Two Cases of Tension Pneumocephalus after Endonasal Skull Base Surgery and Vestibular Schwannoma Surgery

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ABSTRACT

Pneumocephalus, the presence of air in the cranial cavity, is a rare but serious complication of both head trauma and post-neurosurgery procedures. Tension pneumocephalus, marked by significant air accumulation causing mass effect and neurological symptoms, is even more uncommon and demands prompt intervention. The authors report two cases of tension pneumocephalus. The first case involved a 52-year man who experienced a rapid loss of consciousness after endonasal skull base surgery. Decompressive craniectomy was performed, and the patient recovered with conservative management. The second case was a 41-year woman who developed tension pneumocephalus within an hour after vestibular schwannoma surgery, leading to loss of consciousness and cerebral infarction. Despite conservative treatment, her condition worsened, and care was withdrawn after three weeks without improvement. The Mount Fuji sign on CT is a key indicator of tension pneumocephalus. Urgent neurosurgical intervention, such as trephination or burr hole craniotomy, is critical to relieve pressure and prevent further neurological damage. Needle aspiration and ventriculostomy are additional treatment options. Anaesthetic management should focus on avoiding nitrous oxide, maintaining cerebral perfusion, and controlling airway pressures. These cases highlight the need for vigilance in identifying tension pneumocephalus and initiating timely treatment to optimise patient outcomes.

Key Words: *Tension pneumocephalus, Endonasal skull base surgery, Decompressive craniectomy*.

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INTRODUCTION

Pneumocephalus, the presence of air in the cranial cavity, can result from surgical procedures that involve dural disruption. When air accumulates without escape, it can lead to tension pneumocephalus (TP), causing increased intracranial pressure (ICP) and neurological impairment due to mass effect, and brain herniation to the worst.[1] Common symptoms include headache, seizures, confusion, and neurological deficits, with more serious cases progressing to altered consciousness, cranial nerve dysfunction, bradycardia, and even cardiac arrest.[1]

Here, the authors report two cases of TP. One case occurred four days after endonasal skull base surgery, while the other developed within an hour post-neurosurgery procedure, leading to cerebral infarction. These cases highlight the need to consider TP in patients who exhibit sudden neurological deterioration following procedures involving the dura.

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CASE 1:

A 52-year male with a malignant nasopharyngeal tumour underwent a 14.5-hour endoscopic resection. The procedure was uneventful. On the second postoperative day, he developed decreased consciousness, became unresponsive, and showed no purposeful movements. The Glasgow Coma Scale (GCS) score was 6. An emergency CT scan was performed to rule out postoperative intracranial haemorrhage. CT revealed a large haemorrhage in the left temporal lobe along with significant pneumocephalus (Figure 1A). Treatment was initiated promptly, including coagulation-promoting medications and mannitol to reduce bleeding and ICP. The patient's mental status improved after one day of treatment but worsened again on the fourth postoperative day. CT scans showed a significant accumulation of intracranial air, especially in the frontal lobe region (Figure 1B). The air continued to enter through the unclosed surgical sinus tract, and the patient's symptoms persisted despite mannitol treatment. Therefore, burr hole drainage was performed *via* a left frontotemporal incision to effectively evacuate the accumulated intracranial air, targeting the region of maximal air collection identified on CT imaging.

Following the air drainage surgery, the patient's consciousness returned to normal, and CT scans showed a reduction in intracranial air. After a week of observation without recurrence of symptoms, the patient was transferred for rehabilitation. Upon discharge, the patient's consciousness and muscle strength were both normal.

Figure 1: (A) Emergency non-contrast CT scan demonstrating a large haemorrhage in the left temporal lobe with significant pneumocephalus. The prominent accumulation of intracranial air suggests serious postoperative complications. (B) On the third postoperative day following endoscopic skull base tumour resection, a CT scan revealed a substantial frontal air collection with compressed brain parenchyma, forming the characteristic Mount Fuji sign, indicative of tension pneumocephalus.

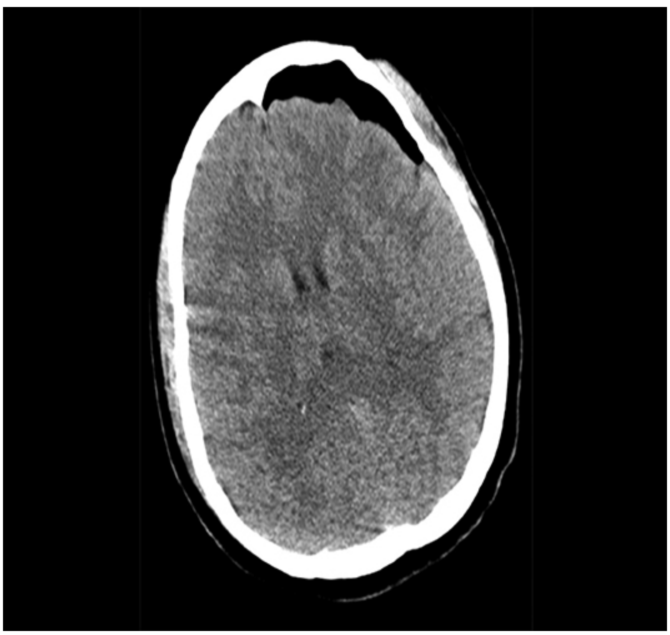

Figure 2: Following surgery for a vestibular schwannoma, the patient's head CT showed significant intracranial pneumocephalus.

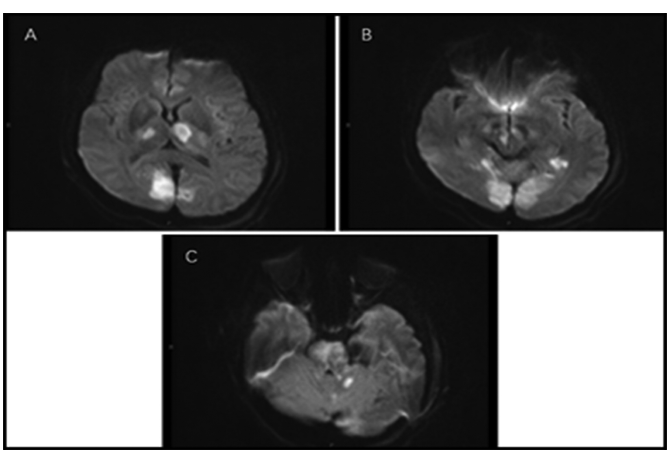

Figure 3: Three slices (A-C) magnetic resonance images (MRI) of the patient's head depict multiple cerebral infarctions in various regions, including the basal ganglia, thalamus, occipital lobes, left temporal lobe, and pons, with concurrent presence of intracranial pneumocephalus.

CASE 2:

A 41-year female was admitted for the treatment of a vestibular schwannoma, with preoperative imaging showing a tumour measuring 3.0 × 3.3 × 2.8 cm, causing compression of the brainstem, trigeminal nerve cerebellopontine angle segment, and deformation of the fourth ventricle. To alleviate tumour-related symptoms, the decision was made to perform tumour resection *via* the retrosigmoid approach under general anaesthesia. During surgery, the large tumour size necessitated multiple manipulations near the brainstem, leading to ventricular premature beats and drops in blood pressure, which resolved upon cessation of manipulation.

The 7-hour surgery concluded uneventfully, with the patient awakening 12 minutes postoperation. Following extubation criteria confirmation by the anaesthesiologist, the endotracheal tube was removed. The patient regained muscle tone, was oriented to person and place, and exhibited no adverse neurological signs. In accordance with routine postoperative care, the patient underwent a 20-minute observation period in the operating room before being transferred for a CT scan, during which she suddenly experienced a loss of consciousness. The CT results revealed a significant amount of intracranial pneumocephalus and no significant intracranial haemorrhage (Figure 2). The surgical team decided to continue observation. However, the next afternoon, the patient's consciousness did not improve. Subsequent MRI showed multiple cerebral infarctions in various regions, including the basal ganglia, thalamus, occipital lobes, left temporal lobe, and pons, in addition to the previously noted left-sided intracranial pneumocephalus (Figure 3).

Due to the lack of neurology services, the patient was transferred to a comprehensive hospital for further management. Despite three weeks of treatment, the patient remained comatose, prompting the family to opt for discharge. At the time of discharge, the patient's consciousness had not recovered.

DISCUSSION

Pneumocephalus is a rare condition most commonly caused by traumatic head injuries or iatrogenic dural breaches during surgical interventions.[2] Some studies suggested that pneumocephalus is associated with infection, encephaloceles, and tumour progression. Furthermore, other studies indicated that, in rare cases, Valsava’s manoeuvre may also lead to pneumocephalus.[3-5] In the presented cases, one patient developed pneumocephalus following a malignant nasopharyngeal tumour resection surgery under endoscopy, which compromised the integrity of the cranial base. Two patients experienced TP due to air entering the cranial cavity during a craniotomy procedure.[3,6]

Two mechanisms have been proposed to explain the occurrence of pneumocephalus. The first mechanism is the ball valve effect, where intracranial tissue near a dural defect allows air to enter but prevents its escape.[6,7] The inverted bottle mechanism is the second mechanism to explain the development of pneumocephalus. This mechanism suggests that CSF leaked through the damaged dural, subsequently reducing pressure inside the intracranial cavity, which ultimately facilitates the entry of air from the atmosphere into the cranial cavity. If the dural defect remains unresolved, air will continue to accumulate, potentially leading to TP, which can cause mass effect and cerebral herniation.[6,8]

Pneumocephalus may present with symptoms such as confusion, dizziness, disturbances, and personality changes, though it can also remain asymptomatic.[6] Headache and changes in mental status are the primary symptoms, with even a small amount of air (less than 2 mL) within the cranial cavity capable of inducing these symptoms.[9] Diagnosis is primarily done using a non-contrast CT scan, capable of identifying even minimal intracranial air (as little as 0.5 mL) and effectively ruling out other diagnoses.[6] The characteristic CT finding of subdural air includes compression and separation of the bilateral frontal lobes, creating a heaped-up appearance resembling the silhouette of Mount Fuji, indicating that the gas pressure exceeds the surface tension of the cerebrospinal fluid between the frontal lobes.[2] In the current case reports, one patient exhibited the Mount Fuji sign and both patients presented with unilateral intracranial pneumocephalus.

In the case of TP, urgent surgical intervention is recommended to relieve ICP until further evaluation and definitive repair of the dural defect can be performed. This intervention, known as emergency trephination or burr hole craniotomy, aims to alleviate tension physiology.[7,10] Other therapeutic options include needle aspiration, drilling of burr holes, ventriculostomy, and closure of dural defects, all of which can effectively manage TP.[8] Intraoperative anaesthesia management in patients with TP should avoid nitrous oxide, hyperventilation, and high airway pressures, to avoid worsening the condition. Providing 100% oxygen can help speed up the absorption of the intracranial air.[8]

In conclusion, although TP is an uncommon condition, it remains a serious complication that can occur after cranial surgery. Any alteration in a patient's mental status following endoscopic skull base surgery or other dural-related procedures should prompt consideration of the possibility of TP. Given the risk of rapid deterioration, prompt brain imaging is critical for diagnosis, and immediate neurosurgical intervention is key to effective treatment. Early recognition and swift action are vital to prevent severe outcomes.

PATIENTS' CONSENT:

Written informed consent was obtained from all patients and/or their legal guardians for publication of the case details and accompanying images.

COMPETING INTEREST:

The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:

YW: Conceptualisation, data collection, case collection, medical history, imaging analysis, and writing of the original draft.
XS: Data collection, case collection, imaging data, writing, review, and editing.
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