ORIGINAL ARTICLE

Management of Cerebrospinal Fluid Otorrhea

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KEYWORDS
Cerebrospinal fluid leak from ear; Otoliquorrhea; Mastoidectomy; Antrotomy; Meningitis

Abstract
Introduction: Cerebrospinal fluid otorrhea results from an abnormal communication between the subarachnoid space and tympanomastoid compartment; most of them are of traumatic etiology. They have clinical interest due to the potential risk of meningitis, directly related to the aetiology. Our aim was to show our experience in the management of this process.
Methods: A total of 17 patients were diagnosed and treated for cerebrospinal fluid otorrhea from 2003 to 2011.
Results: In our study, the highest percentage of cases was spontaneous cerebrospinal fluid otorrhea, with a wide clinical presentation. The diagnosis was based on the determination of beta-2-transferrin and radiological studies, especially important for its locator value. The treatment of choice was surgery.
Conclusions: Cerebrospinal fluid otorrhea is a rare entity in otorhinolaryngological pathology. Its diagnosis is suspected through otorrhea, hearing loss and aural fullness, while computed tomography and magnetic resonance help us to locate the defect. Surgery is the preferred technique, and its success is based on multilayer technology with 2 or more support materials.
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PALABRAS CLAVE
Fístulas de líquido cefalorraquideo en oído; Otoliquorrhea; Mastoidectomy; Antrotomía; Meningitis

Manejo de las otoliquorrheas

Resumen
Introducción: Las fístulas de líquido cefalorraquídeo en el oído derivan de una comunicación anormal entre el espacio subaracnoideo y el timpanomastoideo, la mayoría de etiología traumática. Tienen gran interés desde el punto de vista clínico por el potencial riesgo de meningitis, directamente relacionado con la etiología. Nuestro objetivo es mostrar nuestra experiencia en el manejo de dicho proceso.

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Introduction

Otoliquorrhea is defined as the outpouring of cerebrospinal fluid through the limits of the temporal bone. Cerebrospinal fluid fistulas (or CSF otorrhoeas/leaks) in the ear are the result of an abnormal communication between the subarachnoid and tympanomastoid compartments. They are often the result of another pathological process. The majority appear following head trauma, but they can also have an iatrogenic, neoplastic or congenital origin, and can even be due to a cholesteatoma, following otological or middle cranial fossa surgery. Spontaneous otoliquorrhea is much less common.

There are 2 population groups which are more frequently affected by this sign: children, in whom congenital malformations represent the most common cause, and adults, in whom middle age, female gender and excessive weight or obesity are usually considered as risk factors for spontaneous otoliquorrheas.

The clinical symptoms associated with these fistulas include the presence of otitis media with effusion (or serous otitis media) and/or watery otorrhea, conductive hearing loss, aural fullness sensation and recurrent episodes of meningitis.

The tentative diagnosis of this type of fistula can be obtained by performing a measurement of the levels of beta-2-transferrin, which is a highly sensitive and specific test. However, imaging tests (computed tomography [CT] and magnetic resonance imaging [MRI]) offer more information, especially through their ability to locate the defect causing the abnormal outpour of cerebrospinal fluid to the temporal bone.

The most significant complication resulting from cerebrospinal fluid fistulas in the ear is meningitis. A definitive repair of the temporal bone defect is critical to prevent this complication. The most commonly used surgical approaches are the transmastoid and through the middle fossa, or a combination of both. However, the key to the success of the surgical procedure lies in the use of a multilayer technique with 2 or more support materials, as it has a success rate close to 100% when artificial materials are combined with multiple layers of autologous tissue.

Methods

We present a retrospective study of the management of cerebrospinal fluid otorrheas, with a total of 17 patients diagnosed with otoliquorrhea between 2003 and 2011. This diagnosis was mainly based on the anamnesis and physical examination, and was confirmed by laboratory and imaging tests. Detection of beta-2-transferrin in the otic exudate and, especially, suggestive computed tomography and/or magnetic resonance imaging scans represented the essential diagnostic criteria.

The following variables were recorded: age, gender, affected ear, triggering cause, clinical presentation, results of the determination of beta-2-transferrin and MRI and CT scans, surgical approach and repair methods employed in each patient, and postoperative evolution with a follow-up of all patients until May 2012.

Results

The ages ranged between 15 and 74 years, with a mean value of 55 years. Regarding gender, 10 of the 17 patients were males and the remaining 7 were females. In total, 54% presented involvement of the right ear, whilst the remaining 46% presented involvement of the left ear. As for their history, the causes most frequently observed were temporal bone fracture in 4 cases (25%), cholesteatoma in 3 cases (18%), and chronic ear infection and iatrogenic origin in 2 cases each (13%). However, spontaneous fistulas were the ones affecting the majority of patients, with 5 cases (31%). No congenital anomalies which justified otoliquorrhea were detected (Fig. 1).

Fig. 2 shows the signs and symptoms which could be observed in our sample. A total of 9 patients presented watery otorrhea with a long evolution, 6 reported hearing loss, 4 patients suffered meningitis, 2 acute otitis media with a torpid evolution despite conventional treatment, and only 1 patient in each case developed vertigo symptoms and facial paralysis.

The beta-2-transferrin test was positive in 13 patients. However, this does not mean that the remaining 4 patients obtained a negative result, but rather that they did not undergo this test.

All patients underwent radiological tests. Specifically, there were 12 (60%) patients who underwent a CT scan and 2 (10%) who underwent an MRI. The remaining 3 cases (15%) underwent both imaging studies (Fig. 3). Through the imaging tests, as shown in Fig. 4, it could be concluded that 9 patients suffered the defect responsible for the fistula at the level of the tegmen tympani, 7 presented it in the tegmen mastoideum, 3 in the bony portion of the internal auditory
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Figure 1  The graph shows the causes most commonly involved in the development of cerebrospinal fluid fistula in the ear and the percentage of our patients in whom each of them was detected.

Figure 2  Bar diagram showing the main signs and symptoms of onset suffered by our patients.

Figure 3  Percentage of patients who underwent a high-resolution computed tomography (HR-CT) or a magnetic resonance imaging (MRI) scan, as imaging tests to complete the diagnostic study.

Figure 4  Radiological findings regarding the main locations of cerebrospinal fluid fistulas in the ear.

Figure 5  Axial and coronal sections of a computed tomography (CT) scan of a 62-year-old male patient suffering cerebrospinal fluid otorrhea due to a defect throughout the roof of the antrum and the tympanic cavity, with liquid content.

Figure 6  Magnetic resonance imaging (MRI) scan of a 45-year-old female patient suffering cerebrospinal fluid fistula in the ear, showing an unspecific mass in the anterior part of the tympanic cavity. Next to it is the diffusion resonance imaging scan, showing the presence of hyperintense material, characteristic of cholesteatoma.

canal and only 1 in the posterior fossa (Figs. 5–7). Moreover, we identified the presence of meningoencephalocele in 3 of the 17 cases comprising the sample.

The most commonly used approach was the transmastoid, with a total of 12 patients (72%), followed by craniotomy through the middle fossa, which was performed on a total of 3 patients (17%). In 2 patients (11%) we employed
medical treatment as an alternative to the surgical option, and obtained results which were not entirely satisfactory (Fig. 8). Fig. 9 shows the materials used for the restoration of the defects located. Tissucol®, a fibrin adhesive system with 2 frozen components (sealant protein and thrombin) which had to be thawed at a temperature not exceeding 37 °C and mixed, was the most used (in 12 of 17 patients). This was closely followed by temporal fascia, which was used in 10 cases. Surgicel® or oxidised cellulose haemostatic mesh helped to repair defects in 7 patients. Cartilage, usually extracted from the tragus, was employed in the closure of 6 fistulas. In 5 patients we also used small fragments of the temporal muscle. Bone powder and bone wax were each employed in 3 patients. Finally, Tutopatch®, a biologically resorbable membrane, was only used in 2 cases.

Regarding the postoperative evolution of these patients, follow-up was carried out until May 2012. We found that the time period for which patients remained asymptomatic and did not require a second operation ranged from 1 month to 7 years, with a mean value of 6 years, taking into account the 17 patients who made up our sample.

**Figure 7** Computed tomography (CT) of a 52-year-old male patient suffering multiple lesions at the level of the tegmen tympani and tegmen mastoideum, with fluid occupying the mastoid cells and cavity. Exploration after the surgical intervention with closure of the defects through a transmastoid approach.

**Figure 8** Graph showing the various possible options for the management of cerebrospinal fluid fistulas in the ear, as well as the proportion of patients who underwent each one.

**Figure 9** List of materials (artificial and autologous) used in the surgical closure of the defects responsible for cerebrospinal fluid otorrhea.

**Discussion**

The defects causing cerebrospinal fluid fistulas are primarily located in the tegmen mastoideum, tegmen antrum and tegmen tympani. These defects not only are usually caused by a head injury, especially in the adult population, but can also be associated with long-standing cholesteatomas, iatrogenic manipulations, tumours and chronic infections affecting the middle ear and congenital malformations, with congenital abnormalities of the lateral wall of the internal auditory canal being the most common cause in children. However, the spontaneous onset of this type of fistulas is also common. In fact, in our study, the majority of cases had a spontaneous origin (31%), followed by temporal bone fractures (25%), while the rest of causes showed less relevance.

Regarding the forms of presentation, these fistulas are usually identified in children aged between 1 and 5 years as cases of meningitis in the context of profound sensorineural hearing loss. Among the adult population, it has been found that female gender, middle age and being overweight or obese represent risk factors for the development of spontaneous otorrhea, with the primary complaint in these patients being symptoms corresponding to otorrhea. In our case, the age range was between 15 and 74 years, so no children took part in our study. Furthermore, although a spontaneous origin was the most common among our sample, the majority of our patients were males (ratio 10:7).

Several theories are currently being considered regarding the pathophysiology of cerebrospinal fluid fistulas with a spontaneous origin. On one hand, small congenital bone defects at the level of the middle ear, fossa and tegmen appear to trigger an increase in cerebrospinal fluid pressure, which in turn would predispose towards dural herniation with consequent dural and bone thinning, leading to the development of otorrhea. Other theories argue in favour of the existence of arachnoid granulations in abnormal locations as responsible for the onset of this phenomenon. In any case, the relationship between factors such as obesity, idiopathic intracranial hypertension and empty sella turcica syndrome and the development of spontaneous fistulas in the ear has been clearly proven. Sleep apnoea-hypopnoea syndrome has also been suspected, since an increase in intracranial pressure during apnoea...
episodes would take place, thus favouring the appearance of otoliquorrhea.\textsuperscript{3-5}

In terms of clinical presentation, there are 4 signs and symptoms that point towards this pathology: unilateral serous otitis media, loss of hearing with conductive hypacusis in the audiometric study, aural fullness sensation and recurrent episodes of meningitis. In addition, there are other alert signs, such as unilateral watery otorrhea, associated rhinorrhea and persistent watery otorrhea after myringotomy.\textsuperscript{3-6} In our patients, the clinical presentation was consistent with the previously listed signs and symptoms. There was only 1 case that began with vertigo symptoms and 1 with facial paralysis.

Additional tests to obtain an accurate diagnosis are based on imaging techniques. However, the determination of glucose concentration in the fluid from the ear and beta-2-transferrin testing can also be used, always considering that the former has a high risk of false positives, whilst the latter is more sensitive and specific.\textsuperscript{7,8} In our study, 13 of the 17 patients underwent the latter test, and the result was positive in all 13 cases, thus we confirm the usefulness and accuracy of the determination. The most commonly used imaging techniques are computed tomography (CT) and magnetic resonance imaging (MRI). If otoliquorrhea is confirmed by a positive beta-2-transferrin test and the defect is apparent with high-resolution computed tomography of the temporal bone, then no further exploration is required. A coronal, T2 MRI study may be useful to confirm the presence of encephalocele. In addition, the test can also diagnose empty sella turcica syndrome, which is associated with an increase in intracranial pressure and spontaneous fistulas. It is also useful in cases where locating the defect through CT is difficult.\textsuperscript{7-9} In our series, the defect was detected with computed tomography alone in 13 patients and with magnetic resonance in 2 other patients. The remaining 2 cases required the combination of both tests. Regarding the defects found, the most frequent location was in the tegmen tympani, with 9 cases, followed by the tegmen mastoideum, with 7 cases. In addition, the presence of encephalocele was corroborated through magnetic resonance imaging in 3 patients. The study with intrathecal radioisotopes (Tc-99m albumin) can be useful in cases where the presence of a cerebrospinal fluid fistula is doubtful. In staining studies with intrathecal fluorescein, 5\% of cases will present risk of epileptic crisis or infection.\textsuperscript{8} Our study population was not subjected to any of these 2 techniques.

Lastly, we must focus on the management of this type of fistulas. Conservative measures are indicated when the cause is a head injury. These will have an efficiency of 83\% at 3 days. Cerebrospinal fluid fistulas which persist over 24 h despite medical treatment will frequently require surgery for a definitive closure. Bed rest with elevation of the head 30\° is indicated in such cases. Laxatives can be used, whereas the Valsalva manoeuvre is contraindicated at all times. The use of diuretics and steroids can be useful, although not as a primary therapy, since they can hinder the location of smaller fistulas. In the absence of infection, antibiotic therapy will select resisters, so a lumbar puncture should be used to confirm it. The use of prophylactics has been approved for situations such as immunsuppression, drainages or penetrating trauma. A lumbar drain is contraindicated unless the cerebrospinal fluid fistula has been located; however, once it has been located, and if obstructive hydrocephalus has been ruled out, then it has proven useful when conservative measures fail. A lumbar drain maintained for more than 2 weeks with persistence of the fistula represents an indicator for surgery.\textsuperscript{6,7} If the cause of the cerebrospinal fluid fistula is postoperative, then early surgery is indicated, with a success rate around 76.9\% following the first intervention, and nearly 100\% after a mean waiting period of 3.9 months. Early entry surgery is also indicated when the aetiology is not traumatic, as only a percentage of around 33\% close spontaneously.\textsuperscript{1,8,9} In our series, 89\% of the sample (15 cases) underwent entry surgery through various approach routes. The remaining 11\% (2 patients) were treated through a conservative approach, requiring operation after some time due to the poor response to this treatment.

Several surgical approaches offering a suitable and sufficient access to repair defects of the middle and posterior fossa have been described. The age, comorbidity, location, number and size of the defect of a patient, as well as the presence of meningoencephalocele, a history of previous repairs and the experience of the surgeon, are factors that must be taken into account when selecting the approach route. In general, the transmastoid approach is considered suitable for defects with a size less than 1.5 cm and appearing in a number less than 2. In terms of location, defects of the posterior fossa or tegmen mastoideum can be perfectly exposed through a transmastoid access. However, defects involving the tegmen tympani are sometimes difficult to manage with this approach without causing conductive hearing loss due to ossicle chain alterations. Craniotomy through the middle fossa enables exposure of the floor of the middle fossa from the tegmen mastoideum to the tegmen tympani. In addition, less common locations for this type of defects, such as the zygomatic root or the internal auditory canal, are more accessible through the middle fossa approach. Nevertheless, we must not forget that this route is associated with a higher number of complications.\textsuperscript{1,8,9} In our study, 72\% of patients were operated by a transmastoid approach, obtaining a good exposure of the defects. The middle fossa approach was only used in 17\% of the sample, and its results were also satisfactory. The combined approach (transmastoid and middle cranial fossa) will enable a better control of the lesion, especially in large defects, as well as a greater ease to interpose support material. Its primary indications will be for multiple defects or those larger than 1–2 cm.\textsuperscript{1,10}

Lastly, it should be noted that the most important factor for the success of the surgery is the use of a multilayer technique, with 2 or more support materials, presenting a success rate near 100\% when artificial materials (Gelita®, Surgicel®, bone wax, etc.) are used together with autologous tissue layers.\textsuperscript{1,10,11} The most widely used combinations in the patients in our sample were Tissucol®/tragal cartilage/Tissucol®/temporalis muscle fascia/Tissucol® and, on the other hand, Tissucol®/bone powder/Tissucol®/temporalis muscle fascia/Tissucol®, with some cases requiring the interposition of Surgicel®. No problems, such as infection, were detected in the immediate postoperative period and our patients were asymptomatic during a period ranging between 1 month and 7 years, with a mean value of 6 years.
Conclusions

Cerebrospinal fluid fistulas in the ear are rare entities, but they can be potentially dangerous due to the associated complications, including meningitis and encephalocele. The diagnosis is often delayed because the symptoms are similar to those of serous otitis media. It is only after observing a persistent, clear otorrhea that this entity is suspected. Patients most often affected by spontaneous fistulas are middle-aged females with excess weight. The diagnostic approach should start with a CT scan, preferably with a high-resolution, of the temporal bone, which in many cases may be sufficient to locate the responsible defect. MRI can be useful to confirm the concomitant presence of an encephalocele. The tegmen mastoideum and tegmen tympani are the most common locations of these defects. The treatment of choice is usually surgical, considering that a middle fossa approach provides maximum exposure, although in the majority of cases the transmastoid approach is sufficient for defects located in the posterior fossa and tegmen mastoideum. The success of this surgery is closely linked to the use of a multilayer technique with 2 or more support materials, combining artificial materials and autologous tissue layers.

Conflict of interests

The authors have no conflict of interests to declare.

References