

# Pneumocephalus: An Uncommon Finding in Trauma

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### SUMMARY

**Pneumocephalus (Intracranial aerocele), defined as intracranial air, is an uncommon complication in head injury patients. It can present immediately following head trauma or be delayed for many days before clinical symptoms occur. We present two cases of extensive pneumocephalus after trauma. The diagnosis was made by computed tomography (CT). When pneumocephalus is suspected, CT can play a vital role in determining the precise location of the gas collection, its relationship to the basal skull fracture site or air sinuses and the amount of mass effect on the brain.**

### KEY WORDS:

*Pneumocephalus, Traumatic brain injury, Basal skull fracture*

### INTRODUCTION

Pneumocephalus, also known as (intra) cranial aerocele may exist in a variety of intracranial spaces, depending upon the underlying cause. Gas collection can occur in several compartments: extradural, subdural, subarachnoid, intraventricular (pneumoventricle), extradural and intracerebral pneumatocele<sup>1</sup>. In the past, plain radiography had an important role in making the diagnosis. Computed tomography (CT) is currently the best modality for visualizing pneumocephalus. We present two patients who were found to have extensive pneumocephalus on CT, one was on the day of admission and the other 10 days after the initial trauma.

### CASE REPORTS

#### Case 1

A 42-year-old man was admitted after he sustained injuries in a motor vehicle accident. He was under the influence of alcohol during the accident and had a short duration of loss of consciousness. There was no bleeding from the ear or nose. On examination, his Glasgow Coma Scale (GCS) was 7/15 and the vital signs were stable. He also sustained right periorbital hematoma. No other injury was found. Skull and cervical radiographs were normal on admission. CT brain showed a fluid level in the sphenoid sinus suggesting the presence of basal skull fracture. His GCS improved to 14/15 one day after the admission. He was treated for alcohol withdrawal symptoms. His condition remained unchanged for the next nine days. On post-trauma day 9, his GCS deteriorated to 10/15. A repeat CT brain was done and it showed extensive multifocal air collection in the basal

cisterns, frontal horn of the right ventricle and the subarachnoid spaces (Figure 1a & Figure 1b). No intracranial bleed was noted. There was no midline shift. As there was no clinical symptom of increased intracranial pressure or cerebrospinal fluid leak, he was treated conservatively with intravenous antibiotics. He recovered and was discharged well on post-trauma day 13.

#### Case 2

A 71-year-old man complained of drowsiness and giddiness following a fall at home when he sustained a hit on his head. There was one episode of vomiting but no loss of consciousness. Glasgow Coma Scale was full on arrival. There was watery blood stained discharge from the right nostril upon leaning forward or during straining. Brain CT (Figure 2a and 2b) revealed a massive pneumocephalus in the anterior cranial fossa as well as middle cranial fossa. Small bony defects were seen in the lateral wall of the right sphenoid sinus and left anterior cranial fossa. He was treated conservatively with bed rest and laxatives to prevent further straining leading to increased intracranial pressure. The CSF leaks resolved spontaneously and he was clinically asymptomatic following the above measures. He was discharged 8 days after admission.

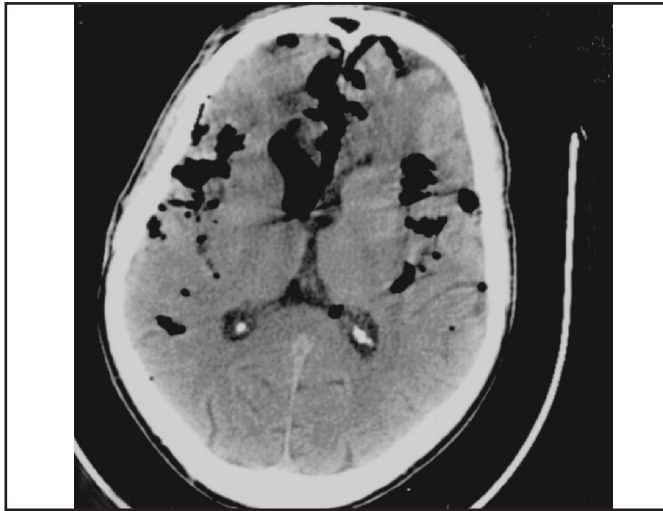
### DISCUSSION

Pneumocephalus is defined as an intracranial gas collection. It may be caused by head trauma, infection, barotrauma following scuba diving and surgery involving the sinuses, orbit, nasal passages or intracranial space<sup>1,2</sup>. Erosion from extracranial infections or tumours may also lead to pneumocephalus. Some cases are idiopathic. The majority of cases are due to either trauma (75-90%) or surgery. Only 0.5% to 1% of all episodes of head trauma result in pneumocephalus<sup>2</sup>. The presence of intracranial gas in a patient with recent head trauma is a sign suggestive of basal skull fracture.

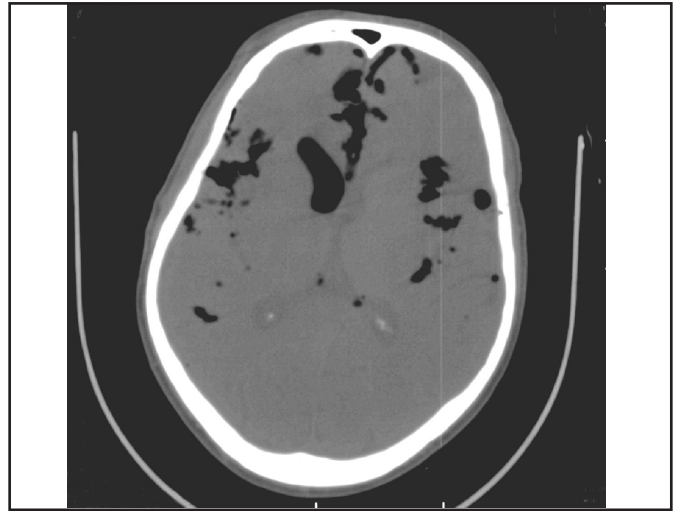
Trauma is the most common cause of epidural air collection and a frequent cause of air in the other intracranial spaces<sup>2</sup>. Air entering the epidural space as a result of basal skull fracture comes from the sinuses in the floor of the anterior or middle cranial fossa, or the orbit. If the dura is breached, air will reach the subdural space; this occurs in about 28% of cases of pneumocephalus. Tearing of the arachnoid will allow air to enter the subarachnoid space. Distinction of subdural and subarachnoid air can be difficult if the two coexist.

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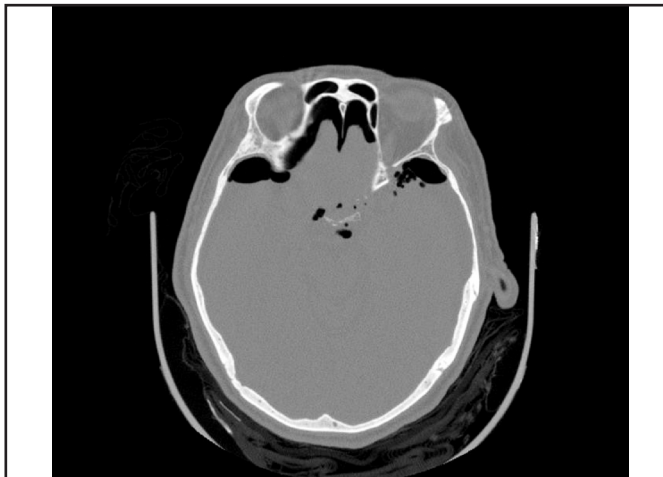
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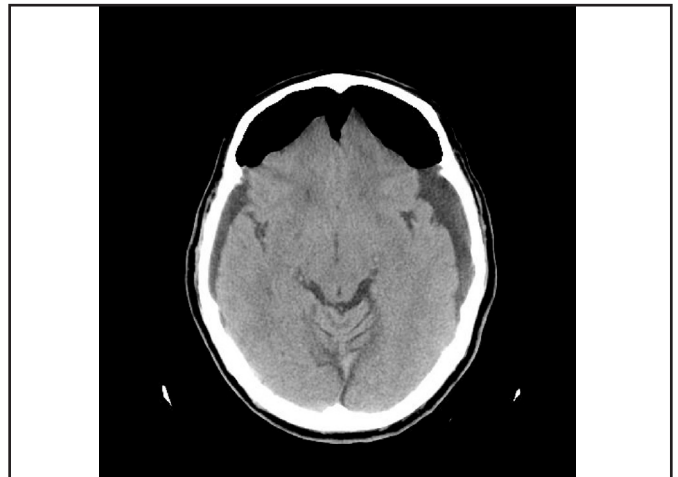
**Fig. 1a:** Axial non contrasted CT brain showing air collection in the subdural space (arrow) and the frontal horn of the lateral ventricle (white arrowhead). (WW-80HU,WL-40HU)



**Fig. 1b:** Same image from Figure 1a, but with wider window width, 1500HU and window level 500HU( bone window)



**Fig. 2a:** A CT image in the bone window(WW-1500, WL-500) shows a fracture of the posterior-medial wall of the right orbit( white arrow) with pneumocephalus in the fronto-parieto-temporal regions bilaterally.



**Fig. 2b:** Mount Fuji Sign( white arrow) with moderately large subdural collection in fronto-parieto regions.( WW-80HU, WL-40HU)

The pathophysiology of each of these types of pneumocephalus usually involves one of the following two mechanisms. It may involve a ball-valve effect, with air being forced through the area of a craniodural defect from coughing, sneezing or other sudden changes in nasopharyngeal pressure. The second mechanism may be due to excessive leak of cerebrospinal fluid (CSF) causing a slightly negative intracranial pressure. As a result, air is drawn into the cranial cavity. This has been likened to the entry of air into an inverted bottle of water as the fluid escapes. The latter is most common during neurosurgical procedures. Other mechanisms of pneumocephalus include: penetrating skull injuries (often resulting in the admission of at least a small amount of air into the cranium), intracranial infection from gas-forming organisms (e.g. Clostridia species) which may result in intracerebral gas collections. Air may also be introduced into the intracranial spaces during lumbar puncture. If enough air collects within the cranium or the

brain itself, mass effect may develop with marked midline shift. This is referred to as 'tension' pneumocephalus and may result in tonsillar herniation syndrome.

Signs and symptoms of pneumocephalus may be quite minor, but occasionally may be serious. The presenting signs and symptoms include headache, CSF rhinorrhoea or otorrhoea, seizure disorder and succussion-splash. CSF rhinorrhoea is the most common sign found in those with post-traumatic pneumocephalus as in the second patient.

Other findings in pneumocephalus may include tympany on percussion of the skull and papilloedema on fundoscopic examination. Presence of intracranial hypertension or focal parenchymal involvement may give rise to headache, confusion, subtle weakness, reflex abnormalities or frank hemiparesis<sup>3</sup>.

The diagnosis of pneumocephalus is usually established radiographically. CT has replaced plain radiography as the modality of choice for delineation of the location, extent and etiology of intracranial air. CT scan is extremely sensitive, and can identify as little as 0.5 cc of air in the intracranial spaces<sup>4</sup>. Pneumocephalus on CT scan is represented by areas of very low attenuation sometimes bordered by a white rim resulting from reconstruction artifact. Air in the epidural space appears as biconvex collection of gas not changing with movement. Subdural air tends to outline the contour of the skull and moves with a change in position of the head, although usually confined by the falx and tentorium. It may separate and compress the frontal lobes, creating a widened interhemispheric space that mimics a picture of a volcano just like Mount Fuji in Japan, hence the term *Mount Fuji sign*<sup>5</sup> which is present in the second patient. Subarachnoid pneumocephalus appears on CT as non confluent gas pockets conforming to the sulci and cisternal spaces, or in the ventricular system. Air collections within the brain (pneumatocoele) appear as round or oval intra-axial gas collections surrounded entirely by parenchyma. The presence of intracranial gas in a patient with recent head trauma is a sign indicative of basal skull fracture. Regardless of the location of the intracranial air this should alert the physician.

The therapeutic approach to traumatic pneumocephalus is similar to that for CSF fistula. The initial treatment is usually conservative, including nursing in head-up position, avoidance of maneuvers that might increase intra-sinus pressures (such as nose-blowing or valsalva maneuver) and antibiotics if there is evidence of meningism. Surgical treatment is indicated when there is recurrent pneumocephalus, or signs of increasing intracranial pressure suggesting development of tension pneumocephalus. Surgical options include direct insertion of a subdural drain connected to an underwater seal or, indirectly, with the use of a saline-primed Camino bolt.

In conclusion, patients with basal skull fracture who develop worsening of their neurological status, should have a CT scan examination to exclude development of complications like delayed pneumocephalus.

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