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Study of trans-Nasal endoscopic repair of cerebrospinal fluid rhinorrhea

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Abstract
CSF rhinorrhoea is the condition in which CSF leaks through nasal cavity due to dural fistula. Common causes are nontraumatic, traumatic, and iatrogenic. Nontraumatic CSF rhinorrhea may be associated with normal CSF pressure or CSF hypertension. Most of traumatic type stop spontaneously within a week to 6 months. Anosmia and meningitis are two main dangers of it. In Nontraumatic type, there is greater flow of CSF. Side is not constant. Headache is common than anosmia. It's common in females and >30 years of age. Iatrogenic type is commonly due to neurosurgical and otolaryngotic approaches to neoplastic diseases and functional endoscopic sinus surgery. Hence based on above findings the present study was planned for study of Trans-Nasal Endoscopic Repair of Cerebrospinal Fluid Rhinorrhoea.
The present study was planned in Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna, Bihar, India. Total 10 cases presented with the watery discharge from left nostril were enrolled in the present study. ENT examination revealed clear watery fluid coming from left nostril on bending forwards which could not be sniffed back which is referred to as the "reservoir sign" and could not stiffen the handkerchief, which is called "Handkerchief sign". Diagnostic Nasal Endoscopy revealed clear pulsatile watery discharge from left sphenoid sinus.
The present study of CSF rhinorrhoea concludes that commonest cause of CSF rhinorrhoea found to be spontaneous in nature, while trauma comes next among our patients. The 11 to 50 yrs of age and Female are the commonest age group affected, Proper clinical history and investigations will identify the leaks and the site of leak and whether there is associated meningoencephalocele or not. Spontaneous CSF rhinorrhoea found to be higher than traumatic, and most patients either spontaneous or traumatic presented with the meningoencephalocele. In our study the most common site of CSF rhinorrhoea found to be in cribriform plate, next being anterior ethmoid while posterior ethmoid, sphenoid and frontal areas relatively less common.

Keywords: trans-nasal endoscopic, repair of cerebrospinal fluid rhinorrhea, etc.

Introduction
Cerebrospinal fluid (CSF) rhinorrhea is a rare but potentially devastating condition that can lead to significant morbidity and mortality for the patient. Disruption of the barriers between the sinonasal cavity and the anterior and middle cranial fossae is the underlying factor leading to the discharge of CSF into the nasal cavity. The resulting communication with the central nervous system (CNS) can result in a multitude of infectious complications that impart significant morbidity and potentially disastrous long-term deficits for the patient.
CSF consists of a mixture of water, electrolytes (Na+, K+, Mg2+, Ca2+, Cl-, and HCO3-), glucose (60-80% of blood glucose), amino acids, and various proteins (22-38 mg/dL). CSF is colorless, clear, and typically devoid of cells such as polymorphonuclear cells and mononuclear cells (< 5/µL).
The primary site of CSF production is the choroid plexus, which is responsible for 50-80% of its daily production. Other sites of production include the ependymal surface layer (up to 30%) and capillary ultrafiltration (up to 20%). CSF represents the end product of the ultrafiltration of plasma across epithelial cells in the choroid plexus lining the ventricles of the brain. A basal layer Na+/K+ ATPase is responsible for actively transporting Na+ into epithelial cells, after which water follows across this gradient. Carbonic anhydrase catalyzes the formation of bicarbonate inside the epithelial cell. Another Na+/K+ ATPase lining the ventricular side of the epithelium extrudes Na+ into the ventricle, with water following across this ionic gradient. The resulting fluid is termed cerebrospinal fluid.
CSF is produced at a rate of approximately 20 mL/h for a total of approximately 500 mL daily. At any given time, approximately 90-150 mL of CSF is circulating throughout the CNS. CSF produced at the choroid plexus typically circulates from the lateral ventricles to the third ventricle via the aqueduct of Sylvius. From the third ventricle, the fluid circulates into the forth ventricle and out into the subarachnoid space via the foramina of Magendie and Luschka. After circulating through the subarachnoid space, CSF is reabsorbed via the arachnoid villi.
Circulation of CSF is maintained by the hydrostatic differences between its rate of production and its rate of absorption. Normal CSF pressure is approximately 10-15 mm Hg, and elevated pressure constitutes an intracranial pressure (ICP) greater than 20 mm Hg.
This article discusses current concepts in the etiology, diagnosis, and treatment of CSF rhinorrhea, as well as long-term management of patients following successful treatment.
Beta2-transferrin assay is currently single best laboratory

test for identifying the presence of CSF in sinonasal fluid. It should be kept in mind, however, that this test does not provide information regarding the site or laterality of the defect.

Another technique, the injection of intrathecal fluorescein, has been used not only to diagnose CSF rhinorrhea but to localize the site(s) where it occurs.

High-resolution computed tomography (CT) scanning is the imaging modality of choice for identifying a skull base defect associated with CSF rhinorrhea. CT scans may demonstrate skull base defects resulting from accidental or iatrogenic trauma, an underlying anatomic or developmental abnormality, or an erosive lesion such as a neoplasm.

Conservative treatment has been advocated in cases of immediate-onset CSF rhinorrhea following accidental trauma, given the high likelihood of spontaneous resolution of the leak. Conservative management consists of a 7-10 day trial of bed rest with the head of the bed elevated approximately 15-30°.

Several surgical options for repair of CSF leaks arising from the anterior skull base exist. Intracranial repair was frequently used (and is still used in select cases) for the routine repair of anterior cranial fossa CSF leaks. These leaks were typically approached via a frontal craniotomy.

Defects in the posterior table of the frontal sinus may be approached externally via a coronal incision and osteoplastic flap. The osteoplastic flap provides the surgeon with a view of the entire posterior table of the frontal sinus and is especially useful for defects more than 2 cm above the floor and lateral to the lamina papyracea.

Compared with external techniques, endoscopic techniques have several advantages, including better field visualization with enhanced illumination and magnified, as well as angled, visualization. Another advantage is the ability to more accurately position underlay or overlay grafts. Multiple studies demonstrate a 90-95% success rate with closure of skull base defects using the endoscopic approach [1, 2, 3, 4, 5, 6].

From the first intracranial repair in the 1900s to the use of endoscopes and image-guidance systems, the management of cerebrospinal fluid (CSF) rhinorrhea has greatly evolved. Dandy is credited with the first surgical repair of a CSF leak via a frontal craniotomy approach in 1926. Various other authors, including Dohlman (1948), Hirsch (1952), and Hallberg (1964), subsequently reported successful repair of CSF rhinorrhea through different external approaches. In 1981, Wigand reported on the use of the endoscope to assist with the repair of a skull base defect. Since then, endoscopic repair has become the preferred method of addressing CSF rhinorrhea, given the high success rate of 90-95% and the decreased morbidity associated with this approach.

The underlying defect responsible for cerebrospinal fluid (CSF) leaks, regardless of the etiology, is the same: disruption in the arachnoid and dura mater coupled with an osseous defect and a CSF pressure gradient that is continuously or intermittently greater than the tensile strength of the disrupted tissue.

Cerebrospinal fluid (CSF) leaks are generally classified as traumatic, iatrogenic, and spontaneous/idiopathic. Traumatic causes include both blunt and penetrating facial injuries. Iatrogenic causes include neurosurgical and otolaryngologic approaches to neoplastic disease, as well as functional endoscopic sinus surgery (FESS). Most spontaneous, or primary, causes of CSF rhinorrhea are now thought actually to be secondary to elevations in intracranial pressure (ICP) that might be seen in patients with idiopathic intracranial hypertension (IIH). Congenital skull base defects and certain tumors can also lead to CSF rhinorrhea [7].

A literature review by Lobo *et al.* indicated that in addition to increased ICP, risk factors for spontaneous CSF leaks include obesity, female gender, and obstructive sleep apnea. In the study, about 72% of patients with spontaneous CSF leaks were female, and about 45% had obstructive sleep apnea [8].

Penetrating and closed-head trauma are responsible for 90% of all cases of CSF leaks. CSF rhinorrhea following a traumatic injury is classified as immediate (within 48 hours) or delayed. The majority of patients with a CSF leak due to accidental trauma (eg, motor vehicle accident) present immediately. Most of the patients (95%) with a delayed CSF leak present within 3 months after the injury.

In contrast to traumatic leaks, only 50% of patients with iatrogenic CSF leaks present within the first week after the insult. In most cases, the patient will have been discharged when the leak presents itself. Hence, educating the patient regarding the common symptoms associated with a CSF leak such as salty or metallic taste is of paramount importance.

Any surgical manipulation near the skull base can result in an iatrogenic CSF leak. Skull base injuries can vary from simple cracks in the bony architecture to large (>1 cm) defects with disruption of the dura and potentially brain parenchyma.

Otolaryngology procedures, including FESS and septoplasty, can lead to a skull base defect and CSF rhinorrhea. Certain neurosurgical procedures such as craniotomy and transsphenoidal pituitary resections are most commonly associated with an increased risk of CSF rhinorrhea.

In patients undergoing endoscopic sinus surgery, the site of injury is most frequently the lateral lamella of the cribriform plate, where the bone of the anterior skull base is thinnest. Other common locations include the posterior fovea ethmoidalis and the posterior aspect of the frontal recess.

Immediate traumatic leaks result from a bony defect or fracture in conjunction with a dural tear. A possible cause of a delayed traumatic leak is a previously intact dural layer that has slowly herniated through a bony defect, finally tearing and allowing the cerebrospinal fluid (CSF) to leak. According to another theory, the tear and bony defect are present from the time of the original injury, but the leak occurs only after the masking hematoma dissolves [9].

Spontaneous CSF rhinorrhea usually manifests in adulthood, coinciding with a developmental rise in CSF pressure with maturity. The dura of the anterior cranial base is subject to wide variations in CSF pressure because of several factors, including normal arterial and respiratory fluctuations. Other stresses include Valsalva-like maneuvers during nose blowing or straining. This can lead to dural tears in areas of abnormalities of the bony floor.

A study by Lieberman *et al.* found evidence of a significant incidence of multiple simultaneous skull base defects in cases of spontaneous CSF rhinorrhea, reporting the existence of such defects in eight out of 44 patients (18.2%) in the study. The investigators suggested that intracranial hypertension may put patients at risk for developing these defects [10].

However, increased intracranial pressure is not always

present in the case of spontaneous CSF rhinorrhea. Other proposed mechanisms for nontraumatic CSF leaks include focal atrophy, rupture of arachnoid projections that accompany the fibers of the olfactory nerve, and persistence of an embryonic olfactory lumen.

A thorough history is the first step toward accurate diagnosis. The typical history of a cerebropsinal fluid (CSF) leak is that of clear, watery discharge, usually unilateral. Diagnosis is made more easily in patients with recent trauma or surgery than in others. Delayed fistulas are difficult to diagnose and can occur years after the trauma or operation. These cases often lead to a misdiagnosis of allergic and vasomotor rhinitis. On occasion, the patient has a history of headache relieved by drainage of CSF. Drainage may be intermittent as the fluid accumulates in one of the paranasal sinuses and drains externally with changes in head position (ie, reservoir sign).

A history of headache and visual disturbances suggests increased intracranial pressure. Sometimes, associated symptoms can assist in localizing the leak. For example, anosmia (present in 60% of individuals with post-traumatic rhinorrhea), indicates an injury in the olfactory area and anterior fossa, especially when it is unilateral. Optic nerve deficits suggest a lesion in the region of tuberculum sellae, sphenoid sinus, or posterior ethmoid cells. Patients with recurrent meningitis, especially pneumococcal meningitis, should be evaluated for a defect that exposes the intracranial space to the upper airway, regardless of the presence or absence of CSF rhinorrhea.

Physical examination should include complete rhinologic (including endoscopic), otologic, head and neck, and neurologic evaluations. Endoscopy may reveal an encephalocele or meningocele. Drainage of CSF in some cases may often be elicited on endoscopy by having the patient perform a Valsalva maneuver or by compressing both jugular veins (Queckenstedt-Stookey test). However, most of the time physical examination is unrevealing, especially in patients with intermittent CSF rhinorrhea.

In patients with head trauma, a mixture of blood and CSF may make the diagnosis difficult. CSF separates from blood when it is placed on filter paper, and it produces a clinically detectable sign: the ring sign, double-ring sign, or halo sign. However, the presence of a ring sign is not exclusive to CSF and can lead to false-positive results [11]. In contrast to unilateral rhinorrhea, bilateral rhinorrhea gives no clue of the laterality of the defect. However, even in this situation, exceptions can occur. Paradoxical rhinorrhea occurs when midline structures that act as separating barriers (eg, crista galli, vomer) are dislocated. This dislocation allows CSF to flow to the opposite side and manifest at the contralateral naris. The clinical findings most frequently associated with CSF rhinorrhea are meningitis (30%) and pneumocephalus (30%).

Unless medical or surgical contraindications exist, surgical repair is recommended in all patients with spontaneous or iatrogenic cerebropsinal fluid (CSF) rhinorrhea in order to prevent ascending meningitis.

In patients with nonsurgical trauma, waiting a period of 5-7 days to allow conservative measures (bed rest, stool softeners, and lumbar drainage) to assist with secondary closure of the traumatic defect is reasonable. However, if CSF rhinorrhea persists beyond this point, or if a large skull base defect is observed at the time of injury, surgical repair is warranted.

If an iatrogenic leak is detected intraoperatively, it should be repaired at the time of the original surgery. In most cases of iatrogenic injury presenting in a delayed fashion, surgical repair is necessary. A lumbar drain placed at the time of repair has not been shown to decrease recurrence of the CSF leak.

The most common anatomic sites of spontaneous cerebrospinal fluid (CSF) leaks are the areas of congenital weakness of the anterior cranial fossa and areas related to the type of surgery performed. The lateral lamella of the cribriform plate appears to be involved in approximately 40% of the cases, whereas a defect in the region of the fontal sinus is detected 15% of the time. The sella turcica and sphenoid sinus are involved in 15% of the cases as well.

Common sites of injury secondary to endoscopic sinus surgery include the lateral lamella of the cribriform plate and the posterior ethmoid roof near the anterior and medial sphenoid wall. Rarely, the leak can originate in the middle or posterior cranial fossa and can reach the nasal cavity by way of the middle ear and eustachian tube. These patients typically present with aural fullness due to a serous middle ear effusion.

Surgical repair of skull base defects resulting in cerebrospinal fluid (CSF) rhinorrhea is contraindicated in any patient who is not medically stable to undergo a general anesthetic or comply with postoperative care.

The management of CSF rhinorrhea depends on the cause, location, and severity of the leak. When trauma is the cause, the interval between trauma and the onset of the leak is important. The natural history of CSF rhinorrhea is highly dependent on the underlying etiology.

Traumatic leaks stop spontaneously in the majority of cases, thus a conservative approach is best. The leakage stops within 1 week in 70% of patients, within 3 months in 20-30%, and within 6 months in most patients. The leak almost never recurs. The opposite is true for nontraumatic leaks, as only one third stop spontaneously. Intermittent leakage over several years is characteristic.

CSF rhinorrhoea is the condition in which CSF leaks through nasal cavity due to dural fistula. Common causes are nontraumatic, traumatic, and iatrogenic. Nontraumatic CSF rhinorrhea may be associated with normal CSF pressure or CSF hypertension [12-14]. Most of traumatic type stop spontaneously within a week to 6 months. Anosmia and meningitis are two main dangers of it. In Nontraumatic type, there is greater flow of CSF. Side is not constant. Headache is common than anosmia. It's common in females and >30 years of age [13]. Iatrogenic type is commonly due to neurosurgical and otolaryngotic approaches to neoplastic diseases and functional endoscopic sinus surgery. Hence based on above findings the present study was planned for Study of Trans-Nasal Endoscopic Repair of Cerebrospinal Fluid Rhinorrhoea.

Methodology

The present study was planned in Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna, Bihar, India. Total 10 cases presented with the watery discharge from left nostril were enrolled in the present study. ENT examination revealed clear watery fluid coming from left nostril on bending forwards which could not be sniffed back which is referred to as the "reservoir sign" and could not stiffen the handkerchief, which is called "Handkerchief sign". Diagnostic Nasal Endoscopy revealed clear pulsatile watery

discharge from left sphenoid sinus.

All the patients were informed consents. The aim and the objective of the present study were conveyed to them. Approval of the institutional ethical committee was taken prior to conduct of this study.

Following was the inclusion and exclusion criteria for the present study.

Inclusion Criteria: All the cases of CSF leak continuous or intermittent lasting for more than two weeks duration, irrespective of the aetiology. The study cases include spontaneous, traumatic, meningoencephalocoeles, post functional endoscopic sinus surgery.

Exclusion Criteria: CSF leaks of less than two weeks duration (medical treatment). CSF leaks with space occupying lesions in the brain.

Results & Discussion

The brain floats in cerebrospinal fluid (CSF) which acts as a shock absorber. Sometimes this fluid comes out through the nose through a defect in the bone separating the nose and the brain, a condition called CSF rhinorrhoea.

The patients carry a risk of meningitis if the defect is not sealed. The neurosurgical procedure used hitherto to plug this defect involves cutting open the skull (craniotomy), lifting up the brain, searching for the defect and plugging it with fascia. This is a major procedure, associated with morbidity and recurrence rate.

Using Endoscopic techniques, the site of leak is located from the nose since the roof of the nose forms the floor of the brain and the leak can be plugged with cartilage and fascia. At Sinus and Nose, we have done over 200 endoscopic repairs of CSF fistulae in the last 15 years. Today our technique is pretty much standardised. For small defects we use temporalis fascia onlay. For defects larger than 4mm, we use cartilage inlay and temporalis fascia onlay. We have repaired defects up to 2cm with septal cartilage. 3 patients required a second procedure, of which one required a third procedure. None required intracranial neurosurgical intervention. The overall success rate is 100%. This procedure can be repeated without much fuss in case of recurrence.

Cerebrospinal fluid (CSF) rhinorrhoea is the leakage of cerebrospinal fluid from the anterior cranial skull base subarachnoid space into the nasal cavity due to a defect in the duramater, bone and mucosa. CSF rhinorrhoea involves breach of large number of anatomical structure, viz. duramater, arachnoid, the skull base, and the mucosa of the nasal cavities and the paranasal sinuses. The main surgical approaches for the surgical repair of CSF leaks are intracranial and extracranial.

Endoscopic guided approach for surgical repair of CSF rhinorrhoea offer the benefit of both panoramic and detailed image of the site of surgery. Owing to the specific direction of view of the endoscopic lens system, it is possible to inspect the circumference of the operating field at 360 degree, by rotating the telescope around it longitudinal axis. These technical features enables direct endonasal access to the anatomical structure at the skull base without the need for cutaneous incisions or cutting through bony segment and without dislodgement of bony structures.

Endoscopic approach is a subset of the extracranial, extradural approach of CSF fistula. Since 1981 when Wigand first used endoscopic treatment to treat CSF rhinorrhea [15]. Endoscopic approach has several advantages including better field visualization with enhanced illumination and magnified as well as angled visualization, ability to more accurately position the underlay or overlay grafts [16]. Major role of anaesthesiologist in endoscopic surgery is to provide clear bloodless field for the surgeon to display his optimum expertise simultaneously providing the patient with the least hemodynamic changes and shorter recovery time. Dexmeditomedine was used by us for the same purpose. Another crucial role of anaesthesiologist in CSF rhinorrhea surgeries is putting Lumbar drain and follow up in postoperative period. Drain can be put before induction or before extubation.

Table 1: Demographic Details

Parameters	No. of Cases
Age	
0 – 10 years	1
11 – 20 years	2
21 – 30 years	2
31 – 40 years	1
41 – 50 years	2
51 – 60 years	2
61 & above years	0
Sex	
Males	4
Females	6
Total	10

Table 2: Aetiology & Association

Parameters	No. of Cases
Aetiology of CSF Rhinorrhoea	
Spontaneous	5
Trauma	4
Post meningitis	1
Association With Meningoencephalocele	
Spontaneous	2
Trauma	1
None	7
Total	10

Table 3: Site of lesion

Site of lesion	No. of Cases
Cribriform plate	6
Anterior ethmoid	1
Posterior ethmoid	1
Frontal	1
Sphenoid	1
Total	10

Table 4: Type of Graft Used

Type of Graft Used	No. of Cases
Middle turbinate	5
Temporalis fascia & middle turbinate	1
Fascia lata & middle turbinate	3
Septal cartilage & middle turbinate	1
Total	10

Ommayo *et al.* [17] series 80 percent of cases are secondary to head trauma, while 16 percent are the result of operations in the nasal / paranasal cavities and skull base. Only about 4 percent of cases considered non-traumatic or spontaneous. D. Richard Lindstrom *et al.* [18] experience in Wisconsin Medical college is given below in number of patients:

Trauma including iatrogenic - 42 and Spontaneous – 13.
According to Kennedy site of CSF leaks among 27 patients found to be 17 patients with leak in ethmoids, while 6 patients in the cribriform plate and in the sphenoid in 4 patients.
Dodson *et al.* [19] treated 29 cases of CSF rhinorrhea with endoscopic techniques. Seventy-five percent had resolution after their initial repair. Duration of follow-up ranged from 3 to 43 months. Lanza *et al.* reviewed 36 patients that underwent endoscopic repair of CSF fistulas. During the first attempt, successful endoscopic repair was achieved in 94%.
D. Richard Lindstrom *et al.* [20] experience in Wisconsin Medical college reported success rate of 91% with the endoscopic closure. Also in properly selected patients, non operative management was ultimately successful in 90% of patients. Because all of these therapeutic modalities can be successful, the managing surgeon must consider factors such as leak location, etiology, and closure method prior to repair.
The most common cause of CSF rhinorrhoea is trauma, whereas spontaneous nontraumatic CSF rhinorrhoea is much less common and can be caused by various etiologies such as neoplasms, especially skull-base tumors, inflammatory, and granulomatous conditions such as Wegener's granulomatosis, syphilis, and basal encephaloceles [22].
The cranial encephaloceles have an approximate reported incidence of 1 in 35,000 cases [23]. The commonest site is through the anterior cranial fossa, whereas temporal encephaloceles are the least common. Pathological herniations of the temporal lobe through dural and bony defects are known as temporal encephaloceles and have been classified into five types by Wilkins and Radtke in 1993 based on the site of origin of these lesions. These five types are lateral, anterior, postero-inferior, antero-inferior, and anteromedial [21]. Of these, the anteromedial type is the least common. The congenital nature of these defects has been challenged in literature, supporting the role of acquired arachnoid pits and pneumatization of inferolateral recess of the sphenoid as etiological causes instead. Temporal lobe encephaloceles, based on their site of origin and on the nature of the dural and bony defects, may present in childhood or in adults with clinical presentations varying from an occult CSF rhinorrhea to conditions such as recurrent episodes of meningitis, otitis media, intractable seizures, and conductive hearing loss [24].
Patients with recurrent or persistent symptoms have to be treated with a definitive surgical repair. The surgical procedure varies depending on the location and size of the osseous defect, presence and the type of CSF leak, and general condition of the patient. An open procedure that included both or either of the intradural and extradural routes was the classic surgical procedure done in the past. The osseous defects are usually repaired using fat, cadaver graft, local muscle, bone chips, or a combination of these materials [25]. With the advent of endoscopic sinus surgeries, managing such cases has become relatively easier with reduced patient discomfort as there is minimal handling of the brain. Endoscopic sinus surgery is the preferred modality of treatment in cases of anteromedial temporal encephalocele, such as our case primarily because of the proximity of these lesions to the easily approachable sinuses [26]. The endoscopic procedures are performed either through the transnasal-transphenoidal or transethmoidal routes, the former approach may at times be unfavorable as it does not always provide complete visualization of the lateral recess of the sphenoid sinus, which is the commonest site of the osseous-dural defect [26].

Conclusion
The present study of CSF rhinorrhoea concludes that commonest cause of CSF rhinorrhoea found to be spontaneous in nature, while trauma comes next among our patients. The 11 to 50 yrs of age and Female are the commonest age group affected, Proper clinical history and investigations will identify the leaks and the site of leak and whether there is associated meningoencephalocele or not. Spontaneous CSF rhinorrhoea found to be higher than traumatic, and most patients either spontaneous or traumatic presented with the meningoencephalocele. In our study the most common site of CSF rhinorrhoea found to be in cribriform plate, next being anterior ethmoid while posterior ethmoid, sphenoid and frontal areas relatively less common.

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