ORIGINAL ARTICLE

Endoscopic Repair of Acquired Encephaloceles, Meningoceles, and Meningo-Encephaloceles: Predictors of Success

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ABSTRACT

Meningoceles, encephaloceles, and meningo-encephaloceles may develop through defects associated with congenital anomalies or through defects produced by tumor, trauma, or surgery. Their initial management, surgical indications, and repair techniques are not universally accepted. We undertook this study to compare the contributions of different surgical techniques and materials to the success of endoscopic repairs of acquired meningo-encephaloceles. We also examined whether characteristics of the patient, the meningo-encephalocele, or the adjunctive treatment influenced the outcome of the repair.

We retrospectively reviewed the clinical charts of all patients undergoing transnasal endoscopic repair of acquired meningo-encephaloceles at our academic hospitals. We encountered 17 patients with meningo-encephaloceles of the anterior fossa and parasellar area; 15 were repaired immediately using transnasal endoscopic techniques. Two persistent leaks associated with hydrocephalus were repaired during a second endoscopic attempt, which was rapidly followed by ventriculoperitoneal shunting. Location and size of the skull base defect, its etiology, and the technique and choice of material used for repair did not significantly affect surgical outcomes. However, the presence of hydrocephalus was significantly related to poor surgical outcomes.

KEYWORDS: Cerebrospinal fluid, endoscopic surgery, meningocele, encephalocele

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Encephaloceles, meningoceles, and meningo-encephaloceles are abnormal herniations of the meninges, brain, or both, beyond the confines of the cranium. Meningo-encephaloceles can be grouped by anatomic location into occipital, sincipital, and basal. Basal variants occur anywhere along the cribriform plate, fovea ethmoidalis, sphenoid bone, or temporal bone.[1,2] Most anterior skull base encephaloceles are congenital although meningo-encephaloceles can be acquired from trauma, infection, neoplasms, and other erosive lesions, or from surgery performed to treat inflammatory or neoplastic diseases of the skull base. Small meningo-encephaloceles may go undetected until they are noted incidentally on imaging studies or when they become symptomatic with a cerebrospinal fluid (CSF) leak or meningitis.

CSF leaks associated with acquired meningo-encephaloceles and CSF leaks of the anterior skull base must be repaired to prevent retrograde infections. Traditionally, CSF fistulae to the sinonasal tract have been repaired through a frontal craniotomy with a success rate of 60 to 80%.[3,4] Advantages of the transcranial approach include direct visualization of the dural tear and exposure to inspect and treat any adjacent brain injury, making this approach ideal for treating patients with acute head injury. Disadvantages include the risk of anosmia, cerebral edema, intracranial hemorrhage, and the need for osteotomies and external incisions.[4] Transcranial closure of the CSF leak, however, diminishes the possibility of life-threatening complications such as pneumocephalus, meningitis, or brain abscess, although it may not prevent them completely.[5]

The extracranial repair of CSF leaks evolved considerably with the advent of nasal rod-lens endoscopes and the development of instruments tailored to transnasal endoscopic techniques.[6,7] Nasal endoscopes are widely available with 0-, 30-, 45-, and 70-degree lenses that offer clear visualization of the sinonasal tract (i.e., the anterior skull base), thus allowing precise localization of a CSF fistula and providing access for its repair.

Despite the popularity gained by endoscopic approaches, their indications are controversial, even among endoscopic surgeons. Furthermore, the techniques used during an endoscopic repair and perioperative management vary considerably. Various grafting materials have been advocated for the repair of skull base defects, including autologous materials such as abdominal fat, septal mucosa and/or cartilage, turbinate bone, and temporalis fascia; homologous materials such as cadaveric pericardium and fascia lata; and other materials such as bone cements. These materials can be used as underlay or overlay grafts, or they can be used to obliterate a paranasal sinus. The adjunctive use of packing and/or fibrin glue and the perioperative use of lumbar drainage are also controversial.

We undertook this study to ascertain whether a particular surgical technique, material, or adjunctive perioperative treatment could affect the outcome of endoscopic repair of acquired meningo-encephaloceles associated with CSF fistulae. We also tried to identify the characteristics of patients, CSF fistulae, and associated comorbidities that could influence the success of surgical closure.

MATERIALS AND METHODS

All patients who underwent a transnasal endoscopic repair of a meningo-encephalocele at any of our affiliated academic hospitals were included in this study. The records were analyzed retrospectively to obtain data regarding the characteristics of patients (i.e., age, gender, and comorbidities), characteristics of the defect (i.e., site, size, etiology, complications), surgical repairs (i.e., type of graft/ flap, overlay/inlay technique), adjunctive therapies (i.e., packing, fibrin glue, and lumbar drain), and outcomes. Follow-up data were obtained through clinical examinations and review of hospital records.

Twenty major variables (Table 1) were evaluated, including etiology, location, associated medical problems, timing of repair, size of defect, type

Table 1 Variables Evaluated

Age
Gender
Medical comorbidities
Etiology
Diagnostic technique
Site of defect
Size of defect
Prior complications
Meningitis
Brain abscess
Pneumocephalus
Prior repair
Timing of repair
Delayed
Immediate
Type of repair
Free tissue graft
Vascularized local flap
Obliteration
Type of graft/flap
Technique for repair
Onlay
Inlay
Obliteration
Use of packing
Use of fixator
Fibrin glue
Gelfoam®
Surgical
Use of antibiotics
Use of lumbar drains/VP shunt
Use of computer-assisted surgery devices
Presence of high-pressure hydrocephalus
Outcome

of grafting materials, instrumentation utilized (e.g., computer-assisted surgery device), perioperative management (including the use of a lumbar drain or ventriculoperitoneal (VP) shunt), the presence of hydrocephalus, and success of the repair. Materials used for surgical repair were classified as homologous grafts and other implants. The classification also included whether they were used as a free graft or as a pedicled vascularized flap and whether they were used as an underlay or overlay patch or as an obliterative graft.

Data were recorded and analyzed using Statistix® (Analytical Software, Jacksonville, FL) software. The correlation between persistence and/or recurrence of a CSF leak and variables such as materials, etiology, location, associated medical problems, timing of repair, type of repair, materials used for the repair, and the presence of increased ventricular pressure were submitted to univariate analysis performed with Chi square or Fisher exact tests.

RESULTS

Characteristics of Patients

From 1989 to 1999, 17 patients (10 men, 7 women) underwent transnasal endoscopic repair of meningoencephaloceles at the University of Pittsburgh Medical Alliance Hospitals and Allegheny General Hospital. Their ages ranged from 37 to 58 years, (mean age = 50 years; median age = 42 years).

Characteristics of the Meningo-Encephaloceles

The origins of the meningo-encephaloceles included iatrogenic injury from prior endoscopic sinus or skull base surgery in five patients and trauma in six patients. Six patients had idiopathic lesions. The origins of the skull base defects that required surgical revision included one craniofacial trauma and one idiopathic case.

Eight meningo-encephaloceles (47%) were located in the sphenoid sinus, six in the region of the cribriform plate (35%), and three in the roof of the ethmoid (18%). One persistent fistula was located in the sphenoid sinus and one was located in the cribiform plate.

Retrospective attempts to ascertain the size of all the defects were unsuccessful. Not all surgical

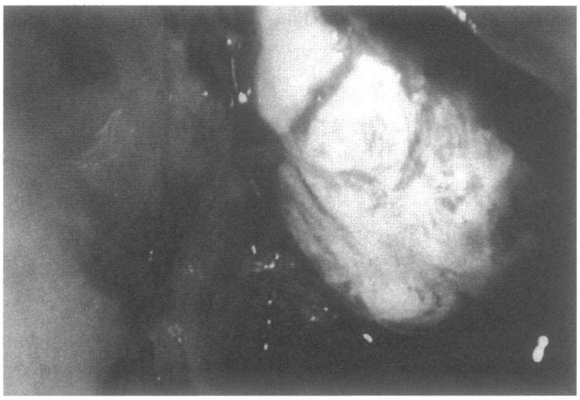

Figure 1 Nasal endoscopic view of left side of nose with large meningo-encephalocele.

or radiological reports stated size, and because many patients were imaged at outside institutions some films were unavailable. However, the size of the defects described ranged from 1.0 to 2.0 cm (Figs. 1, 2).

Surgical Repair

The most frequently used free tissue grafts consisted of turbinate or septal mucoperiosteum and abdominal fat. Homologous pericardium and fascia lata have been the materials of choice because of their availability, thickness, and ease of manipulation. Other materials such as periosteum, dermis, cadaveric dura, septal or turbinate bone, or cartilage were used sporadically or in combination with other tissues. Typically, the sphenoid sinus was obliterated with abdominal fat. An overlay technique (over the defect, i.e., extracranial) was used to repair 32% of the sites, and an underlay technique (between the bone and the dura, i,e., intracranial) was used to repair 41% of the sites. Obliteration (i.e., sphenoid sinus) was used for the remaining 28% of the sites.

A "fixator," such as Surgicel® (Ethicon, Johnson & Johnson, Somerville, NJ), Gelfoam® (Pharmacia-Upjohn, Kalamazoo, MI), Gelfilm® (Pharmacia-Upjohn, Kalamazoo, MI), or fibrin glue, was used to stabilize the grafting material in all cases. Packing, such as Vaseline® (Ethicon, Johnson & Johnson, Somerville, NJ) gauze and Merocel® (Xomed, Jacksonville, FL) sponges, was used according to the surgeon's preference.

Perioperative lumbar spinal drains were used in 63% of the cases. The mean duration of lumbar drainage was 4 days. Perioperative bed rest with the head elevated, stool softeners, and avoidance of straining activities and nose-blowing were prescribed for all patients. Intravenous prophylactic perioperative antibiotics were used a mean of 5 days, which correlated with the length of packing, the presence of a lumbar drain, or both.

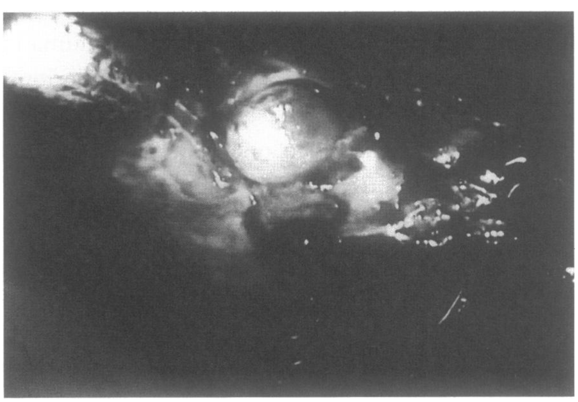

Figure 2 Nasal endoscopic view of a small meningocele in roof of the ethmoid. Mucosa surrounding the defect has been denuded in preparation for placement of the graft.

Surgical Outcomes

Fifteen defects (88%) were repaired successfully with a single-stage endoscopic procedure. Two patients (12%) required a second endoscopic procedure to control the CSF leak and to repair the meningo-encephalocele. The length of follow-up ranged from 10 to 132 months (mean, 26 months; median, 24 months).

The two persistent CSF leaks were associated with high-pressure hydrocephalus. One patient had an idiopathic defect about 1 cm in diameter located in a lateral recess of the sphenoid sinus. The encephalocele was removed using bipolar cauterization and the fistula was repaired by obliterating the sinus with abdominal fat. The leak persisted in the immediate postoperative period so the sinus was reobliterated with abdominal fat. A lumbar puncture was performed to confirm the clinical suspicion of hydrocephalus. A VP shunt was inserted 7 days after the second repair.

A second failure was associated with an encephalocele located in the roof of the ethmoid caused by craniofacial trauma. This patient also had post-traumatic hydrocephalus and had suffered repeated episodes of meningitis. During the initial attempt, the CSF fistula was repaired using fascia lata, septal cartilage, and a composite graft of mucoperichondrium in a layered underlay (inlay) fashion. During the second transnasal endoscopic repair of the persistent CSF leak, banked pericardium was used as an underlay (inlay) patch. Surgicel® and Gelfoam® were used to fix the free grafts in place. Postoperatively, high-pressure hydrocephalus was confirmed by the opening pressure of a lumbar puncture. A VP shunt was used to control the hydrocephalus. The presence of hydrocephalus in the other patients was ruled out with postoperative computed tomography (CT), a lumbar puncture, or both. Only persistence of CSF leak and hydrocephalus correlated significantly ($p = 0.0001$).

DISCUSSION

Meningo-encephaloceles and associated CSF leaks remain a surgical challenge. Etiology and site of origin have been cited as factors that influence the choice of surgical approach. We were able to use a transnasal-endoscopic approach to repair lesions with a wide variety of sites of origin, etiologies, and defect sizes. In our series, 35% of the fistulae were located in the cribriform plate, 18% in the roof of the ethmoid sinus, and 47% in the sphenoid sinus. Many of these lesions were diagnosed by direct visualization with a nasal endoscope. High-resolution CT with contrast was obtained in all patients to corroborate the site of origin to ascertain the extent of the skull base defect and to rule out other sinonasal and intracranial pathology or the presence of vessels within the herniated tissue.

MRI can complement the anatomical information provided by CT in terms of the size and location of the stalk of the lesion and the presence of vessels within the sac. Although not used at our institutions during the period of this study, MR cisternography does not require the intrathecal administration of a contrast agent and may become the imaging modality of choice for the evaluation of CSF fistulae. MR cisternography is noninvasive and has a reported sensitivity, specificity, and accuracy of 87%, 57%, and 96%, respectively, when combined with coronal CT.[8]

Traditionally, CSF leaks have been managed via a craniotomy, but this technique is associated with the risk of substantial morbidity, including anosmia, frontal lobe retraction, and intracranial hemorrhage. Furthermore, failure rates for CSF rhinorrhea were as high as 30%.[3–5,9] Initially, the extracranial repair of CSF leaks involved an external ethmoidectomy approach and the use of a mucosal pedicled flap to close the CSF fistula. Subsequently, free tissue grafts followed by transnasal techniques were advocated.[10–17] Microscopic transnasal techniques for the repair of CSF leaks predate endoscopic technology; however, transnasal repairs became more popular with the advent of endoscopic sinus surgery. Since the first description of endoscopic closure of CSF leaks by Wigand in 1981,[13] multiple reports have described a number of different grafting techniques. The low rate of morbidity and high rate of success associated with the endoscopic approach have made it the procedure of choice for the repair of CSF fistulae not associated with other intracranial pathology that would warrant a transcranial approach.

The choice of materials and techniques used during the endoscopic repair of CSF fistulae depends mostly on the experience and preference of the operating surgeon. In experienced hands, most techniques yield similar results. This contention is well illustrated by Weber et al.,[14] who treated 44 patients endonasally, using the inlay technique in 25 patients and the onlay technique in 22 patients. Their study suggested that grafting techniques may not be a critical factor as long as a judicious repair is performed. This suggestion is corroborated by our experience as well as by other reports.[18–21]

One concept that is critical for all grafting techniques is that the mucosa surrounding the defect should be removed to allow the graft to adhere firmly to the skull base. Herniated dura, brain, or both can be managed with resection or reduction into the intracranial cavity. Most authors agree with transection or resection of the pedicle because encephaloceles seldom contain functional brain tissue, and the intranasal portion is considered to be contaminated.[2] We used inlay, onlay, and obliteration techniques with no significant differences in outcome. Typically, an underlay technique with bone or cartilage, fat, and/or muscle plugs was used for large, bony defects associated with a meningoencephalocele. Sphenoid sinus CSF fistulae were repaired either by an obliterative technique using abdominal fat or hydroxyapatite cement or by using an overlay/underlay.

In our series, 11 different types of grafting materials were used. The most common were turbinate mucosa and septal mucoperichondrium. In addition, various materials were used to fixate the grafts and/or flaps in place, such as Surgicel®, Gelfoam® and Gelfilm®, and fibrin glue. The choice of "fixators" was mainly based on the surgeon's preference. Burns et al.[17] used the endoscope to manage 42 patients with fistulae. They supported the use of a free mucosal graft with fibrin glue for defects of the cribriform plate and roof of the ethmoid. In our series, fibrin glue, although subjectively helpful, did not appear to be critical to obtaining an adequate closure. Conversely, it does not guarantee success as illustrated by our data and by a meta-analysis of the literature by Hegazy et al.[18]

The aspects of perioperative management reviewed included the use of prophylactic antibiotics, the use of nasal packing, and diversion of the CSF, either with a lumbar drain or a VP shunt. Perioperative prophylactic antibiotics were used in 84% of the cases for 4 to 7 days. Patients with indwelling lumbar catheters, packing, or both routinely received prophylactic antibiotics for a length of time that correlated with that of the packing or drain. Lumbar drains were used in 66% of the cases and in most cases were placed at the time of the CSF repair. There was no significant difference in the rates of patients with or without spinal drains. This finding suggests that spinal drains are not always needed, which is also suggested by Casiano and Jassir.[19]

The size of a defect may be a limiting factor for endoscopic repair, but we could draw no conclusions about this variable. The anterior skull base in contact with the sinonasal tract can be exposed; therefore, an endoscopic repair is theoretically possible.

In our series, the only variable that correlated with persistence of the CSF leak was the presence of hydrocephalus. Hydrocephalus was discovered by CT, which showed dilated ventricles, or by lumbar puncture, which showed an elevated opening pressure. Post-traumatic and postinfectious hydrocephalus results from obstruction of the arachnoid granulations, which prevents adequate CSF reabsorption and consequently increases intraventricular pressure. After trauma, obstruction arises from subarachnoid hemorrhage or from inflammatory changes that follow or obstruct the arachnoid villi, which reabsorb CSF. The increased pressure within the CSF pathways creates a pressure gradient; CSF then escapes along the path of least resistance (i.e., the fistula). Temporary diversion of CSF may allow the repair site to scar and to form a stable seal before being exposed to high pressures.

If the hydrocephalus persists and a CSF leak recurs at this stage, permanent CSF diversion (i.e., a shunt) is required. Identification of patients who will require CSF diversion is therefore critical for a successful and permanent closure of the defect. Clinical and radiological clues that lead to this decision include papilledema and evidence of hydrocephalus on CT (i.e., dilated temporal horns or transependymal edema). However, these signs are always absent if a CSF leak actively decompresses the hydrocephalus.

Given our findings, we have modified our management protocol for patients who are at high risk for hydrocephalus, including those with post-traumatic and "spontaneous" meningo-encephaloceles with CSF leaks. These patients are managed with a lumbar drain for 72 hours. Twenty-four hours after the drain is removed, a spinal puncture is repeated to measure the opening pressure. In the presence of active hydrocephalus (i.e., elevated opening pressure), we recommend diverting CSF as an adjunct to the initial repair.

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