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Spontaneous Resolution of Primary Cerebrospinal Fluid Rhinorrhea after Computed Tomography Cisternography

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Abstract

Meckel's Pediatric drug-resistant epilepsy (DRE) is a significant neurological disorder that develops when seizures persist despite treatment with two appropriately selected antiseizure medications. Although only a subset of children with epilepsy develops DRE, prolonged uncontrolled seizures during childhood can result in irreversible cognitive, behavioral, and developmental impairment. Over time, growing evidence has demonstrated that epilepsy surgery is an effective treatment for appropriately selected patients and that earlier surgical intervention is associated with improved relief from seizures and long-term neurodevelopmental outcomes. This review examines the mechanisms underlying pharmaco-resistance, including network reorganization, neuroinflammation, blood-brain barrier dysfunction, and structural abnormalities that contribute to epileptogenesis. Common surgically remediable causes of pediatric DRE, including focal cortical dysplasia, mesial temporal sclerosis, tuberous sclerosis complex, hemimegaloencephaly, and tumor-associated epilepsy, are discussed along with current surgical approaches, including resective, disconnective, and minimally invasive procedures. The evidence comparing early versus delayed surgical intervention is reviewed with emphasis on seizure control, cognitive development, language, behavior, and quality of life. Finally, this review highlights persistent barriers to timely surgical referral, including socioeconomic, geographic, and racial disparities, while exploring emerging advances in neuroimaging, artificial intelligence-assisted lesion detection, and imaging biomarkers that may improve early diagnosis and patient selection. Collectively, the available evidence supports earlier referral for surgical evaluation in children with DRE and suggests that prompt intervention may preserve neurodevelopment, improve long-term functional outcomes, and maximize quality of life.

Keywords: Cerebrospinal fluid leak; Computed tomography cisternography; Cranial base; Spontaneous resolution; Rhinorrhea; Skull base

Introduction

Cerebrospinal fluid (CSF) rhinorrhea, the inappropriate leakage of cerebrospinal fluid into the nasal cavity, represents a critical breach in the skull base's integrity. This condition is broadly categorized into traumatic/iatrogenic and spontaneous etiologies. Primary spontaneous CSF rhinorrhea (PSCSFR) is defined by the absence of a clear precipitating factor such as trauma, prior surgery, or overt skull base tumor [1]. Its incidence appears to be rising, a trend strongly correlated with increasing global rates of obesity and idiopathic intracranial hypertension, which exert chronic pulsatile pressure

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on anatomically vulnerable areas of the skull base, such as the lateral recess of the sphenoid sinus or the cribriform plate [2,3]. The paramount risk associated with an active CSF leak is the development of ascending bacterial meningitis, with reported lifetime risks as high as 19-50% if left untreated, underscoring the imperative for definitive diagnosis and management [4]. The diagnostic gold standard for localizing the site of a CSF leak is computed tomography cisternography (CTC), wherein intrathecal contrast administration is combined with high-resolution temporal bone and skull base imaging [5]. This modality provides exquisite anatomical detail of the bony defect and any associated meningocele or encephalocele. The established and definitive treatment for PSCSFR is surgical repair, typically via an endoscopic endonasal approach, which boasts success rates exceeding 90% in contemporary series [6,7]. Surgical intervention aims to permanently seal the dural and bony defect, thereby restoring the barrier between the sterile subarachnoid space and the colonized sinonasal tract, and eliminating the risk of meningitis. However, a growing body of anecdotal evidence and small case series challenges the notion that surgery is invariably the immediate next step. Several reports have documented instances where CSF leaks, particularly those with minimal flow, have sealed spontaneously following the diagnostic lumbar puncture required for CTC or with a period of strict conservative management [8,9]. Conservative protocols typically entail absolute bed rest, head elevation, stool softeners to prevent straining, and cough suppression. The proposed mechanism for this spontaneous resolution involves a combination of reduced CSF pressure from the diagnostic tap, local inflammatory and clotting responses at the fistula site triggered by the procedure, and the minimization of pressure fluctuations [10]. Despite these observations, the natural history of PSCSFR following CTC remains poorly elucidated. Critical questions regarding the actual incidence of spontaneous resolution, the optimal duration for a trial of conservative therapy, and most importantly-the clinical and radiological predictors of which patients are likely to succeed with non-operative management are largely unanswered [11]. This knowledge gap is particularly consequential in resource-limited settings, where surgical resources, advanced endoscopic equipment, and specialized expertise may be scarce or associated with significant financial burden for patients [12]. Therefore, a rigorous, prospective investigation into the outcomes of PSCSFR after CTC is warranted. This study aims to systematically evaluate the rate of spontaneous resolution following a standardized diagnostic and conservative protocol and to identify specific patient and imaging characteristics-such as leak flow rate, defect size, and skull base morphology-that predict a higher likelihood of non-operative success [13]. Defining such a cohort could spare a subset of patients from the risks and costs of surgery without compromising their long-term neurological safety.

Methodology

A prospective cohort study was conducted at the Department of Neurosurgery, National Institute of Neurosciences & Hospital, Dhaka, from January 2024 to December 2024. The study population consisted of 87 adult patients (aged ≥18 years) presenting with clinically suspected primary spontaneous cerebrospinal fluid (CSF) rhinorrhea.

Inclusion criteria

Patients were included upon confirmation of the diagnosis via a positive beta-2 transferrin test of nasal discharge. Only cases classified as primary spontaneous leaks, with no history of prior skull base trauma, intracranial surgery, or radiotherapy, were eligible for enrollment.

Exclusion criteria

Key exclusion criteria were secondary/traumatic CSF leaks, evidence of active intracranial infection (e.g., meningitis), identifiable skull base tumor on imaging, and patients with medical contraindications to computed tomography cisternography (CTC) or lumbar puncture.

Study procedure

All enrolled patients underwent high-resolution CTC for definitive fistula localization. Following the procedure, patients were admitted for a standardized conservative protocol involving strict bed rest, head elevation, cough suppression, and stool softeners. They were monitored for clinical resolution for a period of six weeks. Resolution was objectively confirmed by the cessation of symptoms and a subsequent negative beta-2 transferrin test.

Data analysis

Data on demographics, leak characteristics (pressure, defect size), and outcomes were recorded. Statistical analysis was performed using IBM SPSS Statistics, Version 23.0. Categorical variables were analyzed using the Chi-square test, and predictive factors for spontaneous resolution were identified through binary logistic regression. A p-value of <0.05 was considered statistically significant.

Result

The study cohort comprised 87 patients with confirmed primary spontaneous cerebrospinal fluid (CSF) rhinorrhea. The mean age of participants was 48.2 ± 11.7 years, with a female predominance (63.2%, n=55). The mean Body Mass Index (BMI) was 32.4 ± 5.1 kg/m², with 73.6% (n=64) of patients classified as obese (BMI ≥30). The average duration of reported rhinorrhea symptoms before presentation was 9.1 ± 7.3 months. Following computed tomography cisternography (CTC) and six weeks of conservative management, spontaneous resolution of the CSF leak was observed in 19 patients, yielding a resolution rate of 21.8% (19/87). The remaining 68 patients (78.2%) required definitive

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surgical repair. Comparative analysis between the resolution and non-resolution groups revealed significant differences in several key parameters. Patients in the resolution group had a statistically lower mean BMI (29.1 vs. 33.3 kg/m², p=0.012) and a significantly shorter mean symptom duration (4.2 vs. 10.3 months, p=0.003). The anatomical distribution of the skull base defects, as localized by CTC, also differed. The most common site overall was the cribriform plate (41.4%), followed by the sphenoid sinus (34.5%). However, spontaneous resolution was significantly more frequent in leaks originating from the ethmoid roof (44.4% resolution rate) compared to the sphenoid sinus (13.3% resolution rate, p=0.032). Crucially, specific CTC and clinical findings were strongly predictive of spontaneous closure. A bony defect size of less than 3 mm was associated with a resolution rate of 46.7%, compared to only 8.2% for defects ≥3 mm (p<0.001). The absence of an associated meningocele or encephalocele on imaging was another significant predictor, with a resolution rate of 31.7% versus 0% in cases where a meningocele was present (p<0.001). Furthermore, leaks categorized as low-pressure (< 20 cm H_2O on opening manometry during lumbar puncture) had a resolution rate of 37.8%, significantly higher than the 5.6% rate for high-pressure leaks (p=0.001). A binary logistic regression analysis was performed to identify independent predictors of spontaneous resolution. The model confirmed that defect size <3 mm (Odds Ratio: 8.92, p=0.001), absence of meningocele (Odds Ratio: 12.45, p<0.001), and low-pressure leak status (Odds Ratio: 5.14, p=0.015) were significant independent factors, while age, sex, and specific defect location were not.

Table 1: Baseline demographic and clinical characteristics of the study cohort (N=87)

Characteristic	Value
Mean age (years) ± SD	48.2 ± 11.7
Gender, n (%)	
Male	32 (36.8%)
Female	55 (63.2%)
Mean BMI (kg/m²) ± SD	32.4 ± 5.1
Obesity (BMI ≥30), n (%)	64 (73.6%)
Mean symptom duration (months) ± SD	9.1 ± 7.3

Table 2: Comparison of clinical features between resolution and non-resolution groups. Independent samples t-test used for continuous variables; Chi-square test for gender

Clinical feature	Groups		p-value
	Resolution (n=19)	Non-resolution (n=68)	
Mean age (years) ± SD	46.1 ± 10.8	48.8 ± 11.9	0.378
Female gender, n (%)	13 (68.4%)	42 (61.8%)	0.791
Mean BMI (kg/m²) ± SD	29.1 ± 4.3	33.3 ± 5.0	0.012
Mean symptom duration (months) ± SD	4.2 ± 3.5	10.3 ± 7.5	0.003

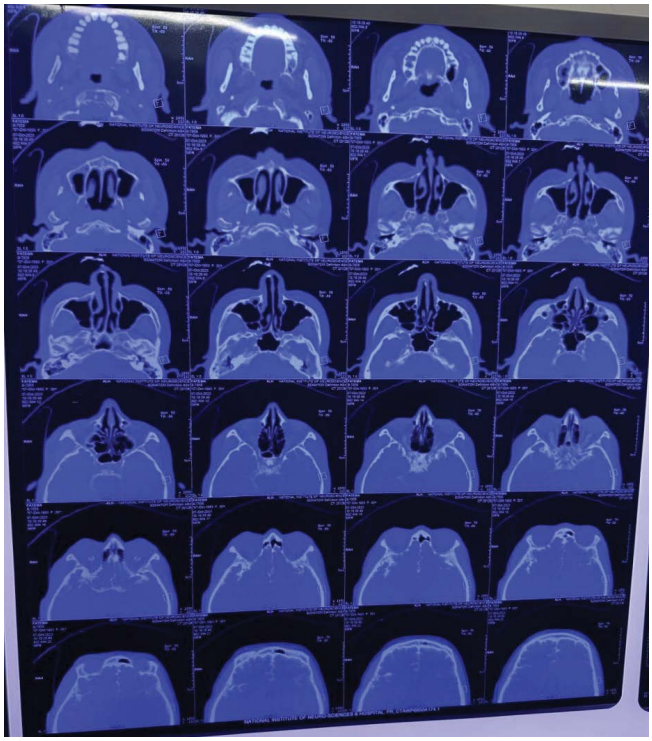

Figure 1: Cisternogram demonstrating CSF leakage into the right nasal cavity via small osseous defects in the anterior cranial fossa at the level of the cribriform plate

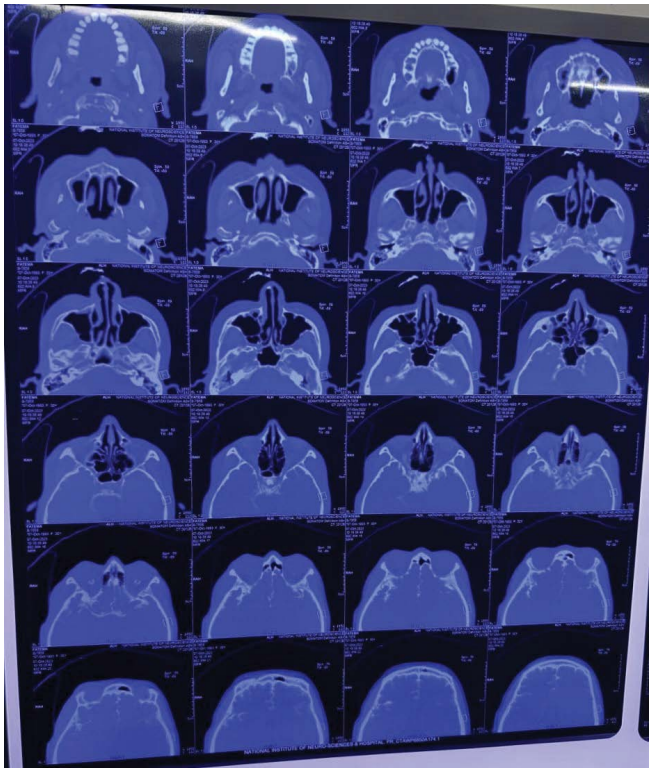

Figure 2: Cisternogram demonstrating CSF leakage into the right nasal cavity via small osseous defects in the anterior cranial fossa at the level of the cribriform plate

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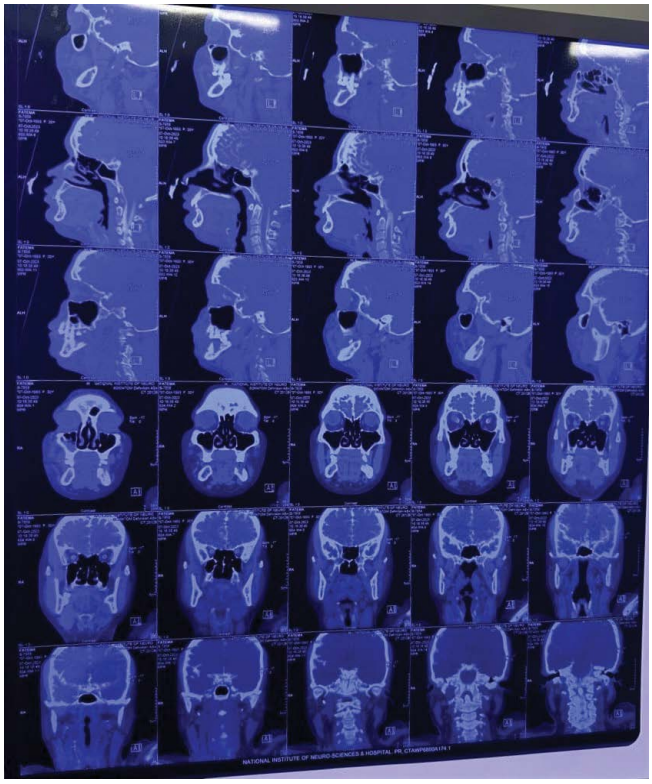

Figure 3: Cisternogram demonstrating CSF leakage into the right nasal cavity via small osseous defects in the anterior cranial fossa at the level of the cribriform plate

Table 3: Anatomical site of skull base defect and associated resolution rate Fisher's Exact Test was used due to low expected counts in some cells

Defect Site	Total cases n (%)	Cases with resolution n (%)	p-value
Cribriform plate	36 (41.4%)	7 (19.4%)	0.661
Ethmoid roof	18 (20.7%)	8 (44.4%)	0.032
Sphenoid sinus	30 (34.5%)	4 (13.3%)	0.246
Frontal sinus	3 (3.4%)	0 (0.0%)	0.999

Table 4: Association of radiological and clinical findings with spontaneous resolution.

Chi-square test used for all comparisons

Predictive factor	Category	Resolution rate (n/N, %)	p-value
Defect size	< 3 mm	14/30 (46.7%)	<0.001
	≥ 3 mm	5/57 (8.8%)	
Meningocele present	No	19/60 (31.7%)	<0.001
	Yes	0/27 (0.0%)	
Leak pressure	Low (<20 cm H_2O)	14/37 (37.8%)	0.001
	High (≥20 cm H_2O)	5/50 (10.0%)	

Table 5: Binary logistic regression analysis of predictors for spontaneous resolution.

Hosmer-Lemeshow test: p=0.721, indicating a good model fit

Variable	Odds ratio (OR)	95% Confidence interval for OR	p-value
Defect size <3 mm	8.92	2.52 – 31.55	0.001
Absence of meningocele	12.45	2.89 – 53.68	<0.001
Low-pressure leak	5.14	1.38 – 19.11	0.015
Ethmoid roof location	2.31	0.68 – 7.83	0.178
Symptom duration	0.89	0.80 – 1.00	0.054
BMI	0.87	0.76 – 1.00	0.051

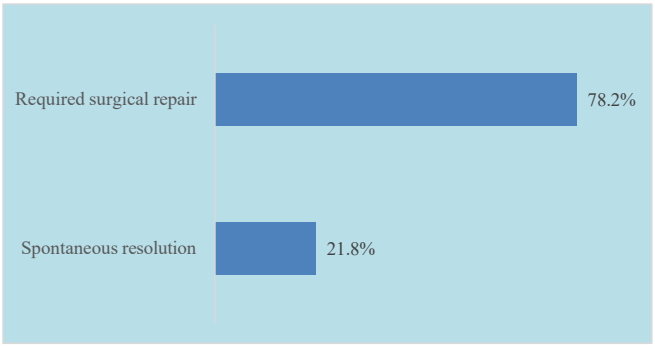

Figure 4: Primary outcome - Spontaneous resolution rate.

Discussion

This prospective cohort study demonstrates that a clinically significant proportion of primary spontaneous CSF rhinorrhea (21.8%) resolves spontaneously following computed tomography cisternography and a structured conservative management protocol. This finding is pivotal, as it provides a robust, evidence-based benchmark for a phenomenon previously supported only by case reports and small series [8,9]. The identified resolution rate suggests that a trial of conservative management is a viable initial strategy for a defined subset of patients, potentially avoiding surgical intervention and its associated risks, including anosmia, epistaxis, and the rare but serious risk of intracranial vascular injury [14,15]. The core contribution of this study lies in the identification of specific, objective predictors of spontaneous closure, which can guide clinical decision-making. Our analysis confirmed that low-pressure leaks (<20 cm H_2O), a bony defect size of less than 3 mm, and the absence of an associated meningocele were strong independent predictors of success with conservative management. These factors are physiologically coherent. A smaller defect presents a smaller area for healing and is less likely to be associated with significant tissue herniation [16]. Low intracranial pressure, often inferred from opening pressure during lumbar puncture,

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reduces the hydrodynamic force driving the leak, allowing local clotting and inflammatory sealing mechanisms to succeed [10]. The absolute correlation between the presence of a meningocele and failure of conservative management (0% resolution) is particularly instructive. A meningocele indicates not only a dural tear but also a failure of the arachnoid membrane, creating a patent sac that is unlikely to collapse and seal spontaneously, thus necessitating surgical intervention [17]. Our findings align with and extend the limited existing literature. Patel et al. similarly identified small defect size as a favorable prognostic factor in their retrospective review [13]. The strong association with leak pressure supports the pathophysiological link between intracranial hypertension and persistent CSF fistulae, reinforcing the importance of managing underlying pressure where possible, even in cases proceeding to surgery [2,18]. The predominance of obese patients in our cohort (73.6%) and the significantly lower BMI in the resolution group further underscore obesity as a key risk factor for PSCSFR and a modifier of treatment outcome [3]. Interestingly, while defect location showed some variation in resolution rates-with ethmoid roof leaks having the highest rate-location was not an independent predictor in the multivariate model. This suggests that the intrinsic characteristics of the defect (size, pressure, presence of meningocele) are more critical than its specific anatomical address within the anterior skull base. This has practical implications, as it shifts the preoperative counseling and decision-making focus from where the leak is to what it looks like on imaging and manometry. The implications of this study are most profound for resource-limited settings, such as the one in which this research was conducted [12]. The ability to identify patients with a high likelihood of spontaneous resolution can optimize the use of limited surgical resources, reserving operating theatre time and specialist expertise for complex cases with unfavorable predictors. It also reduces patient expenditure and hospital stay. However, a protocol for conservative management must be strict and include close monitoring, as failure carries the continued risk of meningitis [4]. The follow-up period, while adequate to capture immediate resolution, does not address long-term recurrence rates, which must be evaluated in future studies. Additionally, the definition of "low-pressure" was based on a single opening pressure measurement, which can be variable. Spontaneous resolution of PSCSFR after CTC is not a rare occurrence. We propose a management algorithm wherein patients with all three favorable factors-low-pressure leak, defect <3 mm, and no meningocele—are offered a supervised 6-week trial of conservative management. Patients with any unfavorable factor, especially a visible meningocele, should be counseled for early surgical repair. This stratified approach personalizes treatment, enhances resource allocation, and improves patient safety.

Limitations

The primary limitations include a single-center design, a modest sample size, and the lack of long-term follow-up data to assess for delayed recurrence. These factors may affect the generalizability of the findings to broader populations.

Conclusion

This study establishes that spontaneous resolution of primary CSF rhinorrhea after CTC is a significant clinical occurrence (21.8%). Defect size <3mm, low-pressure leaks, and absence of a meningocele are key predictors. For patients presenting with this favorable profile, a supervised trial of conservative management is a safe and effective initial strategy, potentially avoiding unnecessary surgical intervention and optimizing resource utilization in clinical practice.

Recommendation

We recommend a 6-week trial of strict conservative management for patients with a low-pressure leak, defect <3mm, and no meningocele. Surgical repair should be prioritized for those with contrary features, especially a visible meningocele, or if conservative measures fail.

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