Transnasal Endoscopic Repair of Cerebrospinal Fluid Rhinorrhea: An Analysis of 22 Cases

Yong-Gang Kong · Yu-Qin Deng · Yan Wang

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Abstract The purpose of this study was to investigate and summarize the surgical procedure and efficacy of transnasal endoscopic repair of cerebrospinal fluid (CSF) rhinorrhea. This is a retrospective study including 22 patients with CSF rhinorrhea who underwent transnasal endoscopic repair between January 2003 and August 2010. The location of the lesion was determined by both HRCT scan and intranasal endoscopy, and the lesion was repaired with a graft from autologous thigh muscle fascia. The grafts were placed and fixed above (inlay) or beneath (onlay) the lesions or defects. The causes of CSF rhinorrhea in our study included trauma, surgical injury, and meningoencephalocele, or idiopathic etiology. There were 15 of 17 patients with histories of trauma or surgical injury who were found to have defects in skull base by HRCT examination. The other 5 patients had an intact skull base, minor local osteoporosis, or bone resorption. All 22 patients had no reoccurrence of CSF rhinorrhea during the follow-up period, which ranges from 4 to 72 months. The transnasal endoscopic approach is a safe and effective procedure, with minimal invasion, for the repair of CSF rhinorrhea.

Keywords Cerebrospinal fluid rhinorrhea · Repair · Endoscopy

Introduction

The etiology of cerebrospinal fluid (CSF) rhinorrhea is diverse; the main causes of CSF rhinorrhea are traumatic brain injury, tumor, infection and congenital deformities [1]. Treatment of CSF rhinorrhea by neurosurgical craniotomy is the most common treatment for CSF rhinorrhea, but the surgery is difficult, results in a large surgical wound, and has a relatively low success rate (<73 %) [2]. Transnasal endoscopic repair of CSF rhinorrhea was first proposed by Wigand [3] in 1981, and has since been validated by clinical practitioners throughout the world [4]. The surgical repair of CSF leakage has evolved with technological advances, and with experience gained by the increasing number of transnasal endoscopic surgeries performed. The safety and efficacy of transnasal endoscopic repair of CSF rhinorrhea have been confirmed, although the details of surgical approaches have varied in different reports [5–8].

In this report, we describe our experience with 22 patients who presented to our otolaryngology department clinic with CSF rhinorrhea between January 2003 and August 2010. These patients had CSF rhinorrhea lesions located in the sphenoid or ethmoid sinus, and transnasal endoscopic repair was performed successfully through either the sphenoid or ethmoid sinus, respectively, for all patients.

Materials and Methods

Patients

Seventeen males and five females were enrolled in our study. The age range of the patients was from 10 to

Y.-G. Kong (✉) · Y.-Q. Deng · Y. Wang
Department of Otolaryngology-Head and Neck Surgery, Renmin Hospital of Wuhan University, Wuhan 430060, China
e-mail: yonggangkong@hotmail.com

68 years and the duration of their CSF rhinorrhea was between 2 weeks and 2 years. Fifteen patients had a history of injury that caused their CSF rhinorrhea. For the other patients, three were diagnosed with idiopathic CSF rhinorrhea, and the rest of the patients had either a surgical injury (2 patients), or a complication of a meningoencephalocele (2 patients) that caused CSF rhinorrhea. All 22 patients had either intermittent or continuous unilateral rhinorrhea, exacerbated when bowing the head. Four patients had complications of intracranial infection, such as fever, headache, nausea, and vomiting, and 2 patients with meningoencephalocele had complications of frequent colds since childhood, fever, persistent unilateral nasal obstruction, intermittent rhinorrhea, and hyposmia. All 22 patients were treated using transnasal endoscopic surgery when conservative treatments failed. The optimal lesion size for intranasal endoscopic repair of the leak is a lesion diameter of <20 mm that is located in the ethmoid plate, the top of the ethmoid sinus, or sphenoid sinus [9]. Therefore, patients with CSF rhinorrhea lesions of <20 mm in diameter were included in our study.

Diagnosis

Cerebrospinal fluid rhinorrhea was diagnosed based on the patient's history of trauma or surgical injury, with the manifestations of spontaneous or posttraumatic, intermittent or continuous unilateral rhinorrhea, exacerbated when bowing the head or when the cervical vein was forcibly compressed. Some patients also had unilateral hyposmia or anosmia. The effluent was determined as CSF according to the diagnosis standard of a glucose concentration in the fluid >1.7 mmol/L.

The leak location was determined by high resolution computed tomography (HRCT) of the head.

Treatments

The routine treatments for CSF rhinorrhea include sitting semi-recumbent, eating a low salt diet, limiting the amount of water intake, avoiding vigorous coughing and nose blowing, and maintaining smooth defecation without straining. Prophylactic antibiotics were administered to prevent or control intracranial infection, and other medications such as 20 % mannitol were prescribed for the patients with high intracranial pressure. Transnasal endoscopic surgical repair was performed if all the above treatments failed.

Surgical treatment was performed under general anesthesia. The patient was laid in the supine position, with their head elevated by 15°. The nasal mucosa was treated with epinephrine to achieve the complete contraction of blood vessels after the nasal cavity was disinfected with

iodoform. A thorough nasal cavity and meatus examination was carried out using a 0° mirror, or 30° or 70° mirrors if necessary. The surgical approach was determined according to the preoperative examination and location of the CSF leak. The ethmoid sinus was exposed from anterior to posterior, if the CSF rhinorrhea lesion was located on the top of the ethmoid sinus; the sphenoid sinus was exposed through the nature antrum if the CSF leak was in the sphenoid sinus. The rear part of the middle turbinates can be partially removed to facilitate the intranasal endoscopic operation. Thorough intraoperative hemostasis was carried out, to ensure that there was no injury to the internal carotid artery, sphenopalatine artery or optic nerve. The leaking fluid was traced using an aspirator if there was visible outflow of draining liquid. If the location of the leak was not clear, the internal jugular vein was compressed to force CSF out of the lesion and can assist in intra-operative leak identification.

Cerebrospinal fluid rhinorrhea was usually characterized by a clear pulsatile dripping fluid. However, if bleeding was combined with CSF outflow, it was difficult to determine the specific location of the leak. CSF reflects white light from endoscopy, whereas chromoproteins in the blood absorb the light thus appearing dark; therefore, the leaking CSF will be located in the brightest area [3, 10]. For patients with a long history of CSF rhinorrhea, the leak was usually surrounded by pale mucosal edema or pinkish granulated tissue. To correct the lesions, an area of bone 2 mm in diameter around the lesion was exposed. For the patients with meningoencephalocele, the rhinorrhea was repaired after the hernia was removed by electrocoagulation. Thigh muscle fascia, fat or nasal septal cartilage can be used as rigid repair materials. Fibrin glue was injected into the lesion first. Small leaks were repaired by muscle fascia and fat tissue, whereas, larger leaks were packed with the muscle fascia and nasal septum cartilage first, and then sequentially packed with muscle fascia and fat tissue. And then it was followed by another layer of fibrin glue, a gelatin sponge impregnated with antibiotics was attached to the graft surface, and an intranasal gauze packing containing iodoform was placed in the lesion area. A 20 % mannitol injection was administered intravenously to reduce CSF loss, especially when the CSF loss was excessive. The 20 % mannitol injection can also facilitate attachment between tissue in the lesion area and the repair material.

Postoperatively treatments included administration of antibiotics and standard postoperative nursing care for the general anesthesia. No nasal wash or packing, and no medication drops were recommended. A dose of 125 mL 20 % mannitol was injected intravenously twice per day to control intracranial pressure. A low salt diet and a higher energy intake were recommended, along with

monitoring of water and electrolyte intake. An electrolyte imbalance was usually observed in patients who had the most CSF loss before surgery, and who received intra-operative treatment for dehydration. Regular and timely examination of blood electrolytes and an accurate record of the patient's 24-hour fluid intake and out flow is critical for the maintenance electrolyte balance. Intranasal iodoform gauze was removed 2 weeks after surgery, and nasal secretions were cleared if they were excessive. Monthly nasal endoscopic follow-up examinations were recommended for 6 months, and once every 6 month thereafter.

Results

The average glucose concentration of the draining fluid was 4.35 mmol/L (range: 2.83–5.26 mmol/L).

The preoperative HRCT examination revealed that 15 (15/17, 88.2 %) patients with histories of injury or surgical injury had skull defects; these defects were located in the ethmoid plate in 7 patients, in sphenoid sinus in 5 patients, and at the junction of frontal sinus and the ethmoid plate in 3 patients (Fig. 1). No defect was detected by HRCT scan in the other 5 patients with either idiopathic CSF rhinorrhea or CSF rhinorrhea due to meningoencephalocele. Minor local osteoporosis or local bone resorption was detected in these patients. A soft tissue herniation from the skull defect into the nasal cavity was revealed in the CT scan in the two CSF rhinorrhea patients with meningoencephalocele; the lesion had sharp and smooth edges, and was connected to the anterior cranial fossa (Fig. 1a). The hernia was identified as belonging to neural tissue from T1 or T2 using brain signals observed in MRI scans. A detailed and thorough examination by nasal endoscopy was carried out from the top and middle nasal meati, the sphenoethmoidal recess, or the pharyngeal ostium of the Eustachian tube. The location of the CSF leak was revealed and identified at the initial examination in 18 patients, and was characterized by pulsatile and clear draining liquid that was dripping from lesion (Fig. 2). Clear draining liquid was observed dripping from the lesion in 2 patients using an additional test of compressing the internal jugular vein; pale edema in the mucosa close to the leak was also observed in these patients (Fig. 3).

All patients were hospitalized for 18–26 days, with an average hospital stay of 21 days. The CSF rhinorrhea was successfully corrected in all 22 patients; these patients were followed up for between 4 and 72 months. There were two postoperative complications, intracranial infection and hydrocephalus, which both resolved. The lesion was filled with granulated tissue after surgical repair (Fig. 4).

Discussion

Cerebrospinal fluid rhinorrhea can be caused by local trauma or surgical injury, or it can have an idiopathic etiology [11], of which trauma is the most common cause. Rhinorrhea usually occurs immediately after trauma, but there may also be a delay in the appearance of symptoms. Treatment of CSF rhinorrhea can involve both conservative and surgical approaches. Conservative treatment of CSF rhinorrhea that occurs immediately after trauma is often recommended for at least 2 weeks before surgical repair because this type of lesion can be self-healing, whether or not dura mater is present in the lesion. However, surgical repair of idiopathic CSF rhinorrhea should be performed as soon as possible after diagnosis.

Transnasal endoscopic repair has several advantages compared to conventional surgical approaches, and is commonly used by neurosurgeons and otorhinolaryngologists. Some advantages of repairing CSF rhinorrhea using transnasal endoscopy are that this surgical procedure allows the direct visualization of the lesion during surgery, thus increasing accuracy in performing the procedure and resulting in a small facial scar; transnasal endoscopy allows the nasal cavity to maintain most of its physiological function; this surgical procedure also reduces the chance of damage to brain tissue and transnasal endoscopy results in fewer complications than intracranial operations.

The success of the transnasal endoscopy surgical procedure is dependent on accurate localization of the lesion. The general location of the leak identified by clinical manifestations, but the accurate localization of the lesion depends on the combination of nasal endoscopy and the other imaging examinations, such as HRCT, MRI, cisternography coronal CT, intraspinal injection of fluorescent dye, and radionuclide cisternography. Nasal endoscopy has been commonly used as a routine preoperative examination because it is inexpensive, convenient, quick, noninvasive, and painless. To accurately localize the lesion, either the internal jugular vein can be compressed or the head patient's head can be bowed to force outflow of CSF during the endoscopy procedure. The location of the lesion in 20 patients (90.9 %) out of total 22 was accurately determined by preoperative intranasal endoscopy.

High resolution CT is useful in the diagnosis of CSF rhinorrhea, especially to reveal coronal and sagittal defects in ethmoid sinus, the lateral wall of sphenoid sinus, and the rear wall of frontal sinus; these defects are detected with a sensitivity of 87–100 % [12–14]. In our study, 77.3 % of lesions were revealed by HRCT inspection (17 patients out of 22). The 5 patients with negative HRCT inspection results had the lesions close to the rear wall of the frontal sinus ($n = 1$), in the junction of the lateral wall and anterior wall of sphenoid sinus ($n = 2$), or in the cracks in

Fig. 1 The preoperative CT examination revealed that most of patients with histories of injury or surgical injury had skull defects. The *white arrows* indicate the skull defects. As shown in a, a soft

tissue herniation from the skull defect into the nasal cavity was revealed in HRCT in the CSF rhinorrhea patient with meningoencephalocele

Fig. 2 The location of the CSF leak was revealed and identified at the initial examination in 18 patients, and was characterized by pulsatile and clear draining liquid that was dripping from lesion. *asterisk*,

indicates the clear draining liquid. *Black arrows* indicate the nasal septum and *white arrows* indicate the middle turbinate

the ethmoid sinus ($n = 2$); these areas were not visible on the HRCT scan.

MRI can also be useful in detecting CSF rhinorrhea lesions. The advantage of MRI is that it is non-invasive, it does not require injection of drugs through a lumbar puncture, and it provides images of multiple tissue layers.

MRI is also useful in diagnosing meningoencephalocele and/or CSF rhinorrhea, with the sensitivity of 89 % [15]. However, MRI imaging cannot detect bone defects.

Cisternography CT and radionuclide cisternography are able to accurately detect the location of lesions, but images are not provided in real time and thus surgeons may miss

Fig. 3 Pale edema in the mucosa close to the leak was observed in the CSF rhinorrhea patients. *Black arrows* indicate the pale edema in the mucosa close to the leak. *White arrows* indicate the nasal septum

Fig. 4 The lesion was filled with granulated tissue after surgical repair. *Black arrows* indicate the granulated tissue. *White arrows* indicate the nasal septum

any inactive CSF leakage lesions. The sensitivity of these procedures is relatively low, at only 33–48 % [10].

We recommended preliminary identification of the CSF rhinorrhea lesion location by intranasal endoscopic to make a detailed inspection of the nasal cavity, middle nasal meatus, sphenoethmoidal recess, and the pharyngeal ostium of Eustachian tube. The preliminary examination should then be followed by a high resolution CT inspection and 3D reconstruction which will allow the location of most of the lesions. The cisternography coronal CT and radionuclide cisternography can be performed to help locate lesions in difficult locations. In rare cases where the location of the lesion cannot be revealed preoperatively, an endoscopic exploration during the surgical procedure is recommended.

The criteria for repairing CSF rhinorrhea lesions endoscopically are stringent. The success rate of transnasal endoscopic surgery to repair CSF rhinorrhea is closely correlated to the location and size of the lesion. The top of ethmoid, ethmoid plate, and sphenoid sinus, which are the optimal regions for intranasal endoscopic repair of CSF rhinorrhea, can be directly visualized under endoscopy. However, transnasal endoscopy is not suitable for repair of large defects of dura mater. A lesion of <20 mm in

diameter and localized on the top of ethmoid sinus, the ethmoid plate, and the sphenoid sinus were suggested as optimal conditions for repair using transnasal endoscopy [9]. A lesion with a diameter of larger than 20 mm is usually caused by severe injury or by a tumor, and should be repaired by the other approaches.

In this study, the patients had lesions <20 mm in diameter, the maximum diameter being about 18 mm. During the surgical procedure, a diameter of 2 mm of granulated tissue was cleared around the lesion to facilitate the healing process. Resection of meningoencephalocele should occur before the transnasal endoscopy repair procedure, to prevent loss of function and intracranial infection. Repair material should be selected cautiously. Larger lesions require four layers to repair the defect, using fascia lata, nasal septal cartilage or the middle turbinate, and fat tissue as repair material, while smaller lesions require fewer layers and repair materials used are fascia lata and fibrin. The graft size should be slightly larger than the leak, to reduce the chances of acquiring an intracranial infection because of the poor local blood supply and resulting central necrosis of the graft; the graft must be tightly attached to the lesion, and fixed by fibrin glue to prevent dislocation or

removal. Finally, the nasal cavity is packed with iodoform gauze, to prevent bacterial growth, to provide a scaffold for the graft, and to reduce the stimulation to nasal mucosa.

In conclusion, the transnasal endoscopic approach is an effective and safe procedure for repair of CSF rhinorrhea in the ethmoid sinus and sphenoid sinus. Advantages of the procedure are the accurate localization of the lesion site, minor injury to surrounding tissues during surgery, maintenance of most of the nasal cavity's physiological function, and reduced risk of complications associated with intracranial operations. Compared with the traditional repair approaches such as craniotomy, the intranasal endoscopic procedure has the advantages of low recurrence rate and minimal facial invasion. The success rate of transnasal endoscopic repair of CSF rhinorrhea was 100 %, with no recurrence observed during a follow-up period of 4–27 months.

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