections were acquired in 8 minutes per scan, and two to three scans were needed to cover the area required in each projection. A shorter scan time (4 minutes), which includes eight sections and a TR of 5000, can be added to the 10 000 TR scan to cover the area required. The average time for the MR cisternographic examination, including petrous bones and sinuses in coronal and sagittal projections, was approximately 48 minutes. Both coronal and sagittal images were obtained in 35 patients, and coronal views only were obtained in two cases. Additional diagnostic imaging examinations included thin-section coronal CT in 24 patients, CT cisternography in seven patients, and both coronal CT and CT cisternography in six patients.

Twenty-four of the 37 patients had exploratory surgery for fistula. Twelve patients had craniotomy, 11 patients had endo-

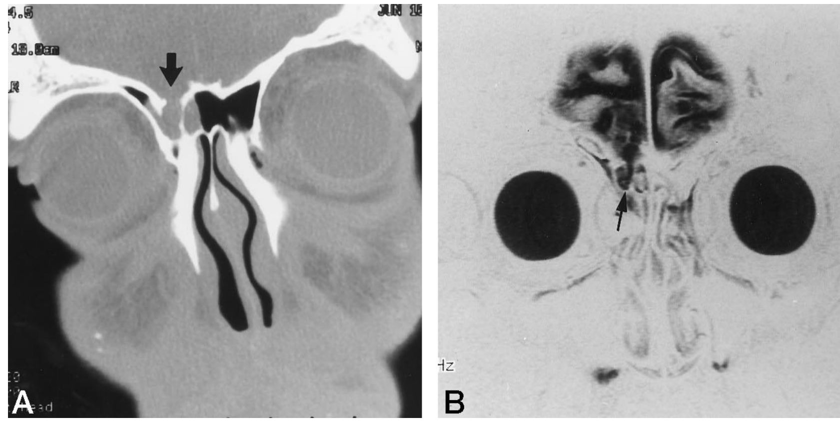

FIG 1. Fistula detection (positive MR cisternography) in a patient with posttraumatic rhinorrhea after a motor vehicle accident.

A, Thin-section coronal CT scan shows bone defect in roof of right anterior ethmoidal sinus (*arrow*).

B, Coronal MR cisternogram shows CSF-intensity fistulous tract (*arrow*) at site of bone defect seen in *A* caused by posttraumatic fistula, confirmed at surgery.

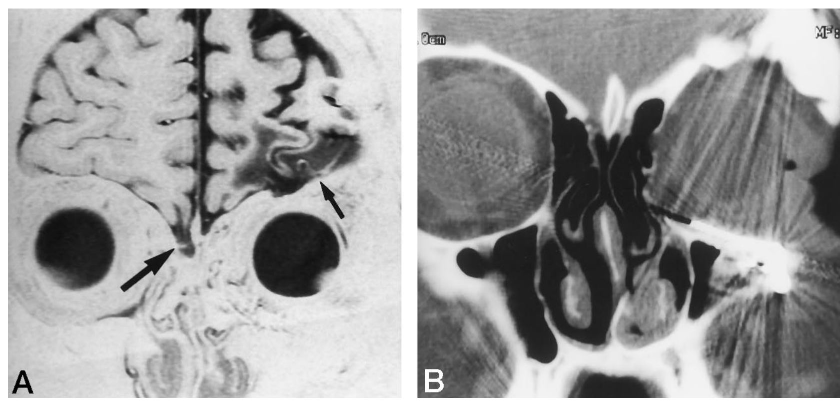

FIG 2. Positive MR cisternography in a patient with posttraumatic fistula that was seen at endoscopic surgery in the right cribriform plate (*large arrow* in *A*).

A, Contused left frontal lobe (*small arrow*) associated with fracture of the left orbit and left ethmoidal sinus.

B, Thin-section coronal CT scan does not show a definite fracture or bone defect on the right side. (This case was not included in the statistical evaluation.)

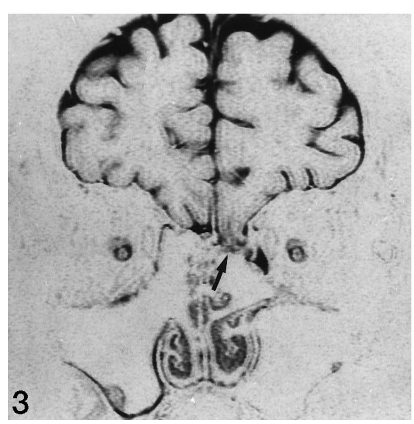

FIG 3. Positive MR cisternography in a patient with brain herniation (*arrow*) into the left anterior ethmoidal sinus after endoscopic surgery. The brain herniation was confirmed at surgery. (This case was not included in the statistical evaluation.)

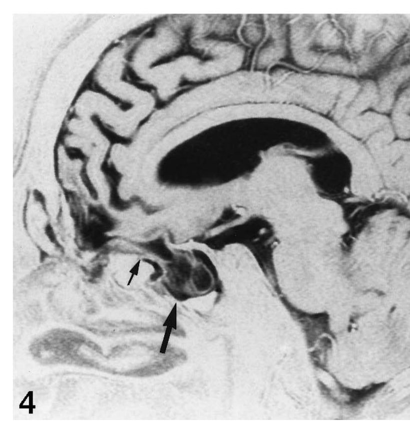

FIG 4. Positive MR cisternography in a patient with posttraumatic herniation of contused brain into the sphenoidal sinus (*arrows*). The patient also had another fistula into the anterior ethmoidal sinus.

scopic surgery, and in one patient craniotomy was performed after unsuccessful endoscopic repair of the fistula.

The MR cisternographic examinations were interpreted only with knowledge of the clinical history; readers were blinded to findings at coronal CT and CT cisternography. The clinical history included information that CSF rhinorrhea was suspected. In the patients with a suspected fistula after craniotomy (n = 10), the location of the fistula (eg, petrous bone, anterior cranial fossa) was known at the time the MR cisternograms were interpreted.

Criteria for performing MR cisternography for the diagnosis of fistula were 1) presence of a continuous T2 high signal from the subarachnoid space to the paranasal sinuses or petrous bone and/or 2) presence of brain herniation into the sinuses or petrous bone (Figs 1–4). MR cisternograms were considered negative for CSF fistula if a definite separation was seen between the CSF of the cranial cavity and the high signal in the paranasal sinuses or petrous bone and no evidence of a fistulous tract was found (Fig 5). Results of surgery were classified as positive if one or more CSF fistulas were identified and localized and as negative if no fistula was found. Surgical criteria for diagnosis of CSF fistula at craniotomy was the presence of a violation of the dura and an osseous defect. At nasal endoscopy, a CSF fistula was diagnosed when an osseous defect of the sinus was identified with an accompanying dural defect with visualization of clear fluid, either pulsatile or elicited with the Valsalva maneuver, and with or without the presence of herniated brain tissue. In some patients, surgery was not performed. Patients who did not have surgery, including those who refused treatment and those who had surgery that did not access the site of suspected fistula so that the MR cisternographic diagnosis could not be confirmed (eg, patients shunted for increased intracranial pressure), were excluded from statistical evaluation (n = 13). Statistical analysis of the MR cisternographic findings as compared with the findings at surgery was performed in the remaining 24 patients.

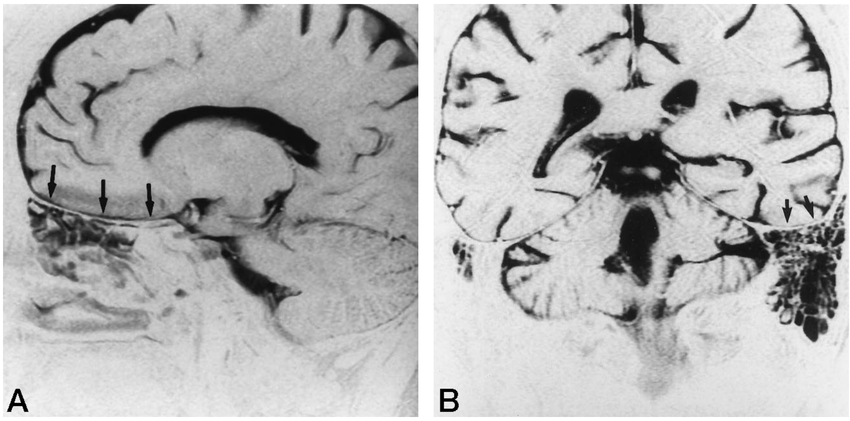

FIG 5. Negative MR cisternography (no fistula detected) in two patients with sinusitis and mastoiditis. There is clear separation between CSF beneath the cerebral hemisphere and adjacent sinuses or petrous bone.

A, Parasagittal MR cisternogram shows clear separation of the CSF beneath the frontal lobe from the high signal (reversed video) of sinus inflammation (*arrows*); no fistula is detected.

B, Coronal MR cisternogram in another patient shows clear separation between CSF beneath the left temporal lobe and inflammatory changes in the mastoid air cells (*arrows*); again, no fistula is detected.

Results

MR cisternography depicted 41 CSF fistulas in 26 patients and was negative for fistulas in 11. Multiple fistulas were detected in 11 patients. The fistulas were located in the ethmoidal (n = 26), frontal (n = 6), and sphenoidal (n = 5) sinuses and in the petrous bone (n = 4).

In the subset of 24 patients who had surgery, 38 fistulas were diagnosed (either as positive or negative) at MR cisternography. Areas that did not show a fistula at MR cisternography and that therefore were not explored surgically were not included in the statistical evaluation. Surgical findings agreed with preoperative MR cisternography in 31 of 38 diagnoses for presence or absence of fistulas (Table). These included 27 MR cisternographic diagnoses of fistulas and four diagnoses negative for fistulas that were surgically verified. Surgical findings differed from those at MR cisternography in seven of 38 cases, including four CSF fistulas found at surgery that were not diagnosed preoperatively by MR cisternography and three fistulas diagnosed at MR cisternography that could not be found at surgery. There was no significant difference between the MR cisternographic results and the surgical findings (McNemar's $\chi^2 = 0$, $P = 1.00$). Sensitivity was 0.87 (95% confidence interval, 0.75, 0.99), specificity was 0.57 (95% confidence interval, 0.29, 0.85), and accuracy was 0.78 (95% confidence interval, 0.65, 0.91).

Correlation of findings at MR cisternography with those at surgery (38 fistulas in 24 patients)

Surgery	MR Cisternography	
	Positive	Negative
Positive	27	4
Negative	3	4

Note.—There was no significant difference between the MR cisternographic results and the surgical findings (McNemar's $\chi^2 = 0$, $P = 1.00$). The sensitivity was 0.87 (95% confidence interval = 0.75, 0.99), specificity was 0.57 (95% confidence interval = 0.29, 0.85), and accuracy rate was 0.78 (95% confidence interval = 0.65, 0.91).

Discussion

CT cisternography was introduced in 1977 (1) and to the present has been considered the procedure of choice in the evaluation of cranial CSF fistulas. However, this is an invasive diagnostic procedure with attendant discomfort and morbidity associated with lumbar spinal puncture and introduction of contrast material into the subarachnoid space.

Detection of fistulas has been reported with an accuracy ranging from 22% to 100% (3), with a higher rate of fistula detection reported when there was active CSF leak during the diagnostic procedure. An overall accuracy of 65% increased to 85% when only actively leaking fistulas were considered (3). In one series in which such procedures as the Valsalva maneuver were used to increase intracranial pressure, the accuracy of fistula detection by CT cisternography was reported to be 100% (6). Manelfe et al (2) reported only a 33% rate of fistula detection in patients who did not have an active CSF leak during the diagnostic examination. In our series, a fistulous tract was accurately depicted by MR cisternography in five patients who did not have an active CSF leak at the time of the imaging examination.

Patients with recurrent meningitis are thought to have intermittent reopening of their fistulous tracts after the initial posttraumatic episode of rhinorrhea. It has been postulated that nose-blowing, the Valsalva maneuver, and, possibly, minor trauma not reported by the patient may be etiologic factors related to this reopening. In other cases, increased intracranial pressure due to hydrocephalus may be the most important causative factor (5). Idiopathic spontaneous CSF fistulas may occur subsequent to rupture of a congenital CSF diverticulum or from a diverticulum associated with increased intracranial pressure (13) (Fig 6). These diverticula may communicate with the petrous bone, the frontal sinus, or the middle cranial fossa from a lateral extension of the sphenoidal sinus (15, 16).

MR cisternography, by virtue of its ability to enhance CSF signal with suppression of the adjacent tissue signal, would be expected to be superior to conventional MR imaging. Even with the use of fast spin-echo sequences, conventional MR imaging does not allow suppression of the signal of adjacent tissues, thus masking the fistulous tract or at least making its

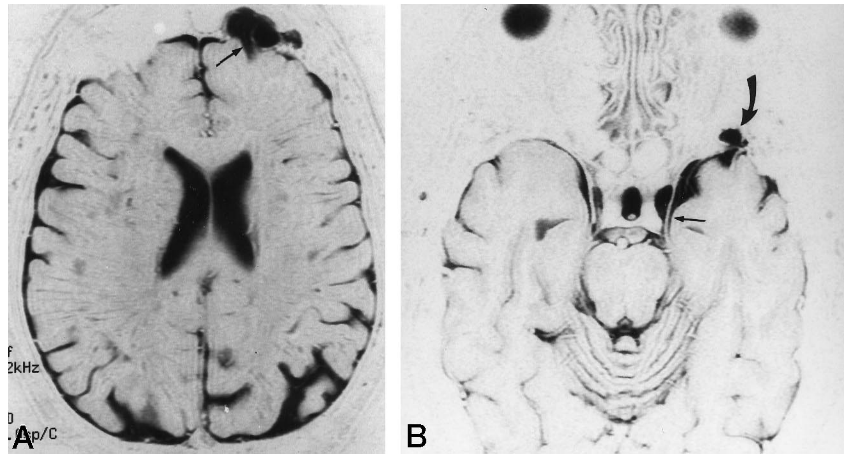

FIG 6. Subarachnoid diverticulum, which may lead to spontaneous CSF rhinorrhea.

A, Congenital left frontal diverticulum is seen close to the frontal sinus (*arrow*) on axial MR cisternogram. The diverticulum was explored and confirmed at surgery. The operation was intended to avert future rhinorrhea.

B, Left anterior temporal diverticulum (*curved arrow*) in a patient with pseudotumor cerebri. A fistula could have occurred if the patient had had a hyperpneumatized sphenoidal sinus extending into the greater wing of the sphenoid (16). Note also a CSF diverticulum extending into the left cavernous sinus (*straight arrow*).

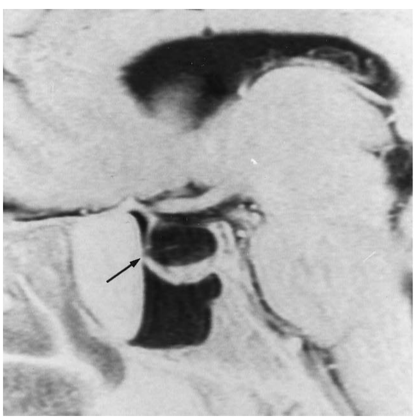

FIG 7. Posttraumatic sphenoidal sinus fistula from empty sella (*arrow*) is seen on sagittal MR cisternogram. This is an uncommon type of CSF fistula. The patient elected not to have surgery.-

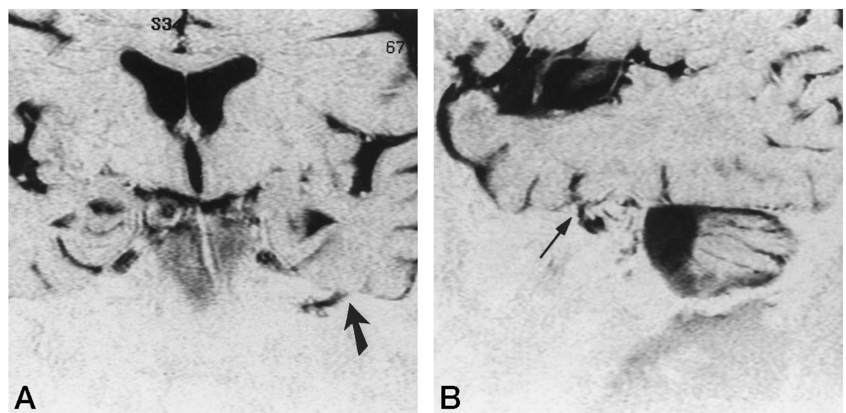

FIG 8. Postoperative left petrous bone fistula (*arrows*) seen on coronal (*A*) and sagittal (*B*) MR cisternographic sections, another uncommon site for a CSF fistula. This fistula was confirmed and repaired at craniotomy.

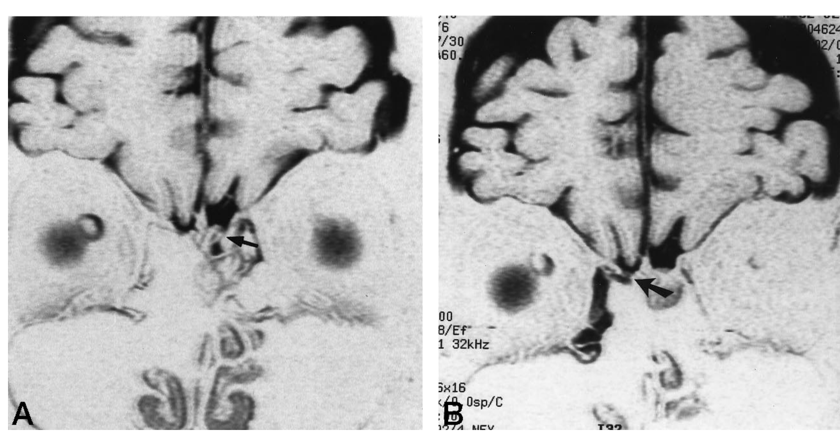

FIG 9. Postendoscopic sinus surgery fistula.

A, Narrow left anterior ethmoidal fistulous tract. No bone defect was seen on coronal CT scan (not shown). The fistula was confirmed and repaired at endoscopic surgery.

B, A relatively wide right ethmoidal fistula (*arrow*) is seen on coronal MR cisternogram. The fistula and rhinorrhea occurred in the same patient as in *A*, 11 months after successful endoscopic closure of the left ethmoidal fistula. The right-sided fistula was confirmed and repaired at endoscopic surgery.

detection more difficult. In a report by Nicklaus et al in 1988 (8), the value of MR imaging in the diagnosis of CSF fistula to the petrous bone was discussed in two cases. Signal changes were shown in the petrous bones in coronal sections in one case and in transaxial sections in the other. A definite fistulous tract was not established, and the authors concluded that MR imaging was not the diagnostic procedure of choice. Recently, however, other authors have reported 100% success in detecting a CSF fistula with the use of both spin-echo and fast spin-echo T2-weighted sequences (9, 10). In these reports, however, the diagnosis of fistula in some cases was made in the axial projection, where it is difficult to accurately separate the CSF signal from fluid in the adjacent sinuses. In patients being examined for CSF leak, high signal in the mastoid air cells or the paranasal sinuses adjacent to the skull base may be caused by inflammatory changes of sinusitis or mastoiditis and not necessarily to CSF accumulation (Fig 5). Accurate diagnosis of a CSF fistula cannot be made unless the high signal of the fistulous communication can be seen in direct continuity with the intracranial subarachnoid space (Figs 1, 2, 7–9). The fistulous tract may be depicted in both coronal and sagittal projections. In some patients with large bony defects, usually after trauma, MR cisternography may also show herniation of brain tissue (Figs 3 and 4). In other cases, the fistula may be accurately depicted in only one of the two projections. We recommend that both coronal and sagittal views be obtained in every MR cisternographic study. Transaxial sections are useful in delineating fistula to the frontal sinuses. Coronal high-resolution CT sections provide excellent detail of osseous anatomy that may suggest the location of a CSF fistula when a fracture or postsurgical bony defect is seen. However, in some cases, the coronal CT scan shows defects that are not at the site of the fistula. The fracture may not be associated with a rent in the dura, so that a fistula does not occur, or an associated dural tear may later become obliterated by scar tissue. Similarly, fluid seen within a sinus in relation to an osseous defect cannot be regarded as a reliable indicator of the site of a fistula. However, coronal CT is noninvasive and, for some patients, will improve the efficiency of diagnosing a fistula at MR cisternography by allowing a more focused MR cisternographic examination.

In considering the results of the statistical analysis, it should be kept in mind that drainage of a CSF fistula is intermittent in many patients, which may increase the frequency of false-negative diagnoses at MR cisternography. Although placing the patient in a prone position may increase the chance of eliciting an active CSF leak during the imaging examination, this is uncomfortable for the patient and may result in image degradation from motion artifacts. In the future, echo-planar imaging in conjunction with the Valsalva maneuver and a short scanning time may represent an improved technique for fistula diagnosis by MR cisternography in some patients if improvement in the resolution of these images is achieved.

Conclusion

MR cisternography is an efficacious, noninvasive, cost-effective imaging technique for the evaluation of suspected CSF rhinorrhea, with a sensitivity, specificity, and accuracy of 87%, 57%, and 78%, respectively, as compared with surgical results. We recommend the combination of plain thin-section coronal CT scans followed by MR cisternography as the optimal imaging approach for these patients.

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References

1. Drayer BP, Wilkins RH, Boehnke M, Horton JA, Rosenbaum AE. **Cerebrospinal fluid rhinorrhea demonstrated by metrizamide CT cisternography.** *AJR Am J Roentgenol* 1977;129:149–151
2. Manelfe C, Cellerier P, Sobel D, Prevost C, Bonafe A. **Cerebrospinal fluid rhinorrhea: evaluation with metrizamide cisternography.** *AJR Am J Roentgenol* 1982;138:471–476
3. Chow JM, Goodman D, Mafee MF. **Evaluation of CSF rhinorrhea by computerized tomography with metrizamide.** *Otolaryngol Head Neck Surg* 1989;100:99–105
4. Tolley NS, Lloyd GA, Williams HO. **Radiological study of primary spontaneous CSF rhinorrhea.** *J Laryngol Otol* 1991;105:274–277
5. Creamer MJ, Blendonohy P, Katz R, Russell E. **Coronal computerized tomography and cerebrospinal rhinorrhea.** *Arch Phys Med Rehabil* 1992;73:599–602
6. Naidich TP, Moran CJ. **Precise anatomic localization of atraumatic sphenoethmoidal cerebrospinal fluid rhinorrhea by metrizamide CT cisternography.** *J Neurosurg* 1980;53:222–228
7. Colquhoun IR. **CT cisternography in the investigation of cerebrospinal fluid rhinorrhea.** *Clin Radiol* 1993;47:403–408
8. Nicklaus P, Dutcher PO, Kido DK, Hengerer AS, Nelson CN. **New imaging techniques in diagnosis of cerebrospinal fluid fistula.** *Laryngoscope* 1988;98:1065–1068
9. El Jamel MS, Pidgeon CN, Toland J, Phillips JB, O'Dwyer AAJ. **MRI cisternography and the localization of CSF fistulae.** *Br J Neurosurg* 1994;8:433–437
10. Stafford-Johnson DB, Brennan P, Toland J, O'Dwyer AJ. **Magnetic resonance imaging in the evaluation of cerebrospinal fluid fistulae.** *Clin Radiol* 1996;51:837–841
11. DiChiro G, Girton ME, Frank JA, et al. **Cerebrospinal fluid rhinorrhea: depiction with MR cisternography in dogs.** *Radiology* 1986;160:221–222
12. El Gammal T, Brooks BS. **MR cisternography: initial experience in 41 cases.** *AJNR Am J Neuroradiol* 1994;15:1647–1656
13. El Gammal T, Brooks BS. **Imaging of the cranial subarachnoid spaces.** In: Taveras JM, Ferrucci JT, eds. *Radiology, Diagnosis-Imaging-Intervention.* Philadelphia, Pa: Lippincott-Raven; 1996;2: 1–19
14. Krudy AG. **MR myelography using heavily T2-weighted fast spin echo pulse sequences with fat presaturation.** *AJR Am J Roentgenol* 1992;159:1315–1320
15. Yeates AE, Blunenkopf B, Drayer BP, Wilkins RH, Osbourne D, Heinz ER. **Spontaneous CSF rhinorrhea arising from the middle cranial fossa: CT demonstration.** *AJNR Am J Neuroradiol* 1984;5: 820–821
16. Quint DJ, Levy R, Cornett J, Donovan C, Markert J. **Spontaneous CSF fistula through a congenitally fenestrated sphenoid bone.** *AJNR Am J Neuroradiol* 1996;166:952–954