

TITLE: Endoscopic Repair of CSF Rhinorrhea

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Introduction

Cerebrospinal fluid leaks occur due to varying etiologies. A common presentation includes headache, and the presence of either unilateral rhinorrhea or otorrhea. Cerebrospinal fluid rhinorrhea involves a breakdown of all barriers that separate the subarachnoid space from the upper aerodigestive tract, namely the mucosa of the nasal cavity or paranasal sinus, skull base, dura mater, and arachnoid membrane. CSF leaks potentially lead to ascending meningitis with ten percent mortality risk. While most leaks due to blunt trauma do well with conservative management, most of the other causes require surgical intervention. Endoscopic repair of these defects is widely practiced, and has led to 90% success rate after first repair.

Cerebrospinal Fluid Physiology

Cerebrospinal fluid (CSF) is continually produced, absorbed and circulated in the ventricles and around the surface of the brain and spinal cord. It functions to give physical support and buoyancy, protect the brain as a buffer during intracranial pressure (ICP) fluctuations, remove metabolic wastes, and it regulates the chemical environment of the brain. The adult has approximately 90 to 150 ml of CSF circulating at any given time. It is produced in the lateral, third, and fourth ventricles by the choroid plexus (60%). The remainder is produced from intracellular metabolic degradation of glucose and from ependymal cells across the parenchymal capillaries. CSF is produced at a rate of 0.35 mL/min or 500 mL/day. Flow of CSF begins in the lateral ventricles through the foramina of Monro into the third ventricle and then into the aqueduct of Sylvius to the fourth ventricle. From the fourth ventricle, it travels through the midline foramen of Magendie and laterally through the foramina of Luschka to communicate with the cisterna magna. The CSF bathes the brain and spinal cord, and its flow terminates when it is resorbed in the arachnoid villi located in the dural sinuses. The ICP is intimately related to the rate of cerebrospinal fluid turnover. Normal ICP is 5 to 15 cm H₂O while supine, and it changes with movement, time of day, cardiac cycle, and respiratory phase. It is raised during REM sleep, sneezing, laughing and Valsalva maneuvers. When ICP remains high, leakage of CSF may occur in the skull or spinal canal. This also occurs when there are any defects to the dura.

CSF Rhinorrhea

Patients with CSF rhinorrhea present with clear rhinorrhea (unilateral or bilateral), headache, recurrent meningitis, and unilateral intranasal masses. When performing the history, it is important to ask about onset, duration, severity, laterality, and associated symptoms. Also note history of facial trauma, sinus surgery or neurosurgical procedures, history of hydrocephalus, or recurrent meningitis. Physical examination requires a complete otolaryngologic exam including cranial nerve testing and nasal endoscopy. Findings include bony deformity, visualization of defect, and clear rhinorrhea. Differential diagnosis includes atrophic rhinitis, allergic rhinitis, autonomic dysfunction, sinonasal polyps, and temporal bone fracture.

Diagnostic testing begins with analysis of the nasal secretions. Beta-2-transferrin is a protein found in CSF, perilymph, and aqueous humor. It is produced by neuraminidase activity in the brain. Once fluid is collected, an electrophoresis is performed to detect the protein. This is a highly sensitive and specific assay that has been used for the detection of CSF in fluids. The only drawback to beta-2-transferrin is the time it takes for analysis. A newer assay that detects beta-trace protein has been developed and only takes fifteen minutes to perform. Beta trace protein is the second most abundant protein found in CSF. Its concentration is approximately thirty-five times more concentrated in the CSF than in serum. The assay has a similar sensitivity and specificity to the beta-2-transferrin assay, but it is contraindicated in diseases that increase serum beta trace or decrease CSF beta trace such as, meningitis and renal failure. In addition to these screening tests, imaging must be performed to help identify possible locations of dural defects.

Imaging

To achieve a successful repair, it is important to localize any defects preoperatively. There are many modalities used for imaging including high resolution CT, magnetic resonance imaging, radioisotope cisternography, metrizamide CT cisternography, and MR cisternography. HRCT and MRI are the most used, with the other tests adding information when there is a low flow leak, or intermittent leak.

CT provides information about bony detail, bone defects, and can help plan surgical approaches. The posterior table of the frontal sinus and the lateral and posterior walls of the sphenoid are best assessed using the axial plane, while the cribriform plate, fovea, and sphenoid roof are best visualized in the coronal plane. When clinically indicated, CT scanning should include the temporal bone.

MRI can be used when an encephalocele is the cause of CSF rhinorrhea. MRI can elucidate the contents of meningoceles, which can contain large vessels, or actual brain matter. MR cisternography is a recently developed technique that uses a fast spin-echo sequence with fat suppression and image reversal to highlight CSF fistulas. This technique may supplant other forms of cisternography that require intrathecal administration of contrast material such as metrizamide CT cisternography, or radioisotope cisternography.

Intrathecal fluorescein may be used to visualize CSF fistulas using a nasal endoscope. This allows the examiner to directly visualize the size of the defect, its location, and its rate of flow. A blue filter may need to be applied to the endoscope for areas of intermittent or low flow leaks. IT fluorescein may be used preoperatively or during the repair. 0.5% -10% sodium fluorescein (2.5-50mg) is mixed with 10 mL of CSF fluid and injected into intrathecal space over a 10-20 minute period. This remains an off-label use, and can have significant complications if used in high doses. Severe complications occurred with dosages of 500 mg or more and include seizure, transient pulmonary edema, transient numbness to extremities, and death. All of these preoperative tests help differentiate the etiology, location and size of defects. This information is invaluable to surgical planning.

Etiology

CSF leaks are classified as traumatic, congenital, spontaneous, iatrogenic, or secondary to tumor invasion of the skull base. Etiology of the CSF fistula is the most important determinant of successful repair. Blunt trauma is a major cause of CSF rhinorrhea, with 3% of closed head injuries and 30% of all skull base fractures. Usually, the rhinorrhea presents within the first 48 hours, however it may take up to three months before the episode of rhinorrhea. Many of these leaks are intermittent due to blockage of dural defect by edema, bone chips, or blood clot. Because of these inhibitors to flow, many leaks secondary to blunt trauma can be managed conservatively, but the clinician should be aware of the 30-40% chance of ascending meningitis developing. Penetrating trauma also accounts for CSF leaks. These defects are usually large and require endoscopic, craniofacial, or combined approaches for closure of defects.

Iatrogenic causes account for another significant amount of CSF leaks. Otolaryngologists, and neurosurgeons must be aware of areas that are prone to injury. Endoscopic sinus surgery carries a less than one percent risk of CSF leak. The most common locations for injury are the lateral lamella of the cribriform plate and the posterior ethmoids near the anteromedial wall of the sphenoid. During transphenoidal hypophysectomy, damage to the sellar diaphragm causes a leak. Skull base surgery also carries the risk of iatrogenic CSF fistula.

Trauma and iatrogenic causes are the two most common causes of CSF rhinorrhea, while congenital, spontaneous, and tumor invasion are relatively rare. Congenital causes of CSF rhinorrhea are relatively rare. Hydrocephalus and congenital skull base defects are the most common types. The defects are usually large and funnel shaped. Patients present with a meningoencephalocele and rhinorrhea, and they have normal ICP. In contrast, spontaneous leaks occur when all the other causes have been ruled out. These patients usually have increased ICP and an empty sella on imaging. Benign intracranial hypertension has been postulated as the cause, and most of these patients present as obese females (BMI>30) with constant headache. Skull base tumors may cause CSF rhinorrhea by direct tumor extension into the bone and dura.

Surgical Repair of CSF Rhinorrhea

The first repair of CSF leak was performed by Dandy in 1926 using a frontal craniotomy. This technique had a 60-80% success rate and was the gold standard for decades. In 1981, the first endoscopic CSF rhinorrhea repair was performed by Wigand. This has become the standard of care due to less morbidity, and 90% first time success rate.

The key to endoscopic surgical repair of CSF rhinorrhea is an accurate preoperative assessment of location of the fistula, its dimensions, and the anatomy of the surrounding area. Sites of lesions include cribriform, ethmoid, sphenoid, and frontal sinuses, most of which are easily assessable transnasally. The items needed for repair include topical nasal decongestant, local anesthetic, rigid nasal endoscopes (0° and 45°) as well as endoscopic instruments. If IT fluorescein is to be used, then a yellow light filter for the endoscope and a blue filter for the light source may aid in identifying the defect. The nose may be irrigated with antibiotic solution to decrease the risk of meningitis post-operatively.

Important perioperative issues include the use of lumbar drain, anesthetic plan, and preoperative antibiotics. The lumbar drain is useful in regulating ICP, administering IT fluorescein, and in helping reduce encephaloceles. It is usually not removed until 24-72 hours post operatively. In addition to lumbar drains, it is important to reduce positive pressure ventilation to avoid pneumocephalus and changes in ICP. To combat this, rapid sequence intubation can be performed to reduce the amount of time the patient is masked. At the end of the procedure, a deep extubation can decrease the amount of positive pressure ventilation and decrease spikes in ICP caused by coughing. Patients should receive preoperative ceftriaxone because of its CSF penetration, or either trimethoprim-sulfa or levofloxacin in those with cephalosporin allergies.

Approaches

The **direct paraseptal** approach may be used to reach defects of the cribriform, or ethmoid roof. A complete ethmoidectomy and maxillary sinusotomy are usually needed for adequate exposure. In addition, frontal sinusotomies, sphenoidotomies, and middle-superior turbinectomies may also be necessary for additional exposure. Once the defect is visualized, the mucosa is completely stripped away in preparation for the graft. This is critical for decreasing the risk of mucoceles, and in increasing the chance that the graft will remain in place. After the site is prepared, the encephaloceles need to be reduced. This may be done by using bipolar electrocautery at the stalk. It is important to ablate the encephalocele at the stalk so that it can not retract into the skull and hemorrhage. Next graft material is placed to patch the defect. Graft material includes cartilage, bone, mucoperichondrium, septal mucosa, turbinate, fascia, abdominal fat, conchal cartilage, free tissue or pedicled tissue, and composite grafts. Closure techniques include overlay, underlay, combined and obliteration. With overlay, the graft is placed extracranially. With underlay, the graft is placed between dura and bone. In combined techniques, a graft is placed deep to the dura, between dura and bone, and then an extracranial overlay is used. Obliteration requires complete mucosal stripping, and placement of abdominal fat. Fibrin glue, and degradable packing can be used to aid in wound healing by increasing contact of graft to recipient site.

Defects of the anterior sphenoid sinus can be repaired by a **transethmoidal** approach. Once the defect is in view, it is prepared in the same fashion as for the ethmoid roof. Care must be taken not to strip the mucosa of the lateral sphenoid sinus in order to avoid unnecessary damage to the carotid artery or optic nerve. The graft is then placed, and abdominal fat is used to support the graft, but not completely obliterate the sinus.

If the defect is located in the lateral sphenoid sinus, then a **transethmoidal-pterygoid-**

sphenoidal approach should be used. After performing an ethmoido-sphenoidotomy and a wide middle antrostomy it was possible to identify the posterior wall of the maxillary sinus. Next, the posterior wall of the maxillary sinus is removed and the pterygopalatine fossa is entered. The internal maxillary artery and its branches are identified, clipped, and divided to expose deeper areas of the pterygopalatine fossa. Cranial nerve V2, the vidian nerve, and the sphenopalatine ganglion are dissected free and preserved if possible. The pterygopalatine artery was then coagulated and it was possible to drill the anterior wall of the sphenoid sinus and the pterygoid base until exposure of the lateral wall of the sphenoid sinus and the floor of middle cranial fossa. Any encephaloceles are ablated and the graft is placed after preparation of the site.

Limitations

In appropriate cases, endoscopic sinus surgery has high success rates with minimal complications, however, there are cases when an extracranial or intracranial repair is necessary. Frontal sinus defects usually require an extracranial approach using an osteoplastic flap and frontal sinus obliteration. If the defect extends into the frontal sinus isthmus, then a combined endoscopic and extracranial approach may be needed. Defects that are multiple, comminuted, broadly attenuated, tumors with intracranial extension, high pressure leaks requiring CSF diversion, and large bilateral defects may require craniotomy for adequate exposure.

Postoperative management –

Patients are placed on bedrest with slight head of bed elevation (15°-30°). The patient is to avoid nose blowing, sneezing and Valsalva maneuvers, all of which raise ICP. Patients should be placed on stool softeners, and some may benefit from acetazolamide, which decreases CSF production. If lumbar drains were placed, meticulous care must be taken to maintain CSF homeostasis. Drains are usually clamped, then removed at 24-72 hours post-op. Once discharged, the patient should be advised to discontinue CPAP to avoid pneumocephalus, and should have activity restricted for four to six weeks. Repeat endoscopic exams are necessary to identify persistent leaks.

Complications –

Persistent leak requiring a second operation occurs with 5-10% of repairs. Most of these are definitively closed with a second endoscopic operation, bringing endoscopic success rates to 97%. For those that still persist, a third open procedure may be required. Other complications include:

- Persistent leak (5-10%)
- Pneumocephalus
- Intracranial hemorrhage or hematoma (0.3%)
- Frontal lobe abscess (0.9%)
- Anosmia (0.6%)
- Chronic headache (0.3%)
- Meningitis (0.3%)

Conclusion

In summary, CSF rhinorrhea occurs when there is a fistula in the skull base and presents as clear rhinorrhea. Nasal fluid analysis with screening assays, beta 2-transferrin or beta trace protein, can confirm the presence of cerebrospinal fluid. Imaging helps confirm skull base defects, presence of intranasal masses, and the contents of encephaloceles. High resolution CT scans and MRI are essential for preoperative planning and for locating sites of defects. For defects to the cribriform, ethmoid, and sphenoid sinuses, endoscopic repair may be the best option for a lasting repair. Compared to open approaches, endoscopic repair has a lower morbidity, and better overall success rate.

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