

# Current Imaging of Cerebrospinal Fluid Leaks

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## ABSTRACT

*A CSF leak results from a defect in the dura and skull base. Due to the risk of potentially devastating central nervous system infection, it is an important entity. Timely diagnosis of CSF leaks is crucial. Laboratory testing of nasal or aural fluid drainage for the presence of the protein Beta ( $\beta$ )-2 transferrin plays a key role in establishing the presence of a CSF leak. Such assays are not always available, making imaging pivotal in the diagnosis of this entity. The development of minimally invasive endoscopic repair further underscores the importance of imaging as precise anatomic localization is important for repair. In this article, we review the literature and make suggestions for the appropriate radiological investigation of patients with suspected CSF leaks.*

## Imágenes Médicas Actuales de Pérdidas de Fluido Cerebroespinal

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## RESUMEN

*Las pérdidas de fluido cerebroespinal (FCE) son el resultado de un defecto en la dura y la base craneal. Debido a que tales pérdidas presentan el riesgo de infecciones capaces de devastar potencialmente el sistema nervioso central, las mismas constituyen una entidad importante. El diagnóstico a tiempo de pérdidas del FCE es crucial. Las pruebas de laboratorio realizadas al drenaje del fluido de la nariz y los oídos a fin de detectar la proteína Beta ( $\beta$ ) 2 transferrina, desempeñan un papel clave a la hora de determinar la presencia de pérdida de FCE. Estos ensayos no se hallan siempre a disposición, con lo cual la imagen médica se hace fundamental para el diagnóstico de esta entidad. El desarrollo de reparaciones endoscópicas mínimamente invasivas subraya aún más la importancia de la imagen médica, por cuanto se requiere una localización anatómica precisa para realizar la reparación. En el presente artículo, se revisa la literatura y se hacen sugerencias a fin de lograr una investigación radiológica adecuada de los pacientes con sospecha de pérdida de FCE.*

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## INTRODUCTION

Cerebrospinal fluid (CSF) is a protective fluid which circulates around the brain and spinal cord. The normal circulating volume is 90–150 mls (1). It is contained within dural coverings and overlying bone that protect it from the external environment. Combined dural and bony defects in the skull base allow CSF to leak. These defects may occur spontaneously or be secondary to trauma or surgical intervention (2). Leakage can occur into the paranasal sinuses and nasal cavity and less commonly through the petromastoid complex into the middle ear. Patients may present with CSF rhinorrhoea or otorrhoea. Cerebrospinal fluid (CSF) leaks can

resolve spontaneously (3, 4), however, as a result of the free communication with the intracranial space, there is an open portal for transmission of infection. The development of serious complications such as meningitis should never be ignored, a 10% risk of developing meningitis being cited in the literature (5, 6). Cerebrospinal fluid (CSF) leaks continue to present a diagnostic challenge as they are commonly mistaken for rhinorrhoea, however, clear rhinorrhoea may also mimic CSF leaks in extreme cases leading to unnecessary surgery (7).

## Pathophysiology and Causes of CSF Leaks

Cerebrospinal fluid leaks are caused when there is a combined bony and dural defect together with a sufficient pressure gradient that allows CSF to drain externally. The causes include skull base surgery (8, 9), spinal surgery (10), endoscopic sinus surgery (11, 12) and trauma (13, 14). Post-traumatic CSF leaks account for 50–80% of CSF leaks. It is seen in 2–6% of head injuries (15, 16). Rarely,

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congenital defects, such as meningoceles (Fig. 1) lead to CSF leaks (17, 18). In many cases, there is no identifiable cause, so called “spontaneous” leaks (19).



Fig. 1: Sagittal T1W1 of a 6-year old with a frontonasal mass and a watery nasal discharge.

Empty sella has been implicated in some of these spontaneous cases of CSF leak (20) as well as benign intracranial hypertension (21). Spontaneous leaks have also been recorded in the sphenoid sinus (22). Intracranial tumours, in particular those near the skull base have the potential for erosion of the dura and skull base with resultant CSF leak. This has been seen with pituitary adenomas (23). Radiation osteitis is also a recognized cause of CSF leak (24).

## Diagnosis of CSF Leaks

### Physical Examination

The clinical diagnosis may be difficult as CSF leaks may be intermittent or slow. A history of trauma or surgery may be obtained. Physical findings include a unilateral profuse watery discharge, exacerbated by posture or the Valsalva manoeuvre, or headache relieved by leakage of CSF through the ear or nostril. Clinical findings are unreliable and may be mistaken for vasomotor rhinitis (25, 26). Other symptoms relating to CSF hypovolaemia may be noted such as orthostatic headaches, nausea, dizziness, neck stiffness, blurred vision and tinnitus (27).

### Laboratory Analysis

Laboratory testing of nasal or aural fluid drainage plays a key role in establishing a CSF leak. Simple fluid tests such as sugar content are not reliable (28). Beta ( $\beta$ )-2-transferrin is a protein produced by neuramidase activity in the brain. It is found only in CSF, aqueous humour and perilymph. Beta trace protein is also present in CSF and has also been used as an immunological marker (29). Both are highly specific for confirmation of the presence of CSF (100%) with sensitivities of 84% and 91% respectively (30, 31). False positives can occur in patients with chronic liver disease and inborn errors of glycoprotein metabolism (32). As physical examination may be unreliable, it is therefore felt that such

fluid tests should be mandatory (7). In more recent times, there has been a more novel approach to distinguishing between CSF and nasal mucus, an electronic nose (33).

## Radiological Evaluation

In the absence of transferrin testing, imaging plays a key role in establishing the existence of a CSF leak. Imaging is also important in accurately identifying the site of leaks to facilitate appropriate treatment.

Several imaging modalities have been utilized to demonstrate the site of leakage historically while newer techniques continue to evolve. These modalities include plain radiography, computed tomography (CT), CT cisternography (CTC), magnetic resonance imaging (MRI), MRI with intrathecal contrast (MR cisternography or MRC) and radionuclide cisternography.

### Plain films

Plain films are very insensitive in establishing the diagnosis of a CSF leak but may demonstrate pneumocephalus as defects in the paranasal sinuses may leak air into the cranial vault at the same time as CSF drainage into the sinuses (34). Cerebrospinal fluid leaks result from basilar skull fractures which are suboptimally depicted on plain radiographs but an air-fluid level in the sphenoid sinus may be used as a non-localizing finding (35).

### Computed Tomography

High resolution CT gives excellent bone detail. It is the best modality for demonstrating base of skull fractures, particularly with multidetector scanners. In cases of CSF rhinorrhoea, the technique involves thin (usually 1 – 2 mm) sections through the anterior and middle cranial fossa skull base. For otorrhoea, both axial and coronal 2 mm sections are acquired through the petrous temporal bone. Computed Tomography may demonstrate fractures of the cribriform plate (Fig. 2). Sphenoid sinus or petromastoid complex fractures may also be seen, as well as congenital bony defects secondary to meningoceles. Computed Tomography has a reported sensitivity of 89% (36), there being false positives from volume averaging and vascular grooves in the cribriform plate. The recent addition of multidetector CT (MDCT) has further improved the sensitivity of this modality (37).

### CT Cisternography

The CT cisternography (CTC) is an invasive technique requiring intrathecal puncture. It therefore carries the risks associated with a lumbar puncture. These include spinal headaches, CNS infection and rarely seizures. Following lumbar puncture, contrast is instilled and thin CT sections as described above are performed. The CT cisternography findings in a patient with a CSF leak include concentration of contrast medium in a sinus or mastoid air cell or a stream of contrast at the fistula site (Fig. 3). The sensitivity for detection of a CSF leak with CT cisternography was found to

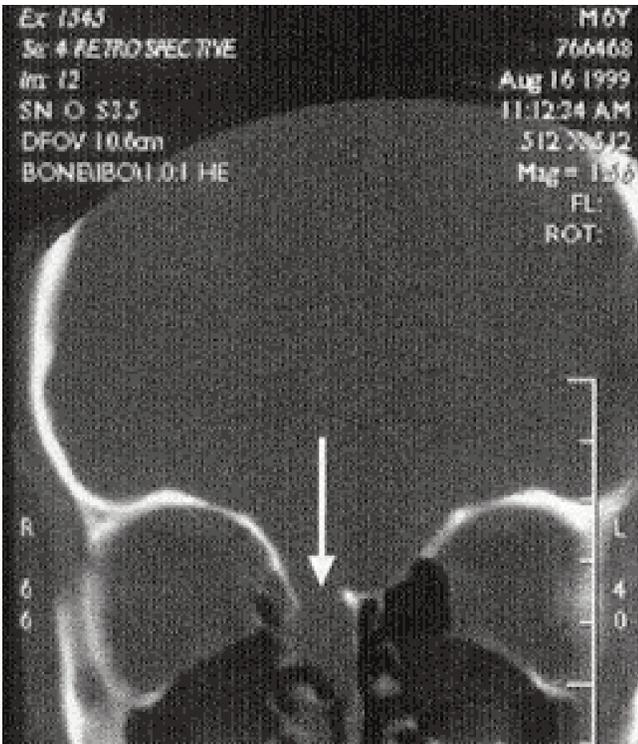


Fig. 2: Coronal CT of a patient with a 2-year history of CSF rhinorrhoea showing a defect in the cribriform plate.

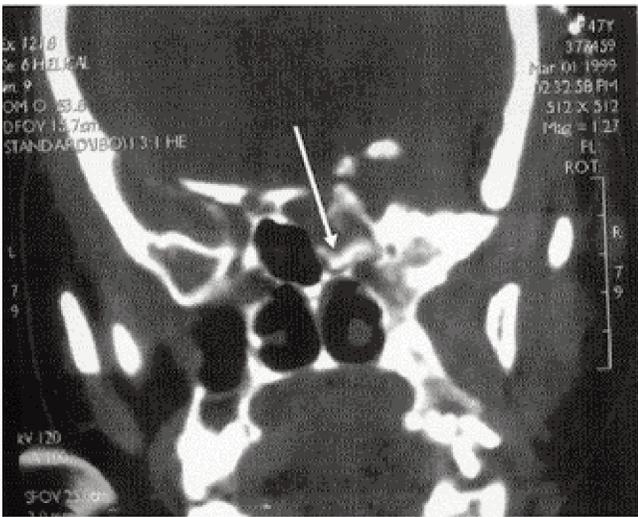


Fig. 3: CT cisternogram of a patient with postoperative CSF rhinorrhoea showing contrast entering the sphenoid sinus through a bony defect.

be 65 – 85% by Stone *et al* (38). When comparing CT with CTC, no cases of a CSF leak were seen at CTC that did not have a bone defect at CT. We therefore reserve CTC for cases in which CT showed multiple bone defects or no bone defect.

### Radionuclide Cisternography

Radionuclide cisternography involves the intrathecal injection of radioisotopes. Isotopes employed for this purpose include  $^{99m}$  Technetium and Indium $^{111}$ . Cotton pledgets are placed in the nose and these are later removed and measured for tracer activity. The sensitivity for detecting CSF leaks is in the range of 50 – 100% (39). The specificity is almost 100% for contemporary radionuclide cisternography (40). It is not widely used today due to the greater sensitivity provided by high resolution CT (38).

### Magnetic Resonance Imaging

Magnetic Resonance (MR) imaging can be used to demonstrate a CSF fistula in multiple planes non-invasively without the disadvantage of ionizing radiation or intrathecal injection of contrast. Coronal T2W fat suppressed sequences should be routinely employed as part of the protocol (36) as it demonstrates the CSF fistula (dural tear) as a high signal cleft traversing low signal bone. Its accuracy in patients with active CSF rhinorrhoea is 89% (41). Whereas CT may demonstrate more precisely the extent of a bony defect, in the case of meningoceles, MRI will be more valuable in differentiating the contents of the sac (Fig. 1).

### Intrathecal Gadolinium Enhanced MR

Intrathecal gadolinium enhanced MRI is a more recent addition to the core of investigations available for detecting CSF leaks. In 1997, the first pilot study of its use was undertaken with eleven patients (42). It involves the intrathecal injection of contrast agent gadopentate dimeglumine by lumbar puncture. In the follow-up study involving ninety-five patients in a multi-centre study, no adverse effects were noted (43). A recent article by Albayram showed a sensitivity of 89% with a higher yield than CT cisternography (44). Goel *et al* had previously demonstrated similar findings in a smaller series (45) as did a subsequent multicentre study by Aydin *et al* (46).

### Combined CT/MRI

Establishing a CSF leak requires demonstrating a combined dural and bony defect. The CT cisternography and radionuclide cisternography can demonstrate such defects but have potential risks as previously outlined and can be a source of patient discomfort. Demonstrating a bone defect at high resolution CT and a dural defect at MRI at the same level can essentially give the same information as cisternography without the risk. Combined CT and MRI (with independent observers) accurately localized the site of leakage with a sensitivity of 89.74% (36).

### Clinical and laboratory correlation

Cerebrospinal fluid (CSF) leaks, though uncommon, continue to present a diagnostic challenge. They may be slow and intermittent or mistaken for rhinitis. Timely diagnosis is

crucial due to the potential for CNS infection. The reported frequency of CSF leaks with meningitis varies and can be as high as 50% (47, 48). Some cases of CSF leak do resolve spontaneously and the use of prophylactic antibiotics is debatable but advocated by some authors. It may reduce, but not eliminate, the risk of infection (49). Therefore, physicians should have a high index of suspicion of CSF leaks in patients with clear watery nasal discharge in the absence of upper respiratory tract infection or similar aural discharge, particularly if there is a history of trauma or if the patient had been treated for rhinitis (26). In such cases, urgent referral to an ENT or neurosurgical service should be made.

Assays for the presence of  $\beta$ -2 transferrin and  $\beta$ -2 trace protein form an essential first line of investigation to confirm the presence of CSF in nasal or aural fluid drainage. When these confirmatory laboratory tests are unavailable, the radiologist's role is paramount. In light of the reported accuracy of combined non-invasive techniques such as CT and MRI, less reliance should be placed on the use of invasive techniques such as CTC or radionuclide cisternography. It is essential that the teams involved in the patient care develop a working algorithm for investigating these patients (Fig. 4).

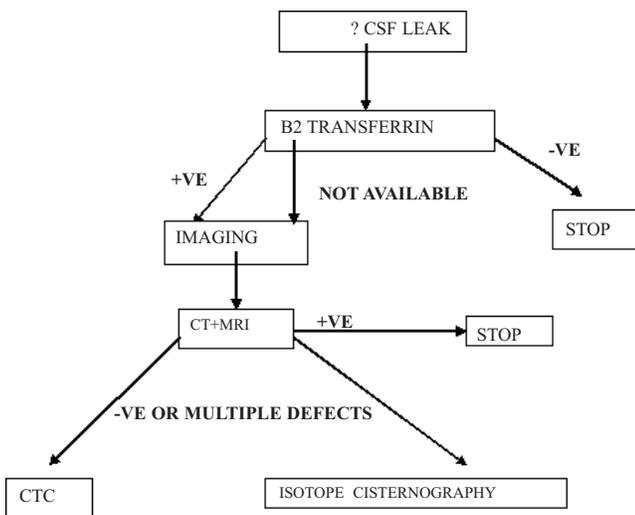


Fig. 4: Suggested algorithm for imaging a patient with suspected CSF leak.

The combination of non-invasive diagnostic techniques (MRI/CT) with high sensitivities and specificities has led to a decline in the use of CTC and radionuclide studies, the latter two modalities being used only in equivocal cases. CSF leaks, though a diagnostic challenge, can be managed successfully with the correct team approach.

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