Posttraumatic Pneumocephalus: The Spectrum in a Tertiary Neurosurgery Center

Vinod Kumar[1] Rajesh Parameshwaran Nair[1] Ajay Hegde[1] Girish Menon R.[1]

[1] Department of Neurosurgery, KMC, Manipal University, Udupi, Karnataka, India

Address for correspondence Rajesh Parameshwaran Nair, MS, MCh, Department of Neurosurgery, KMC, Manipal University, Udupi, Karnataka 576104, India (e-mail: rajeshnair39@yahoo.com).

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Abstract

Traumatic head injuries are often encountered in the emergency triage, and usually these patients have open head injuries or traumatic pneumocephalus secondary to base of skull fractures. The first line of management involves conservative approaches that include the use of carbonic anhydrase inhibitors, loop diuretics, and, occasionally, lumbar CSF diversion techniques. Surgical intervention is considered once conservative management fails after 2 weeks of institution of conservative management. Here, we discuss the various clinical scenarios, clinical presentation, treatment dilemmas, and possible complications in patients with traumatic pneumocephalus.

Keywords
- pneumocephalus
- air bubble
- pneumoventricle
- Mount Fuji sign

Introduction

Pneumocephalus is defined as presence of air in the cranial vault. They are usually seen in posttraumatic open head injuries secondary to base of skull fractures, sinus fractures, postsurgery, and even in postmeningitic cases in lieu of gas-forming organisms. Most common presenting complaints include headache, vomiting, fever, and altered sensorium (meningitis), and in case of open head injuries, they present with cerebrospinal fluid (CSF) rhinorrhea or otorrhea. Based on the extent and line of fracture, patients may have early profuse CSF otorrhea or early lower motor neuron (LMN) type of facial palsy. Most of these patients respond to conservative management, which includes bed rest, oxygen supplementation via mask, broad-spectrum antibiotics, serial computed tomographic (CT) scans of the brain, analgesics, carbonic anhydrase inhibitors, and loop diuretics. In the absence of associated parenchymal contusions or gross pneumocephalus, CSF diversion in the form of lumbar drains is placed for 4 to 5 days with controlled drainage of CSF. Surgery is contemplated only in extensive facial bone fractures or profuse CSF leak despite conservative management or in cases of meningitis, once the infection settles. Fulminant meningitis is almost always fatal and a dreaded complication in open head injuries.

Case 1

A 36-year-old man presented to our triage with the history of a motor vehicle accident (MVA). The accident had occurred 12 hours prior to presentation, and there was no history of loss of consciousness, vomiting, or seizures. He had minimal nasal bleed with no evidence of CSF rhinorrhea.

On general examination, the patient was fully conscious and alert with a Glasgow coma scale (GCS) of 15. His pupils were equal and reacting briskly to light. He had no cranial nerve or motor deficits. Preliminary hematologic investigations were unremarkable. CT scan of the brain showed tension pneumocephalus with "Mount Fuji" sign and pneumoventricle in the left frontal horn (►**Fig. 1a**). The bone window showed a fracture of the frontal bone involving the inner table at the left lateral edge of the frontal sinus and fracture of planum sphenoidale and floor of anterior cranial fossa. There were no associated intracranial contusions or hematomas. The patient was admitted to the intensive care unit (ICU) and managed conservatively with antiepileptics and analgesics. Continuous oxygen supplementation was provided at 6 L/min for the next 48 hours. He was nursed flat in bed and did not develop any CSF leak during his period of hospital stay. The follow-up CT of the brain (►**Fig. 1b**) was done 48 hours after admission, which

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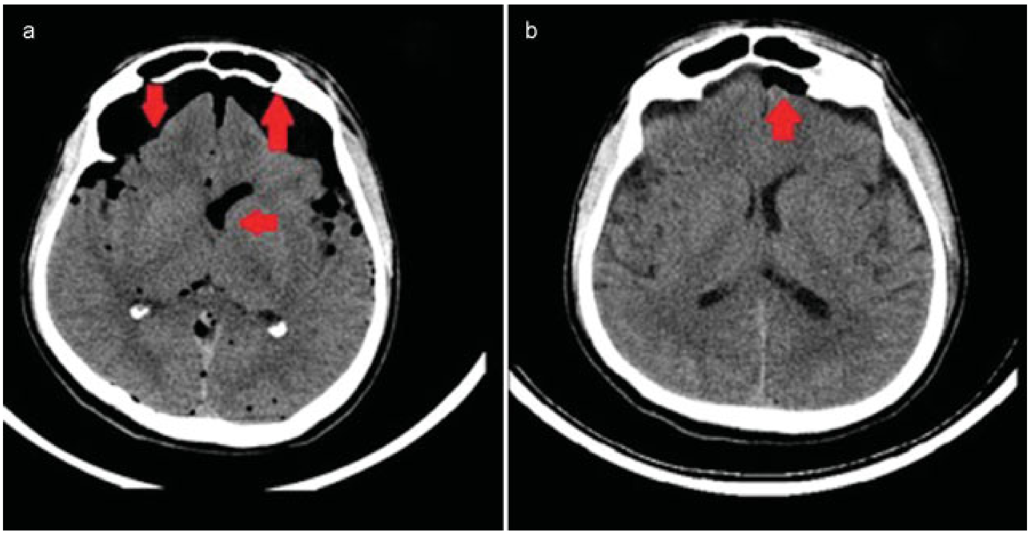

Fig. 1 Plain CT scan of the brain, axial cuts, with breach in the inner table of the frontal sinus with gross pneumocephalus and “Mount Fuji” sign depicted with red arrows and left frontal horn pneumoventricle with sylvian air and air bubbles (a). Repeat follow-up CT of the brain showing gross reduction in the pneumocephalus with only residual small pneumo behind the left frontal bone overlying the convexity—depicted with a red arrow (b).

showed gross resolution of ventricular air with minimal pneumocephalus behind the left frontal bone.

Case 2

Our second patient was a 30-year-old man who presented with an alleged history of MVA followed by loss of consciousness for 15 minutes. The patient was taken to a primary health center where he was intubated and referred to a tertiary care hospital. On initial assessment of the patient in the triage, he was fully conscious and vitals were stable. He was opening eyes to call and obeying simple commands (E3VTM6). Pupils were bilaterally equal and reacting well to light. He had bilateral nasal bleed with left ear; however, there was no evidence of CSF leak. He had no obvious cranial nerve deficits and was hemodynamically stable.

CT of the brain on admission showed massive pneumocephalus with air in all the subarachnoid spaces and basal cisterns (►**Fig. 2a, b**). Right frontal pneumoventricle was also noted with extensive base of skull fractures involving the greater wing of the sphenoid on the right side with petroclival diastasis and associated fracture of the junction of sphenoid and clivus with fracture extending into the sphenoid sinus (►**Fig. 2c, d**).

The patient was sedated and ventilated for 24 hours; however, he developed left-sided CSF otorrhea. We managed the CSF leak successfully with a lumbar drain placement and

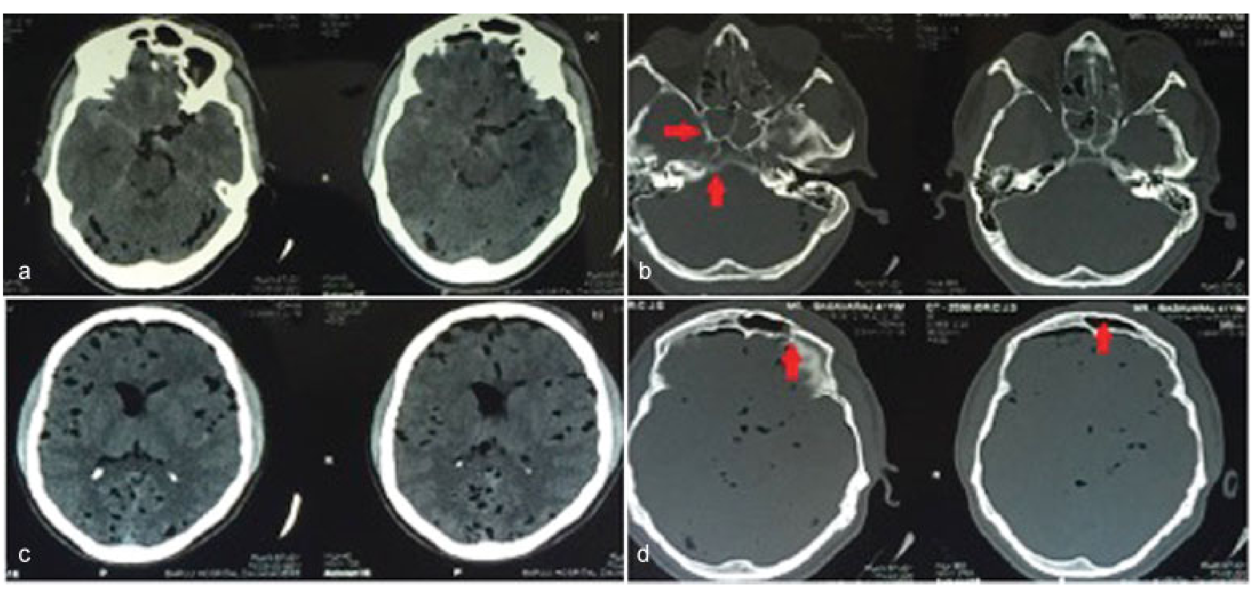

Fig. 2 Plain CT scan, axial cuts, showing pneumo in the basal cisterns with subarachnoid hemorrhage (a, c) with planum sphenoidal and frontal sinus fracture depicted in the bone window (b, d).

Fig. 3 Plain CT of the brain, axial cuts, with left MCA territory infarct depicted as hypodensity noted with a curved red arrow.

guarded drainage over the next 4 days. After extubation, oxygen supplementation was continued with a facemask. Repeat CT scan showed complete resolution of the pneumocephalus and pneumoventricle. The air in the basal cisterns had now been replaced with subarachnoid hemorrhage.

On the fourth day post admission, the patient developed concomitant bacterial and fungal meningitis, which was treated with sensitive antibiotics. He deteriorated neurologically, despite appropriate antibiotics, and was reintubated and ventilated. Repeat CT scan showed an MCA infarct (►**Fig. 3**). Decompressive craniectomy was done in view of raised intracranial pressure (ICP) with midline shift and ipsilateral pupillary asymmetry. Postoperatively the patient made a transient neurologic improvement before his succumbed to meningitis 17 days post-op.

Case 3

The third clinical vignette was that of a 28-year-old man who met with an MVA and presented to us with posttraumatic amnesia. The patient had nasal bleed with no evidence of CSF rhinorrhea. On neurologic examination, he was fully conscious with an intact GCS, right nasal bleed, and left eye relative afferent pupillary defect (RAPD). CT of the brain, at the time of admission, showed diffuse pneumocephalus along the frontal convexities, intraparenchymal and in the basal cisterns with pneumoventricle in the right frontal horn of the lateral ventricle. Bone window showed frontal sinus fracture with hemosinus. Gross cerebral edema was present (►**Fig. 4**).

The patient remained asymptomatic following admission, and a follow-up CT of the brain was done on day 2, which showed complete resolution of the pneumocephalus along all convexities, Pneumoventricle persisted in the right temporal horn, with significant cerebral edema. Minimal CSF leak was present on day 5 of admission. He, later, went on to develop headache with low-grade fever; however, there was no neck rigidity. A guarded lumbar puncture was done, and the patient was started on higher antibiotics in view of meningitis. He showed neurologic improvement with antibiotics, which was given for a period of 15 days. He was discharged in a well-preserved state after 2 weeks of parenteral antibiotics.

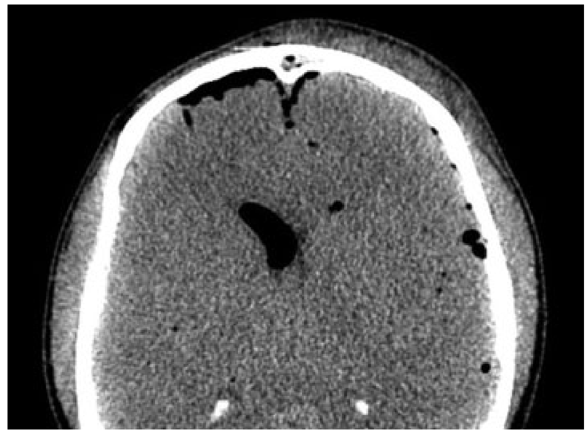

Fig. 4 Plain CT of the brain, axial cuts, with gross edema and right frontal pneumoventricle and diffuse pneumo with right frontal pneumocephalus.

Discussion

The first reported case of traumatic pneumoventricle was diagnosed and treated by Luckett in 1913.[1] Pneumocephalus refers to the presence of air within the cranial vault. It may be intra- or extra-axial. Extra-axial may be epidural, subdural, or subarachnoid, and intra-axial includes parenchymal, intraventricular, and intravascular. Intraventricular air is most commonly associated with a high risk of meningitis, fulminant, often fatal, intracranial sepsis.[2] The most common cause of pneumocephalus remains trauma followed by surgery, barotrauma,[3] and infections from gas-forming organisms.[4]

Many theories have been postulated; however, two theories are most commonly used to explain the development of pneumocephalus. The first one is the “ball-valve” mechanism that describes a unidirectional air movement from the outside into the cranial cavity that then gets trapped. This was described by Dandy.[5] The second one is the “inverted soda-bottle” theory in which excessive CSF drainage or loss results in negative ICP, followed by accumulation of air in the cranial cavity due to a vacuum effect thus created, as proposed by Horowitz.[6]

Trauma is the most common cause of pneumocephalus accounting for 60 to 70% of all cases.[7] The three cases of pneumocephalus, presented in this series, were traumatic in etiology and were primarily due to skull base, frontal bone, or sinus fractures. Both the aforementioned theories can explain the cause for pneumocephalus in our series. Often these patients present with clinical features that include headache, vomiting, and CSF leak—rhinorrhea or otorrhea. CT scan is the diagnostic modality of choice, with an ability to detect as little as 0.5 cm^3 of air. A diagnostic feature on CT scan is the “Mount Fuji” sign, described by a group of Japanese neurosurgeons in which the two frontal poles are surrounded and separated by air. This was positive in one of our cases.[7] This sign is due to extra-axial mass effect with subsequent compression of the frontal lobes, *sine qua non* of tension pneumocephalus. The other characteristic findings on CT scan include the presence of multiple small air bubbles scattered throughout the cisterns ("air bubble sign"),[8] which was present in all three cases.

Pneumoventricle is a rare occurrence in posttraumatic pneumocephalus. It involves breach of the cisterns and entry of air into the ventricular system. The most common association with pneumocephalus is CSF leak and meningitis.

Tension pneumocephalus is a neurosurgical emergency and needs prompt surgical evacuation, especially in case of neurologic deterioration of the patient. None of our patients, however, required surgery. The prognosis is largely related to the type of injury and the number of air bubbles, or pockets, but it has been shown that pneumocephalus with multiple air bubbles is prognostically unfavorable, regardless of the mechanism of injury.[9]

Conservative measures allow 85% of small meningeal tears to seal within 1 week.[10] All our cases were initially managed conservatively, though one patient required decompressive craniectomy for a concomitant MCA territory infarct. Conservative management includes the patient being nursed flat in bed with oxygen supplementation via mask, broad-spectrum antibiotics to prevent meningitis, and analgesics. We routinely did a follow-up repeat scan 48 hours after admission to look for the resolution of pneumocephalus. One patient had CSF rhinorrhea and the other had CSF otorrhea, and both of these patients developed meningitis. One patient developed bacterial and fungal meningitis followed by an MCA infarct. A salvage decompressive craniectomy was performed; however, the patient developed multiple territory patchy infarcts and succumbed to his condition 2 weeks after surgery.

Conclusion

Posttraumatic pneumocephalus is a common entity often encountered in practice, and it requires prompt diagnosis and pertinent treatment for prevention of lethal fulminant meningitis. Surgery is contemplated in patients with extensive facial bone fractures or with frank large defects and persistent CSF leak. Conservative management is usually successful and is often the first line of treatment.

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