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Sajag Kumar Gupta

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Five-patient case series and literature review in post-traumatic tension pneumocephalus

Sajag Kumar Gupta

UPUMS SAIFAI, INDIA

ABSTRACT

Tension pneumocephalus is a rare and potentially fatal neurological disease. To avoid deadly consequences, it demands urgent and rapid intervention. The most prevalent cause of tension pneumocephalus is a head injury. Air can enter the cranium by a fracture affecting the paranasal sinus or the middle ear cavity, or even more rarely, through a complex depressed fracture of the skull vault. Its treatment consists of a simple twist drill and aspiration of intracranial air with or without the insertion of an underwater seal. 100% oxygen should be delivered using a non-breathable mask that hastens air resorption. The authors provide a series of five examples with post-traumatic tension pneumocephalus, focusing on its treatment and review of literature.

Keywords
pneumocephalus,
post-traumatic tension,
pneumocephalus,
Mount Fuji

INTRODUCTION

Pneumocephalus is described as the presence of air in the skull cavity, which might be in the subdural or intraventricular area. Pneumocephalus can occur in 0.5% to 1.0% of head traumas (10). Air can enter the cranium by an injury involving a paranasal sinus or the middle ear space, or, more rarely, through a complex depressed fracture of the cranial vault. The most prevalent cause of pneumocephalus is head injury (10). Tension pneumocephalus is a rare and potentially fatal neurosurgery problem. Tension pneumocephalus can be caused by as little as 25 cc of air (19). It may result in increasing brain compression and worsening mental state owing to decreasing oxygen flow to the brain.

As a result, the ventricles may be displaced, tentorial herniation ensues, brainstem compression develops, and the patient may finally die (19). For the avoidance of deadly complications caused by tension pneumocephalus, immediate attention and careful therapy are necessary. In this work, we provide a series of 5 examples of post-traumatic tension pneumocephalus, highlighting its therapy and conducting a literature review.

CASE SERIES STUDIES

From August 2022 to December 2023, five patients with post-traumatic tension pneumocephalus were hospitalized at the Department of Neurosurgery.

Corresponding author:
Sajag Kumar Gupta

UPUMS SAIFAI, India

sajag.gupta@yahoo.com

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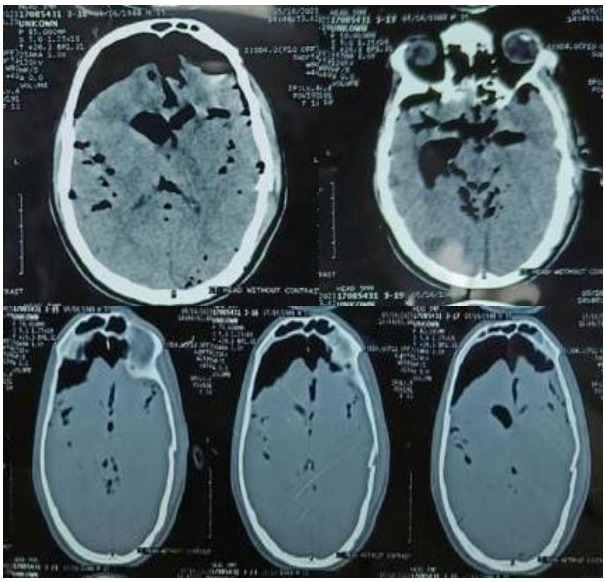
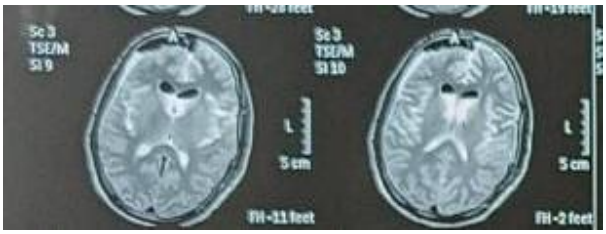
Case 1

A 30-year-old man pedestrian struck by a car reported to the emergency department with a Glasgow Coma Scale (GCS) score of 3/15 and a CT BRAIN that indicated tension pneumocephalus with pneumoventricle and subarachnoid haemorrhage. His GCS score was 3 (E1V1M1), with bilaterally dilated and non-reacting pupils. The patient was intubated, and an urgent twist drill with pneumocephalus aspiration was performed in the casualty. The patient was scheduled for surgery and dural tear repair, but his GCS score did not improve and he died. (Figure 1 a,b)



a)



b)

Figure 1. a) Pre-op Ct head of patient. b) Post-op After Twist Drill shows complete resolution of pneumocephalus.

Case 2

Following a high-speed motor vehicle collision, a 55-year-old male was taken to the Emergency department. After hitting the steering wheel, he suffered severe injuries to his midface. When he arrived to the hospital, his GCS was 12 (motor 5, verbal 4, eyes 3). The initial CT scan of the head and face revealed pneumocephalus and the typical "Mount Fuji" indication. The patient received 100% oxygen treatment. He was handled conservatively, with repeat scans after the fourth and eighth days showing a reduction in the extent of the pneumocephalus and discharged after ten days. (Figure 2)

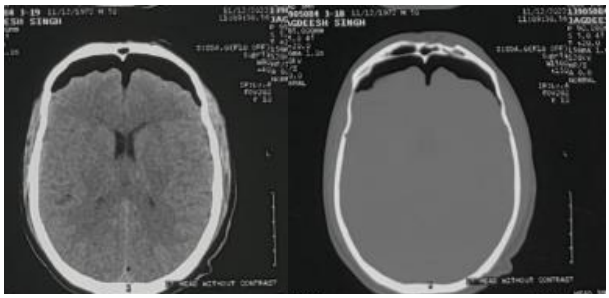


Figure 2. Preop CT head of patient shows Mount Fuji sign.

Case 3

A 35-year-old male pedestrian struck by a car arrived to the emergency department with a Glasgow Coma Scale (GCS) score of 13/15, stable vital signs, multiple face lacerations, pain over the chest wall, and abdominal wall ecchymosis. As an emergency case of tension pneumocephalus, the patient was brought to the Head Injury Intensive Care Unit (HICU). For four days, he was maintained in a flat posture with 100% oxygen supplemented via an oxygen mask. Follow-up head CT scans on the second and fourth days revealed a considerable reduction in the extent of the pneumocephalus. After 11 days, the patient was fully asymptomatic and went home in good general health. (Figure 3)

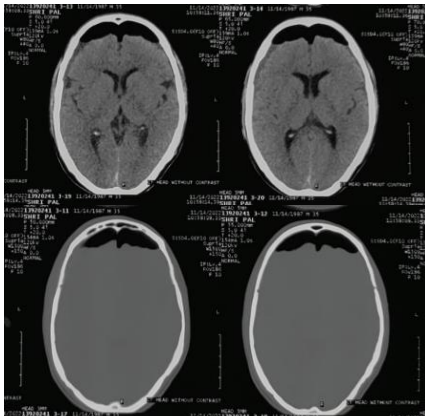


Figure 3. CT head of patient showing pneumocehalus.

Case 4

Following a pedestrian motor vehicle collision, a 30-year-old male presented with acute frontal headache and right CSF otorrhea. He briefly lost consciousness, however, his GCS at the time of arrival was 15 and he had right LMN facial nerve palsy. The vital signs remained constant. An urgent brain CT scan revealed the characteristic "Mount Fuji Sign" (Fig 3a). He was handled cautiously. On the tenth day after the incident, the rhinorrhea stopped on its own. He was released from the hospital after 13 days with clinical and radiological indications of pneumocephalus remission. (Figure 4)

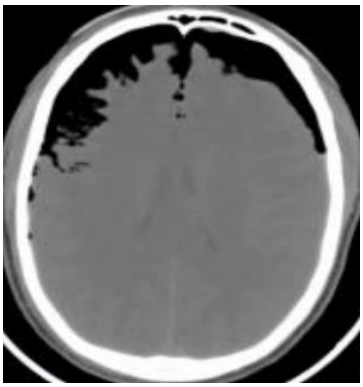


Figure 4. CT head of patient showing pneumocephalus.

Case 5

A 47-year-old male patient appeared with a history of a car accident and injuries to his face and head. He arrived 48 hours after his injury. The GCS score at the time of admission was 11 (E3V3M5). With tension pneumocephalus, a CT scan revealed a fracture of the left frontal sinus and orbital roof. In casualty, a twist drill with pneumocephalus aspiration was performed. For two days, the patient was ventilated electively. His overall health improved to a GCS score of 15 (E4V5M6), and a later CT revealed that the pneumocephalus had resolved completely. He was released from the hospital one week after the injury.

Discussion

For the mechanism of pneumocephalus, two ideas have been offered (10). Dandy proposed a "ball valve" device in which air can only flow in one direction (6). The intracranial pressure rises as air enters the cerebral cavity (10). As seen in Case 1, the pressure gradient between the environment and the intracranial space is minimized, and the osteomeningeal fistula is tamponade by brain tissue. As a result, air is trapped in the cerebral space, causing mass effect (6,10).

Horowitz (9) presented the "Inverted-soda-bottle effect" as another possibility for the development of pneumocephalus. He hypothesized that negative intracranial pressure (ICP) is caused by excessive CSF loss via an iatrogenic lumbar drain, settling into the distend able spinal subarachnoid space, or simply drainage via normal pathways with physiologic activity such as inspiration or the Valsalva man oeuvre (10). However, air can enter the intracranial space as a result of a negative pressure gradient when there is a fistulous connection between the intracranial and outside environments (10).

The most prevalent cause of pneumocephalus is head injury, and pneumocephalus occurs in 0.5 to 1.0% of head trauma (10). Tension pneumocephalus can be caused by orbital and face paranasal sinus bone fractures, gunshot damage, nasogastric tube displacement, and ambu-bag resuscitation (1, 4, 8, 14,19).

The frontal bone architecture may predispose th e patient to pneumocephalus following damage. The dura mater next to the frontal and paranasal si nuses is thin and closely linked to the frontal bone a long the olfactory nerve, and it is easily ruptured by injury, resulting in the formation of a fistulous com munication and, eventually, pneumocephalus (2, 19)

Tumours and infection of the frontal and parana sal sinuses can induce cranial pneumocephalus by e roding the dura mater and bone structures (19). Raised external pressure caused by frequent and se vere nose blowing (3), sneezing (20), coughing (18), or the Valsalva manoeuvre (13) has been linked to t ension pneumocephalus.Pneumocephalus may also be related with thoracic vertebral fractures (17). Inhaled anaesthetic drugs, such as nitrous oxide, may exacerbate tension pneumocephalus because it diffuses from the circulation into an air-filled cavity faster than it diffuses out of the cavity. The result is tension pneumocephalus (14,19).

Tension pneumocephalus can occur in any patient who has had a craniotomy. Burr holes, posterior fossa surgery (16), craniofacial surgery (5, 14, 18), transsphenoidal pituitary surgery (12), ventriculoperitoneal shunt, and lumbar drain installation can all result in pneumocephalus. Sitting during and after cranial surgery increases the incidence of pneumocephalus (13, 18-20). The "gold

standard" diagnostic method for tension pneumocephalus is computed tomography (CT). CT detects the presence of air by comparing the densities of air, fluid, tissue, and bone. CT scans are utilised to determine the amount and location of air and fluid, the presence of a defect, and the impact of trapped air on the brain (19). The Mount Fuji sign is a common CT finding in tension pneumocephalus. The air compresses the frontal lobes in this sign, resulting in a tented appearance of the brain in the skull, known as the Mount Fuji sign. This is similar to Mount Fuji in Japan, which is noted for its symmetrical cone (11).

The treatment of tension pneumocephalus is difficult. Pure oxygen should be supplied through a mask if tension pneumocephalus is diagnosed (19). It is hypothesised that 100% inspired oxygen accelerates air resorption (5, 14, 18, 22). Management is adapted to the aetiology. If a CSF leak is the source, the dural rip should be sealed by endoscopic or open surgery. If a lumbar drain is present, clamp or remove it and lay the patient supine. A seated position allows for sustained air intake via the dural defect. When tension pneumocephalus is identified, all efforts should be taken to reduce the mass effect and intracranial pressure (19). A tension pneumocephalus is a neurosurgical emergency. Twist drilling with needle and syringe aspiration or catheter drainage of air frequently results in quick patient improvement. A closed-water seal system has also been proven in one of our studies (14, 18) to be particularly successful in decompressing trapped air. In situations of chronic subdural hematoma evacuation or brain tumour excision when the brain tissue does not expand to cover the empty area, a drain should be left in place and the patient should be maintained in the supine position until the brain tissue rebounds. This lowers the chance of developing tension pneumocephalus (19, 21). Aside from intracranial air aspiration, medicinal therapy such as mannitol may be used to reduce brain oedema. This has the potential to minimize the mass effect and lower the pressure inside the skull (19).

Definitive treatment in the form of bony and/or dural defect detection and repair is required and the goal. It can be done endoscopically or with an open craniotomy. For patients with significant comorbidities who may not survive an open craniotomy, an endoscopic or extracranial technique is suggested. If the defect cannot be disclosed with the endoscope or if the prior endoscopic repair was unsuccessful (15,19), a craniotomy method may be considered. The open craniotomy method allows for better vision and access to the dura defect. In terms of defect closure, both approaches have the same success rate (7, 19). However, the intracranial method requires more operating and anaesthetic time, as well as greater morbidity and hospitalization. Our one patient improved with a simple twist drill and pneumocephalus aspiration utilizing a closed water seal system, while three others improved with basic conservative treatment. When the patient's neurological status deteriorates, tension pneumocephalus must be tapped as soon as possible using a simple water seal device. With Conservative management, one should not wait too long. A simple twist drill, with or without an underwater seal, will break the lock for trapped intracranial air, resulting in reduced mass effect and intracranial pressure, and therefore improving the overall patient condition. 100% oxygen should be provided, and as a last resort, the dural defect should be corrected if feasible

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