Endoscopic repair cerebrospinal fluid (CSF) rhinorrhea

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Abstract
Cerebrospinal fluid (CSF) rhinorrhea is the result of an abnormal communication between the subarachnoid space and the sinonasal cavity, through a skull base defect. The vast majority of traumatic leaks will heal with conservative measures with surgical intervention reserved for patients who fail to respond to conservative management due to risk of meningitis. A careful diagnostic work up includes testing nasal fluid for Beta trace protein and identifying the site of leak with high resolution CT and or MRI imaging. Intrathecal injection of fluorescein can be extremely helpful in the diagnosis and also used intraoperatively to aid repair. The results of transnasal endoscopic repair have high success rates and are usually the first line treatment strategy.


Key words
Csf, rhinorrhea, repair.

Introduction
Cerebrospinal fluid (CSF) rhinorrhea is the result of an abnormal communication between the subarachnoid space and the sinonasal cavity, through a skull base defect. Persistent CSF leaks are divided into traumatic and non-traumatic. Between 80-90% of CSF rhinorrhea cases are related to trauma, this being either a head injury or iatrogenic following endoscopic endonasal surgery1. Non-traumatic causes include skull base tumours, raised intracranial pressure and congenital skull base defects. The risk of meningitis is a concern amongst these patients and can range from between 10% to 37% if managed conservatively, underscoring the importance of early detection and timely repair3,4,5. Historically, open intracranial approaches have been used to manage such cases, however advances in endoscopic endonasal surgery have revolutionised treatment of CSF rhinorrhea due to significantly less morbidity and higher success rates ranging from 87% to 100%.6

Accidental trauma
Traumatic CSF leaks can be a result of head injuries with anterior skull base fractures. This is seen in 15 to 30% of cases of skull base fractures and more frequently in comminuted fractures. These leaks often occur through the cribiform plate of ethmoid sinus roof due to tightly adherent dura in these areas6. Most patients (80%) will present with CSF rhinorrhea in the first 48hrs and 95% of these patients will manifest within 3 months7. In such cases, leaks rarely require treatment as up to 85% heal spontaneously with conservative management7. Surgical intervention is usually indicated in patients who fail to respond to conservative management due to risk of meningitis.

Iatrogenic trauma
Iatrogenic CSF rhinorrhea accounts for 16% of traumatic cases5. It can occur following routine endoscopic sinus surgery as well as more advanced skull base surgery. The most common site of injury is the lateral cribiform lamella with other sites being sphenoid sinus and posterior fovea ethmoidalis. Risk of CSF leak following functional endoscopic sinus surgery is quoted as 0.5%, increasing with more complex skull base procedures such as clival tumours and revision surgery8. The majority of these will be repaired immediately at the time of injury or will be transferred to a skull base centre for surgical repair.

Non-traumatic
Spontaneous leaks account for the majority of non-traumatic leaks. The exact pathogenesis of spontaneous CSF rhinorrhea is unknown, however it is thought to be related to elevated intracranial pressures (ICP), commonly due to idiopathic intracranial hypertension (IIH)9. Patients with IIH are classically middle aged overweight women and present with headaches, visual disturbance and papillodema. There is an increased prevalence of this disease in the western world over the last few decades,
most likely as a result of the obesity epidemic\textsuperscript{10}. Spontaneous leaks secondary to sustained raised ICP are thought to result from increased dural pulsation with remodelling and thinning of the skull base creating an osteodural defect in pneumatised parts of the skull base\textsuperscript{6}. However, although elevated ICP has been implicated in spontaneous leaks, it is not the case in all patients with spontaneous CSF rhinorrhoea\textsuperscript{11,12}. Historically nontraumatic spontaneous leaks accounted for 4\% of CSF leaks, however more recent data suggests spontaneous leaks may be more common, ranging from 20.8\% to 40\% of all CSF leaks\textsuperscript{10}.

Other causes of non-traumatic leaks include tumours, mucoceles or infective processes eroding the skull base. Congenital causes can occur with or without raised ICP and these include encephaloceles, persistent craniopharyngeal canal (with or without tumour) and congenital widening of diaphragma sella\textsuperscript{13}.

**Diagnosis**

It is very important to have a high index of suspicion based on the history of presenting patients. This includes a recent history of trauma or surgery, which holds true for the majority of patients with CSF rhinorrhea. The most common clinical manifestation is persistent clear rhinorrhea, often unilateral, made worse by bending over or Valsalva manoeuvre\textsuperscript{11}. Some patients may report a history of headaches in the presence of raised ICP or intracranial lesions.

A quick bedside test for CSF fluid is the presence of a double ring sign when drops of the fluid is placed on absorbent filter paper or the “halo sign” on a pillowcase. Bedside glucose detection using test strips is not recommended due to its lack of sensitivity and specificity\textsuperscript{6}. The gold standard test for CSF fluid is to test for Beta 2 transferrin by immunofixation electrophoresis, with a sensitivity of 94\% to 100\% and specificity of 98\% to 100\% \textsuperscript{12}. If there is a high index of suspicion or once the nasal discharge is confirmed as CSF, imaging is required to help locate the precise site of leak.

**Imaging**

**Computed tomography:** (Fig 1)

High resolution (0.5mm slice thickness) CT (HRCT) of the paranasal sinuses and skull base is the first line imaging modality, offering detailed osseous anatomy with greatest spatial resolution to pinpoint a site of dehiscence. HRCT has a sensitivity of 88\% to 95\% in identifying skull base defects with confirmed CSF leak\textsuperscript{14}. HRCT is also useful in delineating sinonasal anatomy for surgical planning and for use of intraoperative image guidance navigation. At the time of imaging an active leak does not have to be present to identify an osseous defect, however in the presence of multiple fractures or defects it can become difficult to identify which defects are responsible for the CSF leak\textsuperscript{10}. Another limitation of HRCT is that it offers poor soft tissue detail.

Having said that, if only one clinically correlating osseous defect is identified, no additional imaging is required before proceeding to surgical repair\textsuperscript{15} unless there is concern that there may be a meningocele or meningoencephalocele.

**Magnetic resonance Cisternogram:** (Fig 2)

Coronal Magnetic resonance Cisternography (MRC) is performed with heavily T2 weighted (T2w) fat saturated images and serves as a complementary imaging modality alongside HRCT in cases of suspected intracranial herniation, due to poor osseous detail\textsuperscript{16}. A positive finding will highlight a CSF column communicating from the subarachnoid space with or without any meningeal or brain herniation. Sensitivity of MRC imaging in identifying the source of leaks is up to 94\% \textsuperscript{9,17}.

**Computed tomography cisternography (CTC):**

This involves the use of intrathecal non-ionic iodinated contrast with scans taken in the prone and supine position,
with supine images also taken before contrast injection for comparison. A positive study will identify extracranial fluid or soft tissue adjacent to the osseous defect with pre and post contrast scans showing interval contrast pooling. CTC historically was the study of choice in identifying CSF leaks however now is rarely used in cases of multiple osseous defects or when other imaging modalities fail to show any defect. Disadvantages of this CTC include high radiation dose due to multiple scans, potential adversity from contrast and that patients have to be actively leaking for a positive scan resulting in low sensitivity rates.

Contrast enhanced Magnetic resonance cisternogram (MRC):
This technique employs intrathecal gadolinium with subsequent T1 weighted sequences. Like with CTC, a positive study will show contrast leakage through dural and osseous disruption. Similar to CTC, MRC also requires HRCT for interpretation. MRC is particularly useful in cases of slow flow or intermittent leaks and offers increased sensitivity in comparison to HRCT with non-contrast MRC. In high flow leaks sensitivity has been reported up to 100% with slow flow leak sensitivity being between 60-70%. Strengths of this technique include less radiation and easier interpretation in comparison to CTC due to better soft tissue/ bone differentiation. Although gadolinium has been used safely worldwide at low doses, there is potential risk of neurotoxicity and so patient selection is very important.

Intrathecal fluorescein: (Fig 3)
The use of intrathecal fluorescein is off-licence yet can be very useful in identifying the location of CSF leaks intra-operatively. Commonly 0.1ml of 10% fluorescein (10mg) is diluted in 10ml of CSF and injected intrathecally via a catheter over 10 minutes. This can be directly visualised intra-operatively and enhanced with the use of a blue light filter. Side effects reported from the use of fluorescein such as seizures are dose dependent and associated with much higher doses. Generally speaking, no side significant side effects have been reported with doses less than 10mg.

Management

Conservative management:
The vast majority of traumatic CSF rhinorrhea can be managed conservatively for up to two weeks, with up to 85% of CSF leaks healing spontaneously. Failing this, the risk of meningitis necessitates for definitive surgical repair. Conservative measures include bed rest, laxatives, and the avoidance of anything that will increase ICP such as lifting heavy weights.

The use of a lumbar drain may also be considered but this carries additional morbidity and the evidence for its use is limited. The use of prophylactic antibiotics is a controversial topic and practice can vary due to conflicting evidence.

A recent evidence based review conferred no added benefit from the use of prophylactic antibiotics in traumatic leaks. All patients should also be given pneumovax vaccination to prevent meningococcal meningitis.
Surgery

Open:
Open approaches to anterior skull base repair is far less common than historically. This can be either with an intracranial or extracranial approach. Open approaches are only rarely indicated. These may include: large encephaloceles, in patients with extensive multiple defects and for leaks associated with intracranial lesions or haematomas. Leaks difficult to manage endoscopically, such as those in the posterior frontal sinus wall, may sometimes require an open cranial approach. However, these techniques are associated with a significantly higher rate of morbidity compared to purely endoscopic approaches.

Transnasal Endoscopic:
Advances in endoscopic sinus surgery have led to it being the preferred method of repairing CSF leaks, due to significantly reduced morbidity and excellent outcomes. Success rate from endoscopic repair ranges from 70% to 100% on first attempt and 86% to 100% in revision/redo surgery. A variety of graft material can be used for repair of the skull base, including fat, bone, allografts, free mucosal or fascial grafts, vascularized flaps as well as synthetic grafts and sealants to hold the repair in place. There is currently no evidence that supports one material to be superior to another and their use very much relies on site and size of defect as well as surgeon’s preference. However, in the presence of large defects (>3cm) or high flow leaks, vascularized grafts (eg nasoseptal or pericranial) confer improved outcomes with lower post-operative leak rates, especially in tumour surgery in which patients may receive post-operative radiotherapy. In reality, surgeons often use a multilayer technique with variety of different materials as underlays and overlays around the defect, with nasal packing to hold the repair in place. The use of lumbar drains has previously been commonly used in the perioperative period, however the current evidence does not support the routine use of lumbar drains. Complications of repair include headache, meningitis, pneumocephalus, haematomas, abscess formation and recurrence. In cases where localising the defect is difficult, intrathecal fluorescein can be used intraoperatively to confirm the exact location of the dural defect and observe CSF leaking using a blue light filter. Complications such as seizures have rarely been reported after its use but this is eliminated when lower concentrations of fluorescein are used.

Conclusion
Trauma still continues to be the most common cause of CSF rhinorrhea. Early diagnosis and swift intervention is the key to managing these patients. In most cases the site of leak can be identified with appropriate imaging and repaired with a transnasal endoscopic approach.

Reference