BAROTRAUMATIC PNEUMOCEPHALUS IN SCUBA DIVER
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Introduction
Barotrauma due to pressure variations during scuba diving is a well known phenomenon; the ENT localization of these accidents is the most frequent and their consequences are generally not very severe. Pneumocephalia represent rare events but their gravity as well as their potential sequelae must draw the attention of the hyperbaric specialists to this pathology.

Method
We report the case of a 27 years old female who performed a scuba diving according to the following elements: normal descent till a maximum depth of 43 meters, a lot of efforts were carried out with some of them on breath-hold; the water was cold. After 35 min, she began the ascent and around 10 meters, she complained of a sudden occipital headache whose intensity increased progressively till the surface; no procedure error was made and the decompression stops were respected. Some hours after, in spite of a treatment by acetylsalicylic acid, symptomatology worsened including asthenia, vertigo and vision troubles. The next morning she was admitted at the hospital with an atypical, important and positional occipital cephalgia.

Results
The neurological examination except a slight right lateral nystagmus was normal. The medical interrogation revealed history of a nasal pyramid fracture 4 years ago. Since this date, the patient had presented two convulsive crisis (the last one 1 year ago) and a persistence of a clear, bilateral rhinorrhea occurring after efforts and travels in mountain. Moreover, she declared to undergo psychotherapy and to be claustrophobic. The skull radiography immediately performed (fig. 1) showed a clearness in the vertex leading to suspect an atypical barotrauma. This examination was completed by a cerebral CT scan (CCT scan) which eliminated any haemorrhage and confirmed the diagnosis of pneumocephalus with bubbles in frontal, occipital and vertex localizations (fig. 2).

The treatment, after hospitalization in neurosurgical unit, included bed rest in half-seated position, analgesic, anxiolytic and antiepileptic drugs. A new CCT scan performed on the 4th day showed the stability of the lesions and selected cuts did not show any osteomeningeal breach. Five days later the patient was able to leave the hospital; a last CCT scan performed after 15 days showed a complete resorption of the lesions. The patient was definitively contraindicated to diving.

Figure 1: Standard skull radiography
Figure 2: Cerebral CT scan
Discussion
This clinical picture is not typical of a diving accident. However, the symptomatology occurred during the diving must be linked with this one.
The mechanism of such a barotrauma is explained by the Boyle-Mariotte’s law and the skull anatomy.
The variations of pressure are normally well tolerated by the major part of divers. During a normal ascent, the expanded air in the middle ear and sinus meatus is passively eliminated. But in certain cases, if there is a lack of permeability or a pre-existent fragility of bone or sinus wall, the trapped air can cause a rupture in this region [1, 2, 3, 4, 5].
In the case of our patient, it is highly likely that the clear rhinnorhea of which she previously suffered correspond to a leakage of cerebrospinal fluid (CSF) through an osteomeningeal breach due to the cranial trauma.
Several pathophysiological hypotheses can be suggested:
Physiologically, the intracranial volume must be constant; so, any variation of its components (brain, CSF, blood) have to be compensated by the reciprocal variation of one of them, otherwise the intracranial pressure would be modified [4].
The major alterations of the CSF pressure are provoked by leakage, changes of position or variations of the intra thoracic pressure; in case of a fistula, when the balance is reached any decrease of pressure will lead to create pneumocephalus. On the contrary, any increase of the CSF pressure (cough, efforts) brings about a transitory CSF extravasation; in this way, the intracranial pressure becomes negative and an equal volume of air can enter into the cranial cavity to equilibrate the pressure [4, 6, 7].
Other factors explain the onset and the worsening of pneumocephalus in this diver: the repeated Valsalva manoeuvres performed during descent can tend towards the CSF leakage and secondarily to reduce the CSF pressure [16]. The dehydration commonly described during scuba diving can decrease the CSF pressure by reduction of its production or by reduction of the vascular intracranial volume.
In this patient, these entire hypotheses have certainly coexisted and played a fundamental role in the pathophysiology of the disease.
Considering the neurological symptoms, the differential diagnosis had to eliminate a cerebral decompression accident or a cerebral air embolism due to overpressure. So, at the admittance the question arose to perform a therapeutic recompression in hyperbaric chamber. Nevertheless, in absence of worsening in the clinical status about 24 hours after the accident, time necessary to carry out the radiological examinations could be taken. Considering the results of the skull pictures, the diagnosis could be confirmed by the CCT scan. This allowed directing the therapeutic reasoning in avoiding a session of hyperbaric oxygen therapy which would have involved an additional entry of intracranial air leading to the aggravation of the symptomatology.
In the case reported, according to the clinical enhancement and the spontaneous drying up of the rhinnorhea, not any other examinations [8] were performed. If the CSF leakage had reappeared a MR cisternography [9, 10] could have been carried out to show the fistula; in this eventuality a surgical treatment could have been proposed [11, 12, 13, 14].
Some clinical pictures of barotraumatic pneumocephalia are more complex and more serious. Even if the important headache is almost constant, there is no pathognomonic sign of these diseases. This explains the delay to perform a positive diagnosis.
Cases reported in the literature occur as well during altitude exposure (7 cases) as during scuba diving (2 cases). One diver deceased and 4 patients had a total recovery after surgical treatment. It is notable that only small variations of pressure can create the lesions [12, 13, 15, 14, 11, 16, 17, 18, 19].
The number of cases during diving is certainly under estimated because of the lack of knowledge about this pathology and in absence of radiological examination, the lesion can go unnoticed.

**Conclusion**
Faced with such a disease, a simple skull radiography makes the diagnosis. The CCT scan will clarify the localization of the lesions and direct a specific treatment. Considering the mechanism of the syndrome, hyperbaric oxygen therapy must be proscribed because of the possibility to worsen the lesions. According to her specific antecedents this patient would have never dive. This accident stresses the necessity of a thorough medical enquiry during the examination of aptitude for diving.

**References**