Mini Review

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Innovations and Evolutions in Endoscopic Repair of Cerebrospinal Fluid Rhinorrhea – A Review of Challenges and Cost-Effective Alternatives for Developing Countries

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ABSTRACT

Cerebrospinal fluid rhinorrhea occurs due to communication between sinonasal mucosa and subarachnoid space secondary to bony, mucosal or meningeal defects. The most pressing issue in the diagnosis and the eventual management is the identification of the Pathology and the localization of the leak. In this regard, the most sensitive and specific laboratory test β2-transferrin or an extension of it, the trace proteins, are unavailable in our region. The next tier of investigation offered to the patient's, are the radiological investigations which includes CT cisternography at the top of the list. Cisternography is a good diagnostic modality especially when intracranial pressure is raised but with low intracranial pressure, leak may not be identifiable on cisternography as well. The most accurate tool for detection of the defect is intraoperative visualization with the help of fluorescein dye. The core intent for this review is to shed light on the crooked corners faced in the diagnosis of the Pathology itself and the management afterwards. The review highlights the advances that have been done in accurate determination of the defect site and it discusses the alternative economical tools that can be used in third world countries.

Keywords: CSF Rhinorrhea; Cerebrospinal Fluid; CSF Fistula; CSF Leak Repair; Endoscopic Sinus Surgery

Mini Review

Abnormal communication between Cerebro-Spinal Fluid (CSF) of subarachnoid space with para nasal sinuses is called CSF rhinorrhea [1,2]. It presents in clinical setting as unilateral, clear, watery, non-foul-smelling rhinorrhea, pronounced on bending forward [3]. The route can be either directly from anterior cranial fossa to the nose or from middle and posterior cranial fossa to Eustachian tube to nose [1]. The causative factors are divided broadly into traumatic causes and non-traumatic causes [1]. The traumatic causes include iatrogenic and non-iatrogenic injuries while non-traumatic causes can be secondary to a tumor, congenital malformation or sometimes spontaneous or idiopathic [1]. CSF leaks are seen in 1-3% cases of closed head trauma, 50%

of these are clinically evident within 48 hours [4,5]. In all of the abovementioned causes, intracranial CSF pressure can be either normal or raised [1]. In modern era the rate of spontaneous CSF leaks has been increased and the etiology tales back to increase in obesity in turn increasing the rate of intracranial hypertension, history of cranial or sinus infections and prior trauma causing weakness of the skull base structures [6].

A few cases of CSF rhinorrhea have been reported post COVID-19 swab testing [7,8]. In children the most common cause is iatrogenic 54% after treatment of skull base tumors, congenital skull base defect 30-40% and head trauma 30% [9]. The youngest patient operated on for CSF leak repair was 1.5 months old [9]. Most commonly involved site is cribriform plate (52-56%) [1,4]. Defects in sphenoid were seen mostly in iatrogenic injuries (27-47.3%) [1,4]. If CSF rhinorrhea is left untreated it may result in serious consequences like meningitis (most common), pneumocephalus and brain herniation [1,2,6]. In untreated CSF rhinorrhea risk of meningitis is 10-40% (10% risk per year (3)) and an early surgical intervention lowers the risk significantly [1].

Radiological Investigations & Lab-Workup

In the management of CSF rhinorrhea the most challenging aspect have been the diagnosis and localization of the defect [10]. The diagnostic workup of CSF rhinorrhea involves radiological and laboratory tests. The laboratory investigations comprised of glucose and chlorine in nasal secretions, which was later modified into glucose oxidation test [10]. Although this test is cheaper but the results are inconclusive, confusing and non-specific hence is no longer recommended, even in a country with low socioeconomic state this is merely a waste of resources [11]. Identification of β2-transferrin by immunofixation and β-trace proteins in nasal secretions are the most sensitive and confirmatory tests for CSF rhinorrhea [1,9]. β2-transferrin has the sensitivity of 87-100% and specificity of about 71-100% [5,9]. In our country β2-transferrin and β-trace proteins testing is not available. Successful surgical repair demands an accurate identification of leak. The reliable radiological sources include combinations of CT and planar tomography, CT cisternography, MR Cisternography, High resolution CT scan and radionuclide cisternography [5].

For cisternography Lumbar puncture followed by intrathecal injection is required. The incidence of complications is low, but it causes patient discomfort and adds to expenses [5]. In Patients with negative preoperative cisternography rate of intraoperative leak identification with help of intrathecal fluorescein is 25-64% [12]. This is a significantly high number and thus one may proceed with the procedure without CT/MR cisternography if the clinical suspicion of leak is high, especially in localities where cisternography is not readily available or the cost of this modality is not bearable by the patient.

Scar to scar-less Surgery

The traditional gold standard for repair of sinonasal CSF leak used to be open craniotomy approach. It would produce an ease of access and broader view for the surgeon [6]. The patients may end up with intracerebral hemorrhage, surgical scar, frontal lobe deficits and long hospital stays ultimately causing a financial burden [13]. The success rate following approach by anterior craniotomy was almost 75% [3]. The first ever repair of CSF leak done purely with endoscopic approach dates back to 1981 when Wigand proposed initial description of skull base repair through nose using rigid endoscopes [1,13]. Rigid endoscopes helps surgeon in a good approach to base of skull and related structures and have multiple advantages to the usual craniotomy approach [1]. With development of fine techniques and durability of nasal pedicle flaps, and endonasal endoscopic approach for CSF leak repair has become the standard of care [6,14]. This approach has the advantage of no surgical scar, magnified visualization, lower surgical morbidity and lower failure rates as compared to open craniotomy technique [1,6]. Success rates of 80-94% for CSF leak repair by endonasal endoscopic approach has been reported in literature [2,6]. The different techniques to repair leak by endoscopic approach include using fascia lata, cartilage, temporalis fascia graft, pedicles flaps and perichondrium [4].

Recent Advances

Computer Assisted Navigation System (CANS)

The para nasal sinuses are bordered by vital structures like orbit, eye and lacrimal drainage system, these structures are prone to injury during endoscopic Rhinological procedures and may cause serious complications [13]. In 1980, Klimek and his team developed the use of Computer Assisted Navigation System (CANS) in rhinology [13]. CANS use a localization technique with help of electromagnets and provides very precise surgical field. Intraoperative, the current position of surgical instruments, their depth, angle and approximate distance with nearby structure is shown [13]. In 2002 the use of CANS for CSF rhinorrhea repair was endorsed by American Association of Otolaryngology [13]. However, this technique is not very cost effective, and its use is mainly recommended in cases of recurrent CSF rhinorrhea. (JUST CHECK IF we can find a reference for this).

Use of Fluorescein Dye

Intraoperative correct localization of defect is the biggest challenge in the management of CSF rhinorrhea [2]. Trendelenburg position of the patient and prolong forced inspiration by the help of anesthetist are a few maneuvers known to raise intracranial pressure and better localization of the leak [15] The use of intraoperative intrathecal fluorescein in localization of site of CSF leak was first described by Kirchner and Proud in 1960, since then it has been

most effective and actively favored [2]. It gives CSF a bright yellow green color which helps to demarcate it from the nasal secretions and irrigation fluids [14]. It is also helpful in checking the proper closure as the CSF is enhanced with a yellow green color and cannot be confused with nasal secretions. The most supported technique for administration of drug in intrathecal space is insertion of lumbar drain preoperatively. Many large cohorts show good safety profile for the dye at doses <50 mg, however complications like seizures, opisthotonus, lower extremity paresis (transient or permanent) and cranial nerve deficits may occur [2,6,12]. Although intrathecal fluorescein is very helpful for the operating surgeon in detection of leak but absence of fluorescein in the nose cannot rule out presence of CSF leak. In a series by Rahul et al, the sensitivity of 73.8% (95% CI 57.7%-85.6%) with false negative rate of 26.2% (95% CI 15.8%-43.5%) has been reported [2].

Fluorescent Properties of Fluorescein

A mixture of lights of different wavelengths, combine to form white light. The color of object we see is actually the particular color's wavelength reflected by that object [14]. Concentrated fluorescein is orange in color but when diluted it gives off a bright yellow-green color. A blue colored light source can intensify the yellow-green effect. The usual ENT light source used in operative rooms creates white light [14]. By placing a blue filter in front of white light blocks all other wavelengths and blue light is produced. This blue light helps in visualization of very minor leaks not visible by white light [14]. A commercially produced blue light filter system is available and costs between 15-20,000USD.

Considerations in a Low Socioeconomic Country

The diagnostic and treatment options for CSF rhinorrhea repair has evolved with time but they are not affordable in certain small setups and third world countries. In post-traumatic cases where history and examination is evident no laboratory and extended radiological tests are required. Intra operative localization followed by repair is a cost-effective option. Other options include;

Topical Fluorescein Dye

As discussed earlier, Intra operative fluorescein lumbar puncture is the most credible method of defect localization by skull base surgeons, but the procedure needs a lumbar puncture expert and has certain complications [2,4,10]. In 2000, Jones et al coined use of intranasal topical fluorescein in intraoperative localization of skull base defect [12]. They applied 5-10% non-diluted fluorescein (amber/yellow) in nasal cavity, CSF flow was noted by change in color (yellow to green) and the source of fluid responsible for color change was traced with standard endoscopic light [12]. In 2003 this method replicated in office-based setting for pre-operative testing by Saafan et al on a cohort of 25, no complications were encountered, and 100% results were seen [15]. In 2009, topical fluorescein was used in clinical as well as operative settings again with 98-100% accurate results [10]. Use of intranasal fluorescein is a tool with high accuracy and can be implemented as an alternative to expensive laboratory and radiological tests in population with restricted resources.

Blue Filter Paper

With surgeon's preference to intrathecal fluorescein another cost effective solution was elaborated by Narinder et all in 2013. He replaced the commercially produced blue filter (fluorescein blue filter system, part # 20 1000 32; Karl Storz GmbH & Co, Tuttlingen, Germany) with a very low cost locally produced filter paper [14]. The night blue filter paper number 74 normally used in photography and stage lights was used [14]. That paper could withstand peaks of temperature. Approximately 5 mm sized disc were cut by the help of hole punch. 0.25 ml of 10% of fluorescein was diluted in 10ml of patient's CSF and given 30 minutes prior by lumbar puncture before the induction of anesthesia [14]. Post operatively the surgeons were asked to rate the ease of identification in compared to the usual white light identification and they rate 7.7/10 [14]. Again this method is very low cost as a single sheet (50 cm x 61 cm) cost around 10 USD and only a 5 mm sized filter paper is required in one case [14]. This area can be a seed for further research in our own population and if proved safe, guidelines for a third world country can be elaborated.

Post-Operative Care

Post-operative care and guidance is an integral aspect of patient care and needs impetus while counseling patients after their surgeries. Primarily the post-operative care would focus on the etiology of the condition; however there are certain common determinants for the care [16]. These include small details like minimizing exertion, avoidance of blowing the nose, keeping the patient in recumbent position for 12-24 hours at least and ultimately guidance regarding air travel and driving. Literature has also stressed on a multimodality approach to the pathology [16]. Though, the surgical intervention might cater to the defect, but in cases involving a spontaneous leak, the underlying pathology can lead to treatment failure [16,17]. Hence, attention should be paid to ancillary studies, if the history raises a clinical suspicion.

Conclusion

CSF rhinorrhea is a disease with increasing incidence. We have discussed the recent consensus on diagnosis, investigation and surgical management on the basis of opinion of experts and evidence-based literature. We have also discussed surrogate cost-effective options in diagnosis and surgical intervention for small setup centers and third world countries. We have also highlighted

the protocols to be followed in post-operative patient care to prevent recurrence.

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