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Central nervous system air pressure: A tension dilemma

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ABSTRACT

Introduction: Tension pneumocephalus may lead to an increase in intracranial pressure and rapid neurologic deterioration and death. Therefore, this condition should be approached as a neurosurgical emergency.

Case Report: A 34-year-old male was admitted for resection of a relapsed meningioma. At the time, the patient complained of bilateral visual loss and intense headaches. A transsphenoidal approach was performed and the tumor's left portion was completely resected. The tumor's right portion was adhered to the ipsilateral carotid artery and optic nerve structures. Its complete removal was unachievable. In the next days, he experienced multiple complications such as worsening amaurosis, vascular thrombosis, and a tension pneumocephalus was diagnosed on a computed tomography (CT) scan after physical exam showed signs of elevated intracranial pressure. He underwent an urgent external ventricular derivation and, the next days, multiple interventions were deemed necessary due to a recrudescent pneumocephalus and ventricle. The patient's Intensive Care Unit (ICU) stay went on with infectious and metabolic complications until a control head CT showed diffuse edema, with loss of cortical differentiation. Due to lack of improvement, despite best efforts, after a multidisciplinary discussion, exclusive palliative care was instituted, and the patient died shortly afterward.

Conclusion: Our case illustrates a rare occurrence of persistent tension pneumocephalus in which multiple interventions were made in order to improve outcomes. Our description demonstrates that further discussion and research regarding the optimized treatment to recurrent tension pneumocephalus is needed, in spite of its rarity.

Keywords: Brain injuries, Intraventricular air accumulation, Pneumocephalus, Tension pneumocephalus, Tension pneumoventricle

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INTRODUCTION

Neurosurgical procedure complications usually demand prompt interventions or close follow-up in order to optimize outcomes and minimize secondary damage. Although rare, tension pneumocephalus (TP) occurs in about 3.1% of adult posterior fossa/occipital surgeries in the sitting position and in about 0.2% of craniotomies in general and may lead to an increase in intracranial pressure and rapid neurologic deterioration [1, 2].

Without treatment, it may result in irreversible neuronal damage and even brain herniation and death. Therefore, this condition should be approached as a neurosurgical emergency [3]. We aim to describe a fatal case of TP, highlighting the importance of clinical awareness of this pathology in order to contribute to its unhesitating and optimized treatment intervention.

CASE REPORT

A 34-year-old male patient, with hypertension, was admitted for an elective and planned resection of a relapsed meningioma. The original resection was six years earlier and surgery was again indicated based on the tumor site and infiltration: tuberculum sellae with paranasal sinus and septum invasion. At the time, the patient complained of bilateral visual loss and progressive and intense headaches. A transsphenoidal approach was performed. Intraoperatively, a liquoric fistula was diagnosed and closed together with septoplasty and bilateral maxillary and sphenoid sinusotomy. The tumor's left portion was completely resected. This resulted in decompression of optic and oculomotor nerves and basilar and A2 portion of the anterior cerebral arteries. The tumor's right portion, however, was intimately adhered to the ipsilateral carotid artery and optic nerve structures. Its complete removal was unachievable due to an extensive bleeding which was promptly contained.

Afterward, the patient was admitted to the ICU in a hemodynamically and ventilatory stable condition. He was breathing on room air and didn't complain of pain. On physical exam, he showed bilateral amaurosis and right mydriasis and his blood pressure was 180 × 120 mmHg. His pupil photoreaction was faint. A new surgery was performed 48 hours later, aiming to decompress the second cranial nerve. During the procedure, a left side vascular thrombosis was noted. The patient was immediately evaluated for percutaneous neurovascular intervention, but arteriography was contraindicated due to elevated thrombus displacement and stroke risk. He was sent to ICU, under sedation and mechanical ventilation, with a third programmed surgical intervention the next day, in which a reminiscent liquoric fistula was corrected together with liquor sampling. A tumor portion that infiltrated right cavernous sinus was also, successfully, resected. Cerebrospinal fluid (CSF) showed pleocytosis and broad-spectrum antibiotics was initiated with a hypothesis of central nervous system (CNS) infection. Cerebrospinal fluid cultures came back negative and antibiotics were discontinued on day 7.

On follow-up physical exam, the patient showed signs of elevated intracranial pressure and a head CT scan was performed (Figure 1). A tension pneumocephalus and ventricle was diagnosed and the patient underwent an urgent external ventricular derivation together with intracranial pressure (ICP) monitoring catheter placement. His ICP, after the drainage, was 5 mmHg. On CT follow-up, 24 hours later, CNS air persisted. Under a hypothesis of a recurrent liquoric fistula the patient was again sent to the operating room with significant improvement after the approach. Shortly after, polyuria occurred, together with dysnatremias. Four days later, a recrudescent pneumocephalus was seen with a diameter of 7.7 cm. A new intervention was performed and, the next day, subcutaneous emphysema was seen on the patient's face and neck without any signs of pneumothorax on lung ultrasound (Figure 2). A new and contralateral external derivation was put into place. At this time, a transcranial doppler (TCD) was performed and showed signs of vasospasm which was promptly treated. A control TCD showed improvement in the same day. The patient remained in ICU care and underwent tracheostomy. The patient's ICU stay went on with multiple infectious and metabolic complications such as sodium disorders, metabolic acidosis, etc. A control head CT done on ICU day 36 showed diffuse edema, with loss of cortical-medullar differentiation and ischemia (Figure 3). A TCD was performed and showed reduced generalized blood flow. Due to lack of improvement despite optimized efforts, after a multidisciplinary discussion, which included patient's family, a decision to institute exclusive palliative care was done by the assisting team. Proportional supportive care was then instituted. Patient's wife, brother, mother, and father were followed by psychology staff. On his 42nd day, the patient died.

Figure 1: Initial CT scan showing a tension pneumocephalus and ventricle (red arrows).

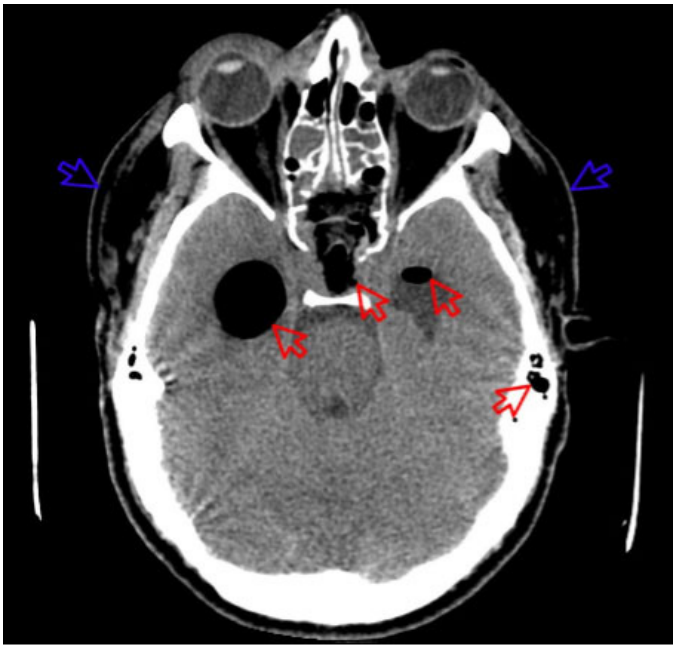

Figure 2: CT scan showing subcutaneous emphysema on the patient head (blue arrows) and persistence of tension pneumocephalus and ventricle (red arrows).

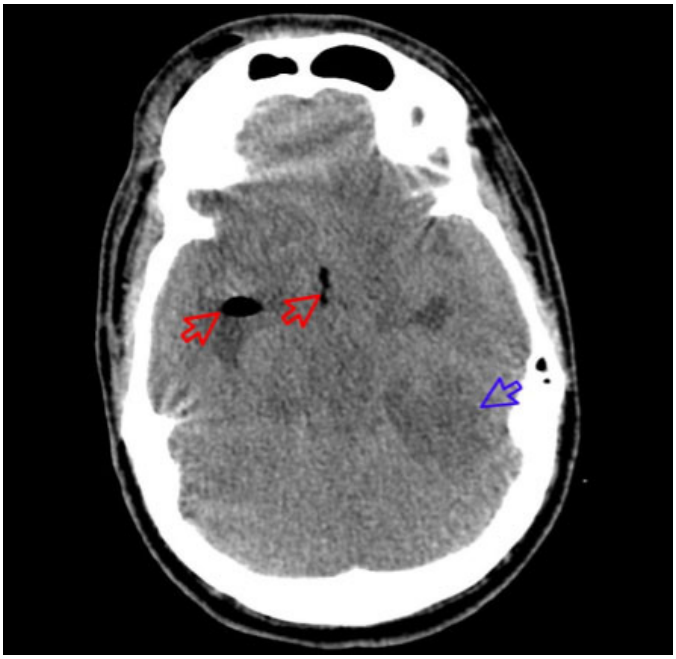

Figure 3: Control head CT scan showing signs of intracranial hypertension and cortical-medullar ischemia.

DISCUSSION

Our case illustrates a rare occurrence of tension pneumocephalus and ventricle following transsphenoidal surgery in which multiple interventions were made, aiming to correct the air leak defect and provide optimal care. Due to its uncommon incidence, the appropriate approach for this emergency, in order to better optimize functional and neurological outcomes is not entirely clear [1, 2]. Therefore, our propaedeutics may present as a strategy and algorithm of care.

Although trauma represents its most common etiology, TP may occur secondary to neurosurgical approaches, as it was with our patient [4] and even secondary to anesthetic procedures and infections [5, 6]. Pneumocephalus is a challenging diagnosis to be done based on clinical manifestations alone. It should always be suspected and sought, depending on the patient's previous medical history—for example, surgical manipulations. The diagnosis rationale encompasses a throughout propaedeutic which should include radiological and anamnesis data. It is usually a silent condition until neurological symptoms develop [6, 7]. When clinically manifested, such as with elevated intracranial pressure, treatment consists of emergent decompression in order to alleviate pressure on the brain parenchyma [4]. The optimized treatment intervention is yet to be clarified and options include, for example, the drilling of burr holes and ventricular derivation, needle aspiration, and closure of a dural defect [2, 4]. Our patient developed multiple sepsis and neurological complications, such as arterial thrombosis, vasospasm, a possible diabetes insipidus, together with metabolic disturbances (i.e., dysnatremias, metabolic acidosis, and others) which surely contributed to his disease severity and outcomes.

Two possible mechanisms may have contributed to our patient's pneumocephalus and ventricle: air entering the CNS cavity (whenever the extra-cranial pressure exceeds the intracranial pressure) or by continuous leakage of CSF (leading to negative intracranial pressure) and air replacing the open cavity. The tension pneumocephalus was diagnosed in the context of a supposedly corrected liquoric fistula. Tension pneumocephalus relapse may have been associated with a subclinical fistulous tract, which might have been an important contributor for the persistent air leak into the central nervous system [2, 6].

Because, initially, our patient developed neurological signs together with elevated intracranial pressure, an urgent intervention was made. Also, air is toxic to neurons, causing further damage to the already compromised brain parenchyma, and that may have led to cerebral edema [4]. This could have been our patient's main cause of clinical deterioration. After the TP diagnosis, our patient was surgically approached multiple times (in different ways) in order to avoid CNS air toxicity and reduce further neuron damage.

Tension pneumocephalus is a potentially fatal condition even if addressed in a timely and proper manner as it was with our patient. Therefore, safety measures, in order to prevent its occurrence, should be adopted meticulously by the whole surgical team without, of course, compromising steps of care. In this setting, the appropriate and most fitting choice of intervention was broadly discussed among the neurosurgical team. The scarce literature regarding TP propaedeutics recommends our initial approach (external ventricular derivation) as

an adequate treatment option [1]. Our patient, despite timely interventions and our best efforts, persisted with a tension pneumocephalus. This, as discussed above, regarding brain damage, surely contributed to his fatal outcome.

CONCLUSION

Tension pneumocephalus should be treated as an emergency in order to optimize outcomes in such a potentially life-threatening condition. This case demonstrates that further discussion and research regarding the optimized treatment to recurrent TP is needed, in spite of its rarity.

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Author Contributions

Diego Bastos Porto – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Beatriz Amorim Beltrão – Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

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Conflict of Interest

Authors declare no conflict of interest.

Data Availability

All relevant data are within the paper and its Supporting Information files.