Chapter 5: Cerebrospinal Fistula

This chapter deals with the etiology, diagnosis, and treatment of spinal fluid leakage from the sinuses, cribriform plate, and ear.

Repair for stopping the leakage of cerebrospinal fluid into the nasal and aural spaces can be executed by extracranial operation, with lower morbidity and mortality rates than those attained by an intracranial procedure.

Cerebrospinal fluid rhinorrhea may have its origin in the frontal sinus, sphenoid sinus, ethmoid sinus, or cribriform plate. Cerebrospinal fluid otorhinorrhea may originate in the mastoid or middle ear and reach the nasal space by way of the eustachian tube. It may exit as otorrhea from the mastoid or middle ear by way of the external auditory canal.

The repair for stemming spinal fluid leakage into the frontal sinus can be made by direct suturing of the dura, grafting fascia lata, or by adipose obliteration of the frontal sinuses. The bilateral osteoplastic flap procedure is used for exposure of the defect.

Spinal fluid otorrhea or otorhinorrhea emanating from the middle or posterior fossa by way of the mastoid can be treated by obliteration, with either a local pedicled connective tissue flap or an adipose autograft. If the spinal fluid leakage is subsequent to a radical mastoidectomy, it may be necessary to use a fascia lata graft. A nasal septal mucoperichondrial pedicled flap is used to stop spinal fluid leakage through the cribriform plate, roof of the ethmoid bone, and sphenoid sinus.

Etiology

McCoy and Ommaya have simplified the etiologic classification into two groups: (1) traumatic (acute or delayed); and (2) nontraumatic, which would include tumors, congenital anomalies, hydrocephalus infection, and primary or spontaneous cerebrospinal fluid rhinorrhea.

Cerebrospinal fluid rhinorrhea of acute traumatic origin may be caused by a crushing injury in which the skull is fractured. This is most commonly due to a war or automobile injury. Penetrating wounds may also result in cerebrospinal fluid rhinorrhea. Most frequently the penetrating object enters by way of the orbit, ethmoid sinus, cribriform area, otic capsule, or mastoid. On occasion, spinal fluid rhinorrhea is produced by the neurosurgeon or the otolaryngologist. Leakage following neurosurgical procedures is usually through the cribriform area and the frontal sinus. It is possible for the otolaryngological surgeon to produce a cerebrospinal fluid rhinorrhea in any of the following ways: (1) by simply removing an intranasal mass which was actually an encephalocele; (2) by rasping of the nasofrontal duct; (3) during operation upon the frontal sinus; (4) during intranasal or extranasal ethmoid operation or a pituitary operation performed by the sphenoid sinus route; or (5) during
mastoid operations, especially when using the translabyrinthine approach for removal of cerebellopontine angle tumors.

Both extracranial and intracranial tumors may produce cerebrospinal fluid rhinorrhea by erosion of the dura mater. The most common tumors causing cerebrospinal fluid leakage are frontal and ethmoid sinus osteomas. Tumors of the olfactory bulb and pituitary gland are common intracranial tumors producing spontaneous leakage. Intracranial tumors in the region of the sphenoid sinus and mastoid may also produce leakage of cerebrospinal fluid.

Congenital defects, with the formation of an encephalocele into the nasal cavity or rupture of a persistent embryonic ventricular lumen of the olfactory tract, can result in spinal fluid rhinorrhea. The discharge is spontaneous, or primary, cerebrospinal fluid rhinorrhea reaches the nasal cavity by way of a prolongation of the subarachnoid space along the filaments of the olfactory nerve. A sudden transient rise in the cerebrospinal fluid pressure, such as with sneezing or coughing, may rupture the membranes which cover a congenitally weak area in the cribriform plate.

**Diagnosis**

Unless a leakage of cerebrospinal fluid is profuse and persistent, the detection of its source is difficult. Thus, the investigation must be systematic and thorough. Leakage should be considered in patients who have had severe trauma to the face, especially in the region of the superior aspect of the nasal bones and the nasal process of the frontal bone. A patient who has had repeated episodes of meningitis should be thoroughly investigated for cerebrospinal fluid rhinorrhea and otorrhea, especially if there is a history of trauma.

Cerebrospinal fluid rhinorrhea may be intermittent. It is most often unilateral. An acceleration in the flow rate with change in position is rather characteristic. If the rate of flow is profuse the patient will swallow frequently when in a recumbent position. The fluid is clear unless there is an associated acute trauma, when it may be sanguinous. It is odorless, salty, and has a specific gravity of about 1.006.

The nasal discharge may be tested with paper strips (glucose oxidase peroxidase and O-Tolidine) for the presence of glucose. This test is not an absolute confirmation that the discharge is spinal fluid, for lacrimal secretions also contain glucose. The protein content of cerebrospinal fluid is much less than that of a nasal discharge. Some of the discharge being tested should be allowed to remain in the test tube. After standing, a sediment will be found in nasal discharge whereas spinal fluid will remain clear. The discharge should be cultured.

Leakage through the mastoid or middle ear will be attended with a conductive hearing loss and the appearance of fluid or air bubbles behind the tympanic membrane.

X rays of the skull, paranasal sinuses, and mastoid cells may reveal a fracture or air in the cranial cavity. The site of skull fractures associated with cerebrospinal fluid rhinorrhea is usually in the frontal area or in the region of the cribriform plate of the ethmoid bone. Pneumocephalus may be present. A fracture in the olfactory area may result in loss of smell. Etiologic factors, as mentioned above, may make the diagnosis obvious.
A most important method for identification and location of the source of cerebrospinal rhinorrhea or otorrhea is by intrathecal injection of either indigo carmine dye or fluorescein and subsequently detecting its presence intranasally or by otoscopy. The patient is placed in a sitting position. Packing impregnated with 4% cocaine is inserted into the nasal cavities both to produce topical anesthesia and to shrink the nasal mucosa. The cocaine packing is removed after 10 minutes. A separate pledget of cotton is inserted into (1) the sphenoid-ethmoidal recess, (2) the region of the olfactory slit, and (3) the anterosuperior nasal cavity. Fluorescein (1 cc of 5% solution) is injected intrathecally with the patient remaining in the sitting position. The room is darkened and the nasal cavity is inspected at regular intervals, using an ultraviolet light source. If there is no obvious evidence of fluorescein at the end of 10 minutes, the three cotton pledgets are carefully removed and inspected for the presence of fluorescein. If no fluorescein is present, three additional pledgets are inserted and the patient is placed in a prone position with his head dependent. The cotton is again examined for the presence of fluorescein at the end of 10 minutes. The fluorescein test can be performed without fear of complications and the results are extremely gratifying.

Cerebrospinal fluid rhinorrhea coming from the middle or posterior fossa and draining into the mastoid antrum and down the eustachian tube may be intermittent even when very active, for when the patient is in the upright or supine position the spinal fluid flows directly into the pharynx. The patient may notice gushes of rhinorrhea with change in head position. The side of the leakage will vary according to the position of the head. Cerebrospinal fluid otorhinorrhea from the mastoid region is best demonstrated by Pantopaque study. Proper positioning and serial x rays, taken for at least 24 hours, may be necessary to demonstrate the point of leakage. Pantopaque will remain in the mastoid cells for many days.

**Treatment**

The early management of post-traumatic cerebrospinal fluid rhinorrhea and otorrhea is conservative. The patient should remain in a semi-sitting position and be given antibiotic therapy. He should avoid nose-blowing, sneezing, and straining. If the leakage persists after 6 weeks, a more aggressive method of therapy should be employed, for sooner or later most of these patients will develop a meningitis which has a very high mortality rate.

Surgical intervention is indicated in the following instances: (1) when the leakage is of more than 6 weeks' duration; (2) when the leakage is intermittent; (3) when pneumoencephalus is present; and (4) when there is a history of recurrent meningitis and cerebrospinal fluid otorrhea.

**Leakage of Cerebrospinal Fluid through the Frontal Sinus**

The repair occasioned by leakage of spinal fluid through the posterior wall of the frontal sinus may be made by using the exposure acquired by the anterior osteoplastic flap procedure. I have used this technique in the following cases: (1) leakage encountered when dissecting a mucocele of the frontal sinus from the anterior fossa dura; (2) leakage due to traumatic lacerations of the posterior wall of the frontal sinus and adjacent dura; and (3) leakage occurring during removal of an osteoma of the frontal sinus which extended into the anterior cranial fossa and was complicated by a frontal lobe abscess.
The frontal sinus(es) is opened by way of the anterior osteoplastic flap, by using either the eyebrow or coronal incision (see Chapter 4). It is very important, at this point, that the entire mucous membrane lining of the frontal sinus be removed. In order to ensure complete removal of the lining and to obtain an adequate blood supply for the adipose implant, the entire inner cortical lining of the frontal sinus must be removed; this is done with a rotating cutting bur. Subcutaneous adipose tissue is obtained from the abdomen, trimmed, and implanted so as to fill the sinus(es) completely. The revascularization of the adipose implant occurs during the first few days by ingrowth of vessels and direct blood vessel anastomosis. Fascia lata may also be used to repair a defect in the dura of the frontal lobe. This is placed over the site of the leak and tucked in behind the bony margins of the posterior wall of the frontal sinus.

**Leakage of Cerebrospinal Fluid through the Sphenoid Sinus**

The approach to the sphenoid sinus by the intracranial route for the repair occasioned by cerebrospinal fluid leakage through the sphenoid sinus is extremely difficult and, in some instances, impossible because of the anatomic development of this sinus. Hirsch was the first to use a septal flap for repair of spinal fluid rhinorrhea emanating from the sphenoid sinus following hypophysectomy. He removed the mucoperichondrium on one side of the posterior septum and the perpendicular plate of the ethmoid bone in order to rotate a mucoperichondrial flap from the opposite side into the sphenoid sinus. This procedure produces a large posterosuperior perforation of the septum, which is of little consequence. A septomucosal flap is employed routinely in performing hypophysectomies to prevent spinal fluid leakage as well as to create a barrier between the intradural space and the nasal cavity in order to avoid subsequent ascending infection.

A complete ethmoidectomy is carried out. A septal mucosal flap must be fashioned prior to entering the sphenoid sinus, for the mucosa covering the anterior wall of this sinus makes up the base of this flap. The length of the flap can be estimated from a study of anteroposterior and lateral laminograms of the sphenoid sinus. The position of the vertical incision determines the length of the mucosal flap (ie, the farther anterior the vertical incision, the longer the septal mucosal flap). Second incision is extended posteriorly from the superior aspect of the vertical incision, along the nasal septum adjacent to the medial aspect of the olfactory slit. This is extended to the front of the sphenoid sinus. The third incision is made parallel to the second incision along the inferior aspect of the nasal septum. The fourth incision is an extension of the second incision across the superior aspect of the anterior wall of the sphenoid sinus. Thus, the flap is based at the inferior margin of the front face of the sphenoid sinus. After the mucosal flap has been carefully elevated and reflected into the nasopharynx, the anterior wall of the sphenoid sinus is removed, by using curettes and Kerrison bone-biting forceps.

Usually it is necessary to remove the intersphenoid septum and a small portion of the posterior aspect of the nasal septum in order to provide wide exposure of the sphenoid sinus complex. The mucosal lining of the sphenoid sinuses is removed. The septal mucosal flap is placed over the point of leakage. If the dural defect is large, it may be plugged with adipose tissue or fascia lata before the septal mucosal flap is reflected in place. A single layer of Gelfoam is placed over the flap before it is packed in place with a 24-inch strip of 1-inch iodoform gauze which has been impregnated with aureomycin ointment. A finger-cot packing
is inserted into the nasal cavity. The wound closure, dressing, and postoperative care are outlined in the section on ethmoidectomy (Chapter 4).

**Leakage of Cerebrospinal Fluid through the Mastoid and Middle Ear**

Spinal fluid leakage by way of the mastoid or middle ear can be successfully stopped by the oblitative technique. If the leak enters the mastoid cells or mastoid antrum and the cellular development is not too extensive, an inferiorly pedicled tissue flap will be adequate. On the other hand, if the mastoid area is large, a pedicle flap may not be sufficient to provide an effective seal. In such cases, a free adipose autograft (obtained from the subcutaneous abdominal layer) is used. This latter technique is employed to prevent spinal fluid leakage following the translabyrinthine approach to the cerebellopontine angle. The dura surrounding the defect is widely exposed so that the flap or graft can be packed snugly against the point of leakage. The mastoid incision is tightly closed in layers without drainage. This technique offers closure of the cranial mastoid defect without damage to either the auditory or vestibular function.

If the point of leakage is the anterior aspect of the mastoid antrum or the epitympanic tegmen, a radical mastoidectomy obliteration procedure cannot be employed. The entire mastoid process and middle ear must be obliterated with adipose tissue or muscle (Rambo), thus eliminating the external auditory canal.

An alternate method for repair of cerebrospinal otorrhea is that of grafting fascia lata over the dural defect. This technique was employed in patient M. S., a 19-year-old female college student who was admitted to the Massachusetts Eye and Ear Infirmary on January 6, 1966, complaining of watery otorrhea on the right side of two weeks' duration. Two years before this admission, an endaural radical mastoidectomy had been performed because of longstanding otorrhea and the presence of cholesteatoma. In June of 1965 a mastoidectomy with obliteration and type III tympanoplasty had been undertaken. Following this procedure, there was necrosis of the muscle pedicle flap and the otorrhea continued. Two weeks before the present hospitalization, the patient was admitted for a revision of her mastoidectomy. This procedure was complicated by cerebrospinal fluid otorrhea.

On examination a herniation of tissue in the region of the tegmen mastoideum and a rather profuse spinal fluid leakage were noted. No complication central nervous system signs or symptoms were present. On January 7, 1966, with a modified Heermann incision with a temporal extension for exposure, a right temporal craniotomy was fashioned in the lower portion of the squamous bone and the temporal dura was exposed. The temporal lobe and dura which had herniated into the mastoid were elevated. These structures were supported and the site of cerebrospinal fluid leakage repaired with a fascia lata graft. Mastoid packing was used to support the graft. The packing was removed on the fourteenth postoperative day. The patient's ear has remained dry.

**Leakage of Cerebrospinal Fluid through the Cribriform Plate and Roof of Ethmoid**

Cerebrospinal fluid leakage by way of the cribriform plate or roof of the ethmoid is repaired by way of an external ethmoid incision.
It is essential to review a few points of anatomy in this region before proceeding with a description of the surgical technique.

**Surgical Anatomy.** The ethmoid labyrinth is pyramidal in shape, being wider posteriorly than anteriorly and wider above than below. The anterior width of the ethmoid is 0.5 to 1 cm. The posterior width is approximately 1.5 cm. The anteroposterior length of the labyrinth is 3 to 4 cm. The height is 2 to 2.5 cm. The medial wall of the ethmoid is made up of the upper half of the if the lateral nasal wall. This is actually an extension of the attachment of the middle turbinate, which also separates the roof of the ethmoid from the olfactory slit in the superior nasal cavity. A prolongation of the orbital plate of the frontal bone is the roof of the ethmoid labyrinth.

The lacrimal bone forms the lateral wall of the anterior ethmoid cells, and the os planum (lamina papyracea) forms the lateral wall of the posterior ethmoid cells. The anterior and posterior ethmoid foramina fairly accurately indicate the level of the roof of the ethmoid and the cribiform plate. The posterior ethmoid cells may be as close to the optic foramen as 1 mm. As a general rule, the outer half of the front face of the sphenoid sinus is the posterior limit of the ethmoid labyrinth.

The number of ethmoid cells varies between four and eight. The most important structures in the proximity of the anterior cells are the lacrimal bone, the floor of the frontal sinus, and the hiatus semilunaris; those in the proximity of the posterior cells are the posterior half of the medial wall of the orbit, the optic nerve, and the lateral half of the front wall of the sphenoid sinus. The plane of the cribiform plate approximately corresponds to: (1) the roof of the ethmoid labyrinth; (2) a horizontal line at the level of the pupils; and (3) the anterior and posterior ethmoid foramina.

**Technique of Operation.** The patient's face is prepared with antiseptic solution and draped so as to expose the lower forehead, eyes, cheeks, and nose. The eyelids are fastened together with a single #5-0 suture to prevent injury to the cornea. After infiltration with a 2% local anesthetic agent with added epinephrine, a 1-inch curved incision is made half way between the inner canthus and the anterior aspect of the nasal ridge. This incision is extended through the skin, subcutaneous tissue, and periosteum. Troublesome bleeding from the angular vessels and their numerous branches in this area is usually encountered. Before proceeding with the operation it is best to control this bleeding by either ligation or cauterization.

A number of retractors have been devised for exposure, but none of them seems as effective as two or three sutures, weighted with heavy hemostats, placed on each side of the incision. By elevating the periosteum laterally, the anterior and posterior lacrimal crests and fossae are identified. The lacrimal sac is displaced laterally, exposing the lacrimal bone, and posteriorly, exposing the lamina papyracea. The anterior and posterior ethmoid vessels are encountered during the elevation of the periosteum from the lamina papyracea. As a rule it is necessary to divide these vessels. Should bleeding occur, it can be easily controlled by cautery or by a short period of packing with gauze saturated with epinephrine solution. The ethmoid labyrinth is entered by perforating the thin lacrimal bone just posterior to the posterior lacrimal crest with a sharp curette. This opening is enlarged with various-sized Kerrison forceps. The anterior ethmoid cells are then removed by using ethmoid curettes and Brownie and Takahashi forceps.
An instrument such as the periosteal elevator is passed intranasally along the nasal septum and then above the middle turbinate, causing the mucous membrane of the lateral nasal wall to bulge into the field. This membrane is then incised, affording the operator a view of the middle turbinate. Turbinate scissors are used to sever the attachment of the middle turbinate; the turbinate is removed with a wire snare. Using the attachment of the middle turbinate as a guide, the posterior ethmoid cells are removed. The upper prolongation of the attachment is then removed. The olfactory slit (cribriform plate) thus becomes continuous with the roof of the ethmoid.

The dural defect is usually easily found with the aid of a surgical microscope. The thin bony roof of the ethmoid labyrinth and cribriform plate is carefully removed until the surrounding dura is exposed. After this has been accomplished, a pedicled mucosal flap is obtained from the nasal septum.

Detection of the site of leakage is facilitated by the injection of 1 cc of 5% fluorescein intrathecally prior to the operation. On occasion the dural defect is sufficiently large to reduce the spinal fluid pressure either intermittently or constantly. In such cases it may not be possible to identify the site of leakage, even when fluorescein dye has been injected intrathecally. It is therefore important to measure the spinal fluid pressure preoperatively, prior to the intrathecal injection of fluorescein. If the spinal fluid pressure is low or no pressure is registered, Hartman's solution* is used to elevate the pressure during the operation. A #20 spinal needle is inserted in the lumbar region (the patient is placed in the sitting position, if necessary) and a spinal catheter is inserted. Two cubic centimeters of 5% fluorescein are added to freshly mixed Hartman's solution and the mixture is infused through the spinal catheter.

(* Hartman's solution comes in a two-unit package. The first package contains potassium, sodium, calcium and magnesium chloride and a small amount of hydrochloric acid. The second contains sodium carbonate and phenol red dye. When the two are mixed, a salmon-pink solution having a pH of from 7.2 to 7.5 results.)

The Hartman's solution is allowed to flow intrathecally after the area of suspected leakage is exposed. The spinal fluid pressure is determined intermittently by means of a manometer attached to the infusion tubing. The orange-yellow spinal fluid will become obvious as soon as the pressure is raised, especially when the level of the patient's head is slightly below that of his body.

The septomucosal flap used to repair a fistula by way of the cribriform plate and roof of the ethmoid is based posteriorly. The superior incision extends along the anteroposterior dimension of the superior nasal septum at the junction of the septum and the olfactory slit. This incision is carried as far anteriorly as is possible. The lower incision is approximately 1.5 cm below, and parallel to, the superior incision. It may be necessary to obtain a somewhat wider flap if the dural dehiscence involves both the roof of the ethmoid labyrinth and the cribriform area. The anterior incision merely connects the anterior aspect of the superior and inferior mucosal incisions. As the mucosal flap is elevated, the perpendicular plate of the ethmoid bone is exposed. It is quite often necessary to remove most of the ascending process of the maxilla in this area to expose the anterosuperior nasal septum.
The septomucosal flap is rotated approximately 90 degrees so as to cover the point of leakage and adjacent dura of the olfactory and ethmoid regions. The flap is carefully packed in place with a layer of Gelfoam saturated with bacitracin solution. This is covered with 1-inch wide iodoform gauze stripping that has been impregnated with aureomycin ointment. A finger-cot packing is inserted into the nasal cavity to prevent inferior displacement of the iodoform gauze. A layer of Gelfoam is placed over the iodoform packing in the region of the external ethmoid incision to prevent the packing from adhering to the periosteum. The periosteal incision is then closed with #4-0 catgut and #5-0 silk or plastic suture material. The dressing consists of a layer of Telfa gauze over the suture line, an eye pad, gauze fluffs, and elastic adhesive. After 24 to 48 hours, the entire dressing and finger-cot packing are removed. The iodoform gauze packing; however, must be left in place until the sixth postoperative day.