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Osteo-Meningeal Breaches of the Anterior Floor of the Skull Base: Mini Review

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Abstract

Osteo-meningeal breaches of the anterior floor of the skull base are a solution of continuity between the meningeal and underneath bony structures. They can be primary or secondary, usually post traumatic or iatrogenic. The main clinical manifestations are rhino-liquorrhea and recurrent meningitis. Radiological investigations are highly contributory by exposing the defect and assessing the herniated content. Optimal treatment depends on the breach parameters and the consequent hernia. Surgery, when indicated, consists on the exposure of the defect and its clogging using different grafts. Endoscopic endonasal approach remains the most currently practiced regarding its aesthetic benefit and conclusive results.

Introduction

The anterior floor skull base osteo-meningeal breaches (OMB) are a solution of the osteo-meningeal continuity producing leakage of cerebrospinal fluid (CSF) through the defect into the contiguous air-filled cavities of the face [1,2]. Its incidence varies from 4.6 to 7.6 cases per year in the US in 2004 and 9 cases per year in Belgium in 2008 [3,4].

Circumstances of Occurrence

The osteo-meningeal breaches can occur at any site but they are more likely seen in the fragile anatomical points. The weak areas in the bone are the ethmoid cribriform plate regarding its perforated and aerated constitution, the facial sinuses (frontal and sphenoidal) specifically when hyperpneumatized with thinned walls and the skull base foramens and ledges [1,2]. In the meninges, the weakest areas are paradoxically the areas of their adherence to the skull base [2].

The OMB in the anterior floor of the skull base can be primary or secondary. Secondary OMB are the main clinical presentation (96%) posttraumatic in 90% of the cases and iatrogenic postoperative in 10%. Following an accidental skull base trauma, tearing or shearing of the dura from its adherences can be caused by acceleration deceleration mechanisms of force. Then, the breach gets maintained by the communicating hydrocephalia. On another hand, CSF leakage represents 66% of endoscopic nasal surgery complications favoured by the surgeon inexperience, the surgical revision but also the predisposing anatomy like asymmetric position of the ethmoid roof and Crista Galli pneumatisation. Also, progressive lysis of the bone causing OMB can be secondary to pituitary or nasal tumors or inflammatory and septic processes such as skull base

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osteomyelitis or fungal sinusitis [1]. The most affected sites are the sphenoid sinus with a highest risk for the anterior ethmoidal roof than the posterior [2].

Primary or spontaneous breaches define CSF leakage unrelated to trauma, surgery, tumor, or previous radiation therapy [5]. Representing 3-4% of OMB [2], they are a diagnosis of exclusion [1]. The bony erosion is the mechanical consequence of the chronic and perpetual contact between the pulsatile meninges and the bone in addition to the imbibition phenomenon. They get divided according to intracranial CSF pressure. OMB with normal CSF pressure are usually related to congenital malformative defects of the skull base, meningocele or meningocephalocele, or hyperpneumatization of the lateral walls of the sphenoid sinus. OMB with intracranial hypertension can be associated to cerebral aqueduct stenosis or an empty sella. The hypertension leads to slow erosion of the spheno-ethmoidal roof and a dehiscence of the sellar floor. Unlike secondary OBM, they usually affect the frontal and ethmoid sinuses and the nasal fossa and rarely the sphenoid sinus [2]. Also, primary OBM are more likely to be bilateral and multiple [5].

Clinical Presentation

The main clinical presentation of OMB of the skull base anterior floor is rhino-liquorrhea and recurrent meningitis. Headaches, nasal obstruction and olfactory troubles can also be reported [2]. The rhino-liquorrhea is described as nasal leakage usually unilateral, intermittent, sometimes abundant, of a colorless salty liquid clear as rock water [1]. Active or inactive, it can be positional and provoked by an antepulsion or genupectoral position, or also by coughing or by Valsalva maneuver. History of facial trauma or nasal endoscopic surgery should be reported. The liquorrhea can appear years after the incident when the natural fibrous scarring ruptures by a minor trauma or an increasing of intracranial pressure [2].

Conventional biochemical analyses of the liquid find increased protein or glucose. Glucose concentrations greater than 0.3 g/L and protein concentrations up to 2 g/L are considered indicative of CSF [6]. But, the necessity of large samples, the contamination in the event of blood and the rate of false positive up to 45-75% are important disadvantages [6,7]. However, even if the determination by glucose test strips in bedside secretions has low sensitivity and specificity, it can be useful in the emergency room [7].

The most specific indicator is the presence of beta2transferrine in the nasal leakage, since it is found almost exclusively in CSF. Only a few other body fluids, such as the cochlear perilymph and the aqueous and vitreous humor of the eye, contain also low concentrations. The initial method was first described in 1979, largely improved today using a method of isoelectric focusing in a highly standardized fashion giving the results within 3.5 to 8 hours with a specificity of 99% and a sensitivity of 97% [6]. Easy and non-invasive, this method is particularly contributing when the leakage is sparse or intermittent [2].

The OMB can also be revealed by nervous system septic complications such as inaugural or recurrent pyogenes meningitis or meningoencephalitis with the Streptoccocus Pneumoniae as the most incriminated germ, cerebral abscess, empyema, cerebral vein thrombosis or osteitis [1,2]. The high incidence of bacterial meningitis indicates prophylactic antibiotic waiting for surgery [8].

Radiological Findings

The main aim of radiological investigations is to confirm the presence of an OMB, specifying its location and eventually, its underlying cause. Cranio-facial CT scan, preferably performed after provocative maneuvers, allows the exploration of the anterior and middle floors of the skull base. The sections are made on fontal and axial planes [2]. It shows a bony solution of continuity between the meningeal structures and the sinuses or the nasal fossa specifying its location and thickness, with hydroaeric level or epidural, subdural or subarachnoidian pneumocephalus realising in its massive form the Mount Fuji sign (air between the tips of the frontal lobes [1]. An opacity can be observed in the airy cavity corresponding to SCF or herniated cerebral tissue [2].

The MRI reveals T2 hyperintense signal between the subarachnoidian spaces and the sinuses or the nasal fossa interrupting the hypointensity of the bone. With an estimated sensitivity between 80 and 93,6% and positive predictive value between 92 and 100%, [2] it can confirm the presence of the OMB even without active nasal leakage. However, few false positive results can be related to post trauma or postoperative fibrosis, the presence of sinusitis or mucocele [1].

The association of CT scan and MRI is the first line imaging investigation, increasing slightly their sensitivity to 95% but majorly their specificity that reaches 100% [2]. In second intention, the invasive MRI with intratechal injection of Gadolinium through lumbar puncture allows better differentiation between facial sinuses, cerebral tissue and CSF spaces by increasing the signal intensity in the cisterns and ventricules [1]. CT cisternography comes in third line since it's an invasive procedure that should only be considered when the diagnosis remains uncertain

following CT scan and MRI [2]. Comparison of images taken in different positions helps the detection of positional rhino-liquorrhea. Isotopic cisternography using technetium or indium is practically not used anymore, even with good sensitivity for small and intermittent fistulae; its spatial resolution is so mediocre that its localisation value is very poor [1].

Bases of Treatment

The therapeutic management of OMB must consider the cause, the anatomic site, the size of the defect, the age of the patient and the underlying intracranial pressure [7]. In the secondary forms of OMB, the treatment of the etiology is mandatory while the breach closing alone is enough for primary OMB [1].

The medical treatment is proposed when the OMB is minimal in order to favour spontaneous scarring. It is based on rest, repetitive lumbar punctures and draining and drugs like diuretics and carbonic anhydrase inhibitors (CAI) [2]. The CAI decrease the rate of formation of H+ and HCO3- within the blood-brain barrier. These ions are usually exchanged for plasma anions and cations, largely Na+ and Cl-, which thus enter the interstitial fluid followed by the entrance of water to maintain osmotic equilibrium. This mechanism is considered to exist not only in the choroid plexus but throughout the central nervous system parenchymal vasculature. And then, the rate of formation of interstitial fluid and cerebrospinal fluid diminish resulting in a marked reduction in intracranial pressure [9].

The actual guidelines from the "French National Authority for Health" (after revision in 2017) concerning Pneumococcal vaccination include patients with OMB as non-immunosuppressed patients with underlying disease predisposing to invasive Pneumococcal infection [10]. The surgical indications are abundant liquorrhea and/or persistent despite medical treatment, recurrent septic complications and multiple and bilateral OMB [2]. In order to visualize the OMB path during surgery, mostly whit non-contributory imaging, an intratechal injection of 0,5% Fluorescein can be performed before starting the procedure. The colorant well distributed with Trendelenburg position infiltrates and exposes the breach. However, it has a high incidence of complications (25%) such as meningitis or epilepsia crisis [2].

The intracranial approach (frontal craniotomy) shows the bony defect and the affected dura next to it. The extracranial approach, trans-ethmoidal, trans-septal or endoscopic endonasal, is indicated for the limited OMB of the anterior floor of the skull base with no associated cerebral lesion [2]. The endonasal endoscopic approach is the classical and most currently practiced because of the aesthetic benefit and conclusive results [7]. They allow the closing of OMB of the criblate plate or the roof of the ethmoid and sphenoid using grafts collected on site (nasal septum) or afar (abdominal fat, tragal cartilage, fascia lata) [2].

The first surgical step is to confirm the diagnosis. In the endoscopic endonasal approach, the surgeon "sees" the breach and the clear CSF flowing. Also, he can provoke the leakage by instrumentally repelling the meninges or the cerebral tissue herniated in the cavity or by Valsalva maneuver or jugular compression [2]. The contents of herniation are best explored through extracranial approach and should benefit from meticulous examination as long as they may modify the grafting technique [5]. The second surgical part consists of clogging the breach by an interposition technic with septal or turbinal mucosa graft, retroauricular or abdominal fat, fascia temporalis or fascia lata of the thigh or neuropatch [2]. As grafting material, the use of bone or cartilage is not required unless herniation of the meninges or brain is present [5] If unsuccessful, with persistent spontaneous fistulas, or large bone crash, or in the presence of a concomitant high-pressure hydrocephalus, a ventriculo-peritoneal or ventricular-atrial shunt is produced [7]. The two life-threatening postoperative complications are mainly represented by intracranial hypertension and meningitis which is prevented by IV injection of third generation of cephalosporin [7].

Conclusion

OMB of the anterior floor of the skull base should always be considered in front of a history of facial trauma or previous endonasal surgery. The main clinical sign is rhino-liquorrhea whose biological analysis confirms the CSF nature. The CT scan and MRI are the first line radiological investigations. And the treatment should take into consideration the type of the breach and the nature of the herniated content without suffering any delay regarding its life-threatening complications.

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