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Fifty-one patients with cerebrospinal fluid rhinorrhea were evaluated at the Mayo Clinic from 1974 to 1977. The causes of the leak were fairly evenly distributed among postoperative, traumatic unrelated to previous surgery, and nontraumatic. The slightly fewer patients with a traumatic cause compared with those reported in most series reflects the referral patterns and surgical nature of the practice at the institution. Three-fourths of the patients had plain films of the skull, although the site of the leak was identified in only 21% of them. Two-thirds of the patients had tomography, which was helpful in 53%, especially in 10 of the 13 patients with traumatic nonpostoperative cerebrospinal fluid rhinorrhea. Posteroanterior tomography generally was more helpful than lateral tomography, except in leaks around the frontal sinuses. Radioisotope cisternography with intranasal pledgets helped localize the site of leak in 50% of patients and suggested the site of the leak in 25%. Radioisotope cisternography with pledgets often gave helpful positive results when the plain films and tomography were not helpful.

Galen conceived of cerebrospinal fluid as an excrementitious liquid expressed from several areas of the brain into the ventricles, especially into the fourth ventricle, where it was stored and then purged into the nose through the infundibulum and the ethmoid bones [1]. He was mistaken in thinking that this was a normal physiologic process, though he drew attention to the pathologic process that will be the topic of this report—cerebrospinal fluid rhinorrhea.

The diagnostic evaluation of cerebrospinal fluid rhinorrhea may vary according to the physician, the etiologic agent causing the rhinorrhea, and the condition of the patient. Localization of the site of the leak as to side and preferably as to exact location is important if surgical intervention is contemplated. Clinical criteria such as anosmia and unilaterality of the rhinorrhea can be misleading.

We reviewed our experience with cerebrospinal fluid rhinorrhea from 1974 to 1977 to determine the value of plain roentgenograms of the head, tomography, and radioisotope cisternography in the preoperative localization of cerebrospinal fluid fistula.

Materials and Methods

Records showed that 51 patients with overt, persistent cerebrospinal fluid rhinorrhea were seen at our institution from 1974 to 1977. In 34 patients, the cause of the leak was trauma: 16 related to previous surgery, and 18 nonpostoperative. In 17 patients, the cause was nontraumatic: three had rhinorrhea associated with increased intracranial pressure, and 14 had spontaneous rhinorrhea associated with normal intracranial pressure.

Plain radiographs of the skull, posteroanterior and lateral tomography of the skull base and the paranasal sinuses, radionuclide cisternography, and other radiographic studies were performed for the preoperative localization of the leak. Linear tomography was used in some cases, while complex motion tomography was used in others. The exact number with each type of tomography is not known. Thirty-nine patients had plain radiographs of

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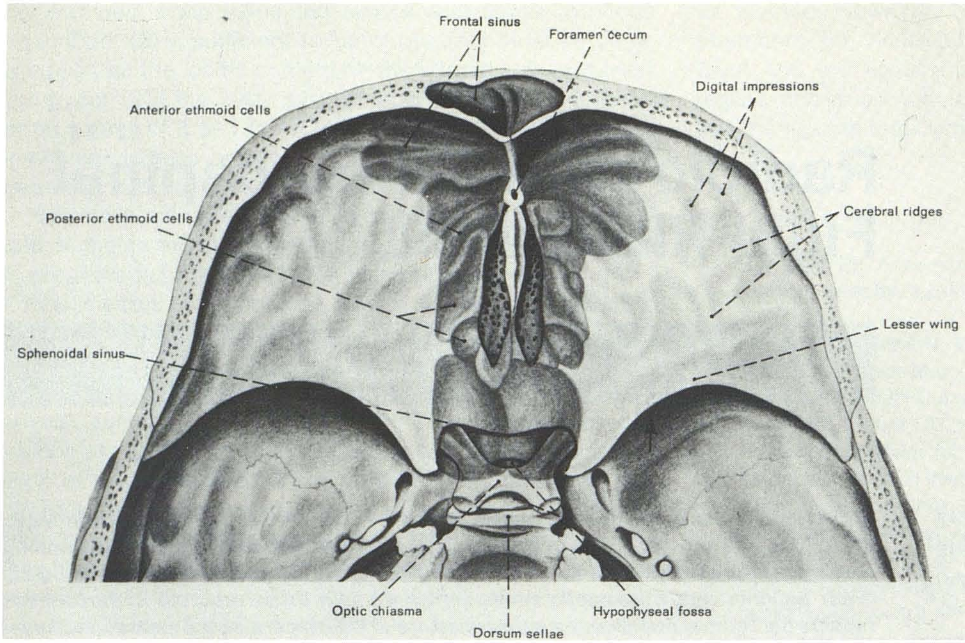


Fig. 1.—Anterior part of skull base, viewed from above. Shaded regions indicate paranasal sinuses that represent potential sites of fracture leading to cerebrospinal fluid rhinorrhea. (Reprinted from [2].)

the skull, 34 had tomography of the skull base, and 13 had radioisotope cisternography, 12 with multiple nasal pledgets inserted for semiquantitative analysis by radioisotope counting techniques.

The studies were considered positive if they localized the site of the leak and negative if they did not. In several patients, a diagnostic study was performed twice, but the results in only one study were positive, and this was counted in the positive results. Of the 40 patients who went to surgery, radiographic studies identified the site of the leak in 22. In the other 18 patients, the site was identified at surgery in 14.

Radiographic Features

Plain radiographs of the head demonstrated the presumed site of the leak in 8 (21%) of 39 patients. Thirty-four patients had tomography of the skull base, and this was helpful in 18 (53%) (table 1). Of these 34 patients, 13 had posttraumatic rhinorrhea that was not related to previous surgery. Within this subgroup, tomography was helpful in 10 (77%). Posteroanterior tomography was more helpful than lateral tomography in most.

Radioisotope cisternography with intranasal pledgets was performed in 12 patients. In four patients, the pledgets helped localize the leak and surgical confirmation was obtained. Plain film and tomographic studies in these four patients were positive in two and negative in two. In three patients, pledgets localized the presumed site of the leak, but surgical confirmation was not obtained owing to patient refusal or clinical considerations. Plain films and tomography demonstrated the presumed site in one of the three patients. In three other patients the side of the leak (surgically confirmed) was suggested by use of pledgets, although localization was not possible. Radiographic studies were helpful in two of these patients. In two patients, neither pledgets nor plain film and tomography were helpful. Cisternal scans without intranasal pledgets were of limited value, although they demonstrated intranasal radioactivity in several patients.

TABLE 1: **Surgically Identified Defect or Lesion in Patients With Cerebrospinal Fluid Rhinorrhea**

Location	Plain Film	Tomogram
Cribriform, ethmoid, orbital roof areas	5/23*†	12/21†
Frontal sinuses	2/5†	4/4†
Sella turcica	1/8	2/6
Petrous area	1/2	1/1
Uncertain	0/2	0/3
Total‡	9/40	19/35†

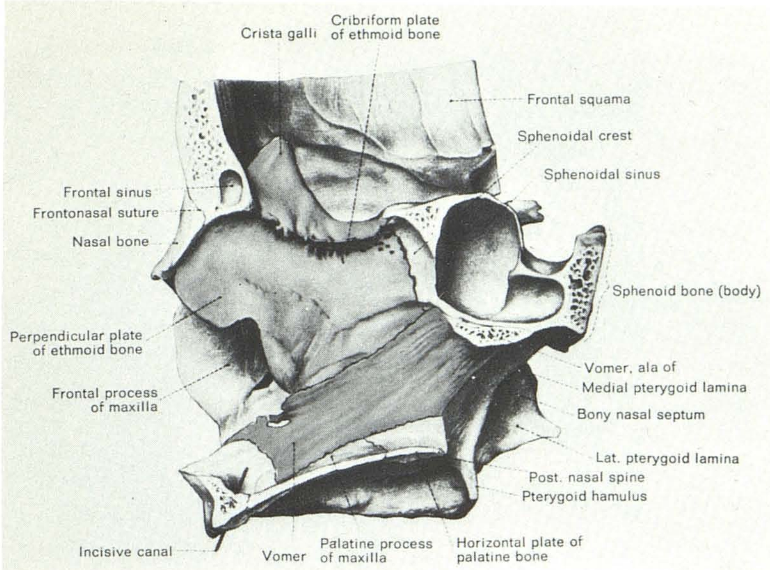
* Ratio of positive to total undergoing study.
† Includes one patient with positive findings in both ethmoid and frontal sinus regions on both studies.
‡ One patient excluded because of numerous fractures that were poorly seen on plain films.

Anatomy Related to Cerebrospinal Fluid Rhinorrhea

In cerebrospinal fluid rhinorrhea, the region of interest is the base of the skull from the frontal sinuses to the temporal bone. Of particular concern is that part of the skull base adjoining the paranasal sinuses (fig. 1).

The frontal sinuses may vary considerably in size and may be asymmetric, with one side extending well over the midline. Usually, a frontal sinus has a horizontal and vertical extension so that it forms a part of the floor of the anterior fossa and the roof of the orbits as well as part of the forehead. The frontal sinus opens beneath the front end of the middle meatus in the nasal cavity.

The cribriform plate, in the midline behind and below the frontal sinuses, is sturdy, although it is traversed by the



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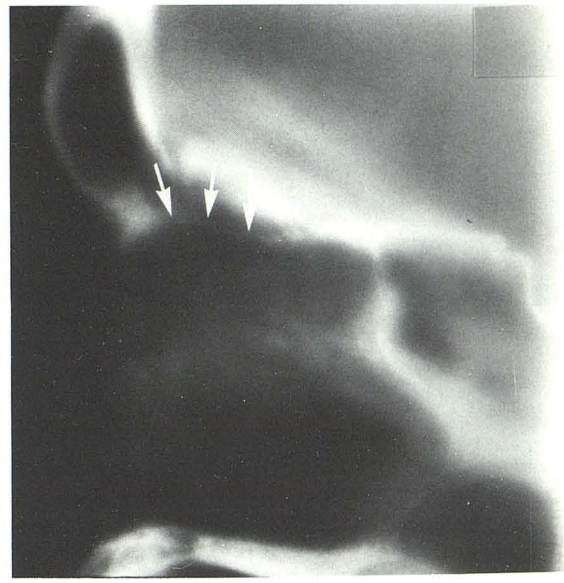

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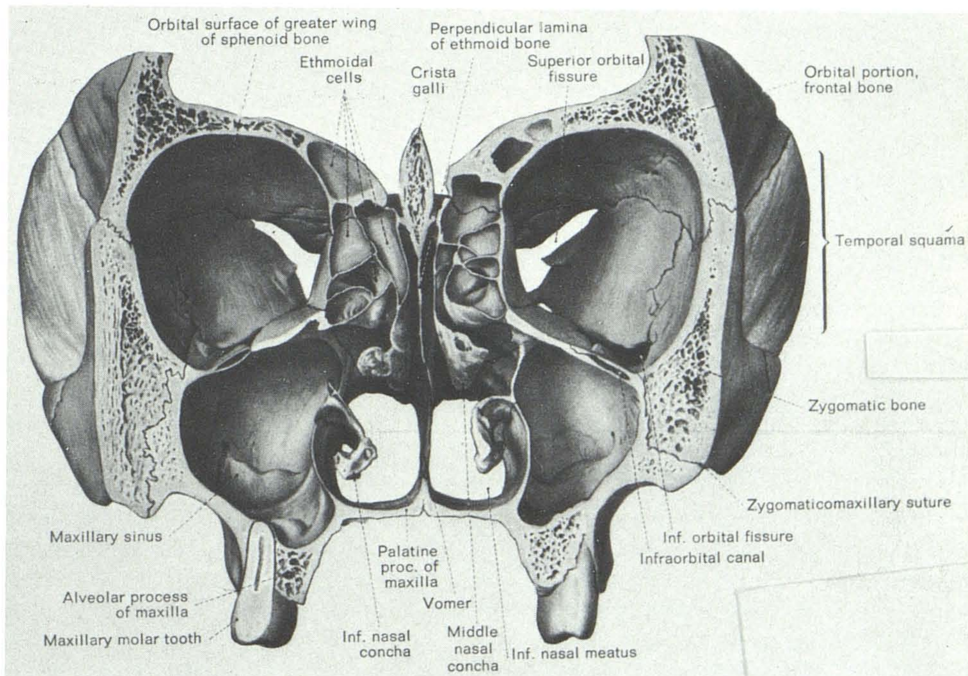
Fig. 2.—**A**, Anterior part of skull base, lateral midline view. Note smooth curve of cribriform plate as it extends from frontal sinus region to sphenoid. (Reprinted from [2].) **B**, Lateral midline tomogram. Stippled appearance (*arrows*) of normal cribriform plate. Crista galli faintly seen projecting upward from anterior part of cribriform plate.

Fig. 3.—Frontal projection at level of crista galli and ethmoid sinuses. Orbital roofs slope downward and medially to cribriform plate. (Reprinted from [2].)



olfactory canals. Just lateral to the cribriform, the floor of the anterior fossa turns sharply upward to join the orbital plate of the frontal bone and forms the roof of the ethmoid complex. The bone is fragile, and the dura is tightly adherent in this region. Many "cribriform plate" fractures may represent fractures in this region [3]. The ethmoid cells open into the middle meatus of the nasal cavity.

The sphenoid sinuses lie posterior to the ethmoid cells in the midline. Above and behind these sinuses lies the sella turcica, and on each side are the carotid artery and the

TABLE 2: **Classification of Cerebrospinal Fluid Rhinorrhea**

Traumatic:	
Postoperative (iatrogenic)	
Other trauma (accidental)	
Nontraumatic:	
"High pressure":	
Tumors	
Hydrocephalus	
"Normal pressure" (spontaneous):	
Congenital anomalies or bony atrophy	
Tumor or osteomyelitis erosions	

Note.—Classification similar to that proposed in [3].

Fig. 4.—23-year-old woman involved in automobile accident 7 years earlier, when numerous facial fractures were suffered. Repeated episodes of cerebrospinal fluid rhinorrhea, with recurrent meningitis. Lateral tomogram. Fracture through posterior wall of right frontal sinus. Surgically confirmed.

cavernous sinus. The sphenoid sinuses also show much variability in size and symmetry. Each sphenoid sinus opens anteriorly into the sphenoethmoidal recess of the nasal cavity.

In the midline on lateral projection (fig. 2) is the bony part of the nasal septum and the cribriform plate, which extends posteriorly to the planum of the sphenoid. The crista galli juts upward from the anterior part of the cribriform.

The frontal projection gives one the advantage of being able to compare both sides and thus to detect abnormality when the findings are more subtle. Slight asymmetry may exist, however, and caution must be exercised so as not to attribute normal variation to bony disruption. The orbital roofs slope downward and medially to the region of the cribriform plate and ethmoid cells (fig. 3). Posteriorly, the ethmoid and sphenoid sinuses are identified.

Leaks into the middle ear through the floor of the middle fossa or after posterior fossa surgery may produce cerebrospinal fluid otorhinorrhea through the eustachian tube. These leaks are best demonstrated on petrous tomograms.

Discussion

Different classifications for cerebrospinal fluid rhinorrhea have been proposed. The one that will be followed in this paper is similar to that proposed by Ommaya et al. [3] (table 2).

Traumatic Cerebrospinal Fluid Rhinorrhea

Trauma, either direct or postoperative, is generally considered to be the most frequent cause of cerebrospinal fluid rhinorrhea and accounted for two-thirds of the patients in our series. The percentage of patients with cerebrospinal fluid rhinorrhea related to previous surgical trauma should be greater in referral centers that perform nasal and transsphenoidal pituitary surgery. About one-third of the patients in our series had surgically related leaks. These often occurred soon after pituitary surgery. The patients were usually returned to surgery, and the sella was repacked without the need for a radiologic workup.

Traumatic, nonpostoperative rhinorrhea was common in previous series [4–6]. Most of the leaks occur in relatively young persons, and many result from traffic accidents [7, 8]. More than two-thirds of the patients in our series had leaks from accidents involving motor vehicles or motor vehicle-bicycle.

Studies by Lewin [9] and Robinson [8] suggest that, in most patients with traumatic, nonpostoperative cerebrospinal fluid rhinorrhea, the leak begins either "immediately" or within 48 hr after the injury. Most leaks stop spontaneously in less than 1 week [9]. In some, it may be difficult to obtain a history of trauma.

Facial fractures accompanying cerebrospinal fluid rhinorrhea may be subtle or multiple and complex. Patients with nasofrontal-ethmoidal fractures or Le Fort III fractures are particularly likely to develop cerebrospinal fluid rhinorrhea, but most patients will not have these complex fractures.

The sites of the fistula in traumatic rhinorrhea can be classed as follows: (1) frontal sinus, (2) ethmoidal sinuses, (3) directly into the nasal cavity, (4) sphenoidal sinus, and (5) eustachian tube. The first two tend to be the most frequent [9, 10].

An example of a frontal sinus fistula is shown in figure 4. This 23-year-old woman was involved in an automobile accident 7 years earlier, at which time she sustained multiple complex facial fractures. Despite several corrective operations, she suffered yearly episodes of cerebrospinal fluid rhinorrhea with recurrent meningitis. The lateral plain film and tomogram showed a comminuted fracture extending through the posterior wall of the right frontal sinus and a fracture line through the right orbital roof. Radioactive cisternography with pledgets was performed twice. Initially, the results of study were negative, but repeat study several months later showed increased radioactivity on the pledget in the right middle meatus—the expected site for a right frontal sinus leak. At surgery, a dime-sized hole in the posterior wall of the right frontal sinus was closed. The patient had no leak postoperatively.

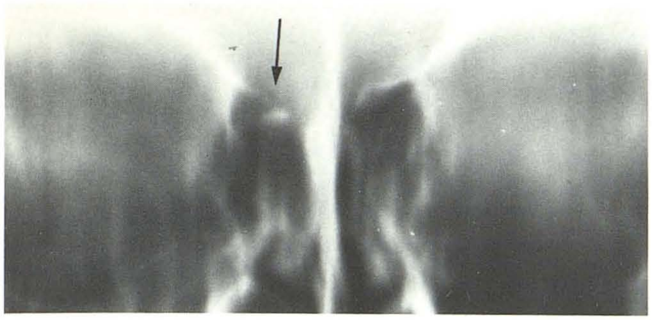


Fig. 5.—10-year-old boy with right-sided cerebrospinal fluid rhinorrhea and pneumococcal meningitis. Anteroposterior tomogram. Bony defect (*arrow*) in roof of right ethmoid sinuses. Surgically confirmed.

An example of a fistula to the ethmoid cells is shown in figure 5. This 10-year-old boy was injured in an automobile accident and suffered right-sided cerebrospinal fluid rhinorrhea and anosmia and later pneumococcal meningitis. The plain film and tomogram showed a bony defect in the roof of the right ethmoid sinuses. The defect was closed surgically, and there was no leak postoperatively.

Traumatic nonsurgical fractures of the sphenoid sinus with cerebrospinal fluid rhinorrhea are uncommon compared with the fractures already mentioned. Many are associated with fractures in other regions. In our series, we had no patients with this type of fracture proved by radiography. Lewin and Cairns [11] reported a small series in 1951 and noted the profuse nature of the rhinorrhea caused by fracture in this region. In all patients, the rhinorrhea persisted unabated until surgery or death. They hypothesized that the profuse flow was caused by a dural tear that established a communication between the cisterna chiasmatica and the nose. A fistula beneath a large cistern would not be likely to close.

Cerebrospinal fluid drainage from the nose does not necessarily imply nasal sinus injury. A 23-year-old woman fainted, apparently striking the back of her head. Later, when she turned onto her abdomen, she noted clear fluid dripping from her left nostril. Radiographs showed a left occipital skull fracture extending into the petrous pyramids (fig. 6). No paranasal fracture was identified. Fractures involving the petrous area may allow spinal fluid to drain into the middle ear and from there to the nose via the eustachian tube. Drainage is promoted by the forward bending of the head. A radionuclide cisternogram with pledgets showed greatly increased activity near the left eustachian tube. The leak stopped spontaneously, as it usually does with these fractures.

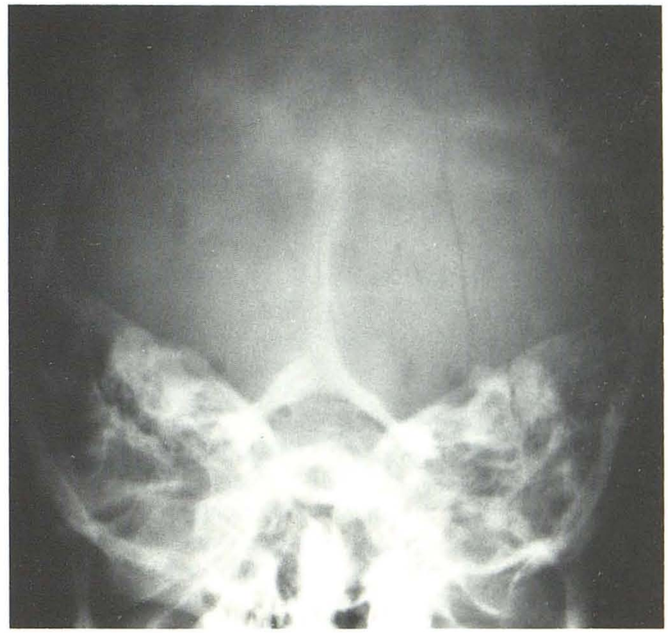


Fig. 6.—20-year-old woman with trauma to back of head and cerebrospinal fluid rhinorrhea on leaning forward. Occipital skull fracture extends through petrous pyramids. Leak stopped spontaneously.

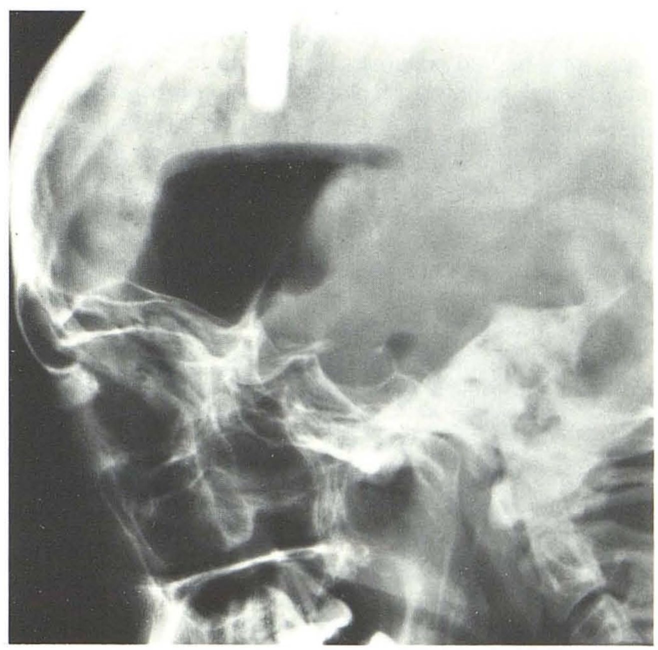


Fig. 7.—25-year-old woman with headache and cerebrospinal fluid rhinorrhea. Skull radiograph showed demineralization in region of sella and planum sphenoidale, with suggestion of increased convolutional markings. Ventriculogram. Grade 2 astrocytoma of third ventricle obstructs foramen of Monro.

Nontraumatic Cerebrospinal Fluid Rhinorrhea

Three of our patients had rhinorrhea associated with increased intracranial pressure. One, a 25-year-old woman, had chronic headaches and rhinorrhea for 5 months. Radiographs of the skull showed demineralization in the region of the sella and planum sphenoidale, with a suggestion of increased convolutional markings raising the possibility of increased intracranial pressure. Ventriculography showed a lesion obstructing the foramen of Monro (fig. 7). Surgery revealed a 3-cm grade 2 astrocytoma of the third ventricle. The tumor was only partially removed. The left frontal lobe was seen to prolapse through several defects in the anterior fossa and cribriform plate. Later reoperation with repair of several other leaks in the right anterior fossa was needed before the rhinorrhea ceased.

The two other patients with increased intracranial pressure were a 22-year-old man with aqueductal stenosis who had rhinorrhea and a 28-year-old woman with a colloid cyst of the third ventricle who had functional-sounding neurologic complaints and occasional rhinorrhea. In each, defects in the base of the skull were found at surgery. Whether the increased intracranial pressure was a cause of, or a contributing factor to, the rhinorrhea remains uncertain.

Nontraumatic, spontaneous rhinorrhea includes congenital bony defects or focal bony atrophy, and uncommonly, leaks associated with pituitary tumors, meningiomas, osteomas, and other tumors either before or after radiation treatment [3, 4]. Congenital defects or focal bony atrophy account for most of the patients. Patients often come to medical attention because of spontaneous rhinorrhea or meningitis. No history of significant trauma can be elicited, and cerebrospinal fluid pressure is not elevated. Surgical findings may vary from large meningoencephaloceles to small bony and dural defects or dehiscences. At times, no abnormality is found, but surgical packing of the region of presumed rhinorrhea stops the leak.

One example with this type was a 15-year-old boy who had a swelling in the nose which had been noted at age 1 year. A diagnosis of meningocele was made. The patient was asymptomatic and advised to have surgery at a later date, after he had matured. Throughout the years, the boy had several episodes of bleeding and cerebrospinal fluid rhinorrhea after minor nasal trauma. At age 14, he contracted pneumococcal meningitis, but because of his family's religious convictions, he declined surgery. The next year, after three episodes of recurrent meningitis, he underwent surgery for a large nasal meningoencephalocele, which was seen best on a tomographic cut. The lesion extended through the right cribriform plate and displaced the crista galli to the left (fig. 8).

Another example is a 29-year-old man who had exhibited increasing irritability and temper tantrums for 2 weeks preceding admission. Physical examination revealed nuchal rigidity, and a lumbar puncture culture grew *Streptococcus pneumoniae*. History revealed that the patient had probable cerebrospinal fluid rhinorrhea as a child and four episodes of meningitis that were not well documented. Otorhinolaryngologic examination demonstrated only a deviated nasal septum. Radiographs of the skull were initially interpreted as negative. Tomograms of the paranasal sinuses revealed a mass in the upper part of the right nasal cavity, with loss of the cribriform in this region (figs. 9A and 9B). Angiography was performed to confirm the diagnosis of meningoencephalocele and to better define the lesion (fig. 9C). An orbital frontal branch of the right anterior cerebral artery appeared to be stretched and, near its anterior end, to turn downward through the cribriform plate instead of following its usual straight course to the frontal lobe. At surgery, an encephalocele was resected and the cribriform defect closed. The patient did well postoperatively.

Fig. 8.—15-year-old boy with nasal meningocele diagnosed at age 1 year. Recurrent cerebrospinal fluid rhinorrhea and meningitis. Anteroposterior tomogram. Large nasal meningoencephalocele extends through right cribriform plate, displacing crista galli to left. Surgically resected.

The lesions in these two patients were transethmoidal meningoencephaloceles. They are relatively uncommon and consist of meningeal sacs, with or without actual brain substance, protruding beyond the cranial confines.

Radionuclide Cisternography

Radionuclide cisternography is a useful tool for the localization of cerebrospinal fluid rhinorrhea [12–14]. Various radiopharmaceutical agents have been used; Yb-DTPA is now being used at our institution. Intrathecal injection is generally made via the lumbar route, though a cisternal puncture may be used. The head is scanned at various intervals after injection, and the head is placed in a position that facilitates the most rhinorrhea (fig. 10). Nasal pledgets carefully placed into particular regions of the nasal cavity have added specificity to the procedure. These pledgets are subsequently removed, and their radioactive contamination is counted. The pledget with the highest count is assumed to have been nearest the leak or the ostium of the sinus with the leak. Radioactive cisternography also may detect abnormalities of cerebrospinal fluid dynamics, such as subarachnoid accumulations or ventricular refluxes which could give additional information regarding the location or cause of the rhinorrhea [15].

The value of isotope cisternography in confirming cerebrospinal fluid rhinorrhea was not fully discussed in the cases presented here. In our series, cerebrospinal fluid rhinorrhea had been clinically diagnosed and localization of the fistula was sought. In these situations, a radionuclide scan that showed increased activity within the nose was not particularly useful to the clinician unless it lateralized or localized the leak. Intranasal pledgets were useful in this regard, however. Pledgets localized the site of leak in more than 50% of patients, and the side of the leak was suggested in 25%. In five of the 10 patients in whom intranasal pledgets

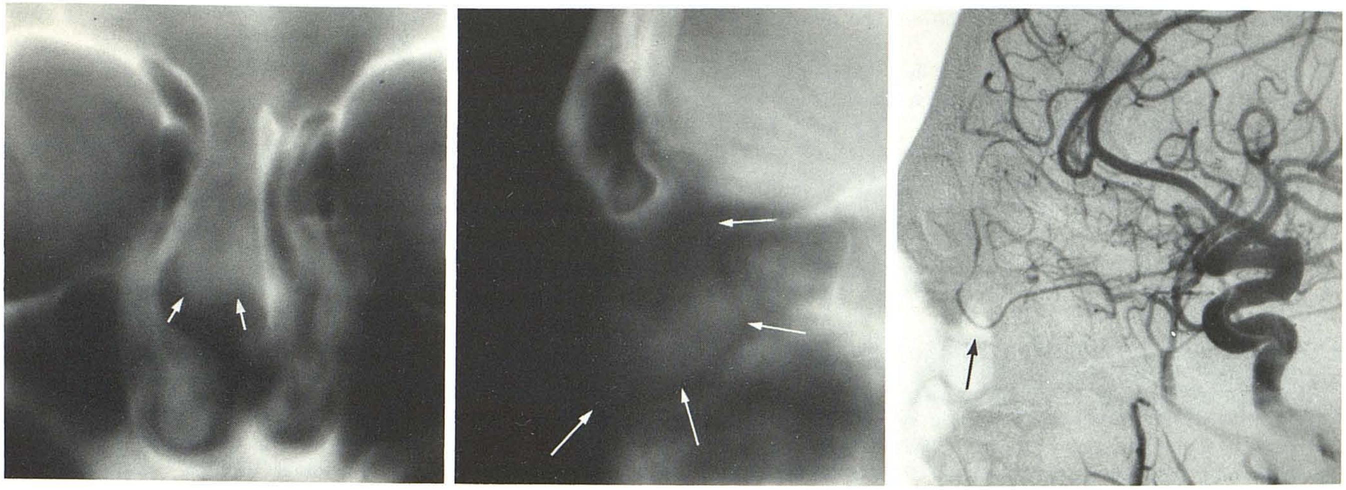


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Fig. 9.—29-year-old man with history of probable cerebrospinal fluid rhinorrhea and meningitis. Anteroposterior (**A**) and lateral (**B**) tomograms. Mass (*arrows*) in upper part of right nasal cavity, with loss of cribriform plate in this region. **C**, Angiogram. Orbital frontal branch of right anterior cerebral artery appears to be stretched; near its anterior end it turns downward through cribriform plate (*arrow*) to supply encephalocele. Surgically resected.

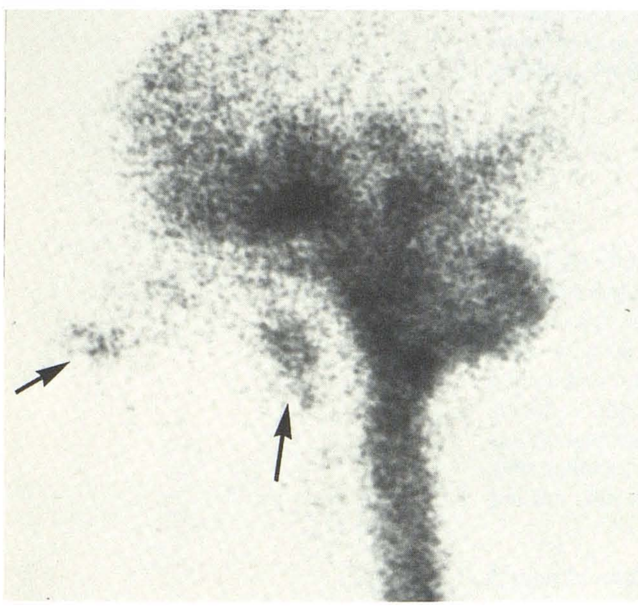

Fig. 10.—Recent case (not included in series): 14-year-old boy with 1 month history of headache, fever, and vomiting. Culture of cerebrospinal fluid grew *Haemophilus influenzae*. Radionuclide cisternogram. Normal activity in basal cistern and abnormal activity anteriorly in nasal cavity and nasopharynx (*arrows*), indicating cerebrospinal fluid leak. At surgery, leak in olfactory bulb region was found and closed.

were helpful, plain films and tomography were not helpful. In two of these 10 patients, however, radiographs localized the leak, whereas pledgets only lateralized the leak.

Unfortunately, fractures of the frontal and ethmoid sinuses may be indistinguishable by radionuclide study because both sinuses have openings into the middle meatal region of the nose. Also, an active cerebrospinal fluid leak is necessary for localization.

In the patient with clinical cerebrospinal fluid rhinorrhea, posteroanterior and lateral tomography of the skull base seems to be a reasonable second step if the site of the leak is not obvious on plain films. Tomography is noninvasive and can be very helpful, particularly when the cerebrospinal fluid leak is related to direct trauma. Radioisotope cisternography with intranasal pledgets was helpful in most cases, however, and should be strongly considered if tomography is not definitive. Other procedures such as pneumoencephalography, computed tomography of the head, intraoperative techniques, and contrast medium (Pantopaque) studies of the nose are occasionally helpful in the evaluation of cerebrospinal fluid rhinorrhea.

Editor's Comment

The high resolution computed tomography scanners, in combination with water-soluble intrathecally injected contrast media (metrizamide), add yet another method to localize the exact point of the cerebrospinal fluid leak to facilitate surgical correction. (Hilal SK. *CSF leaks*. Presented at the International Symposium and Course on Computed Tomography, Las Vegas, 1980.)

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