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CME Article

Clinics in diagnostic imaging (119)

Venkatesh S K, Bhargava V

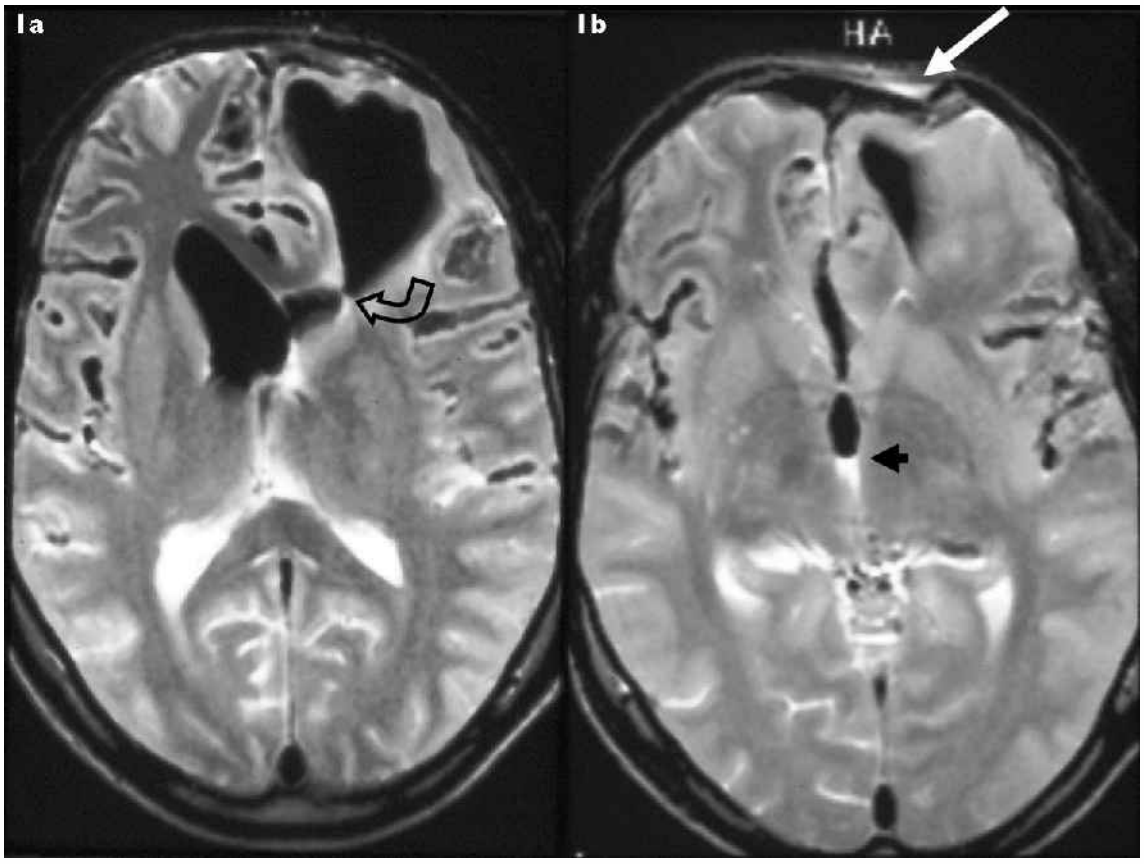

Fig. 1 Axial T2-weighted images of the brain taken at the level of the (a) frontal horns, and (b) third ventricle.

Department of Diagnostic Radiology, National University Hospital, 5 Lower Kent Ridge Road, Singapore 119074

Venkatesh SK, MBBS, MD, FRCR
Assistant Professor

Department of Neurosurgery, Bhopal Memorial Hospital and Research Centre, Karond Chowk, Bhopal, India

Bhargava V, MBBS, MS, MCh
Consultant

Correspondence to:
Dr Sudhakar K Venkatesh
Tel: (65) 6772 2248
Fax: (65) 6779 0190
Email: dnrskv@nus.edu.sg

CASE PRESENTATION

A 36-year-old man presented with headache, restlessness and clear fluid rhinorrhoea of three days duration. He suffered a head injury in a road traffic accident three weeks ago and was hospitalised. Computed tomography (CT) of the head showed a left frontal lobe contusion and depressed fracture of the left frontal bone. He refused surgery for reduction of the fracture and was therefore conservatively managed. He was discharged four days later with no neurological deficits and received nursing care at home. During this admission, he was irritable and mildly febrile. He had no neurological deficits. CT images were unavailable for review. Magnetic resonance (MR) imaging of the brain was performed. What do the MR images in Fig. 1 show? What is the diagnosis?

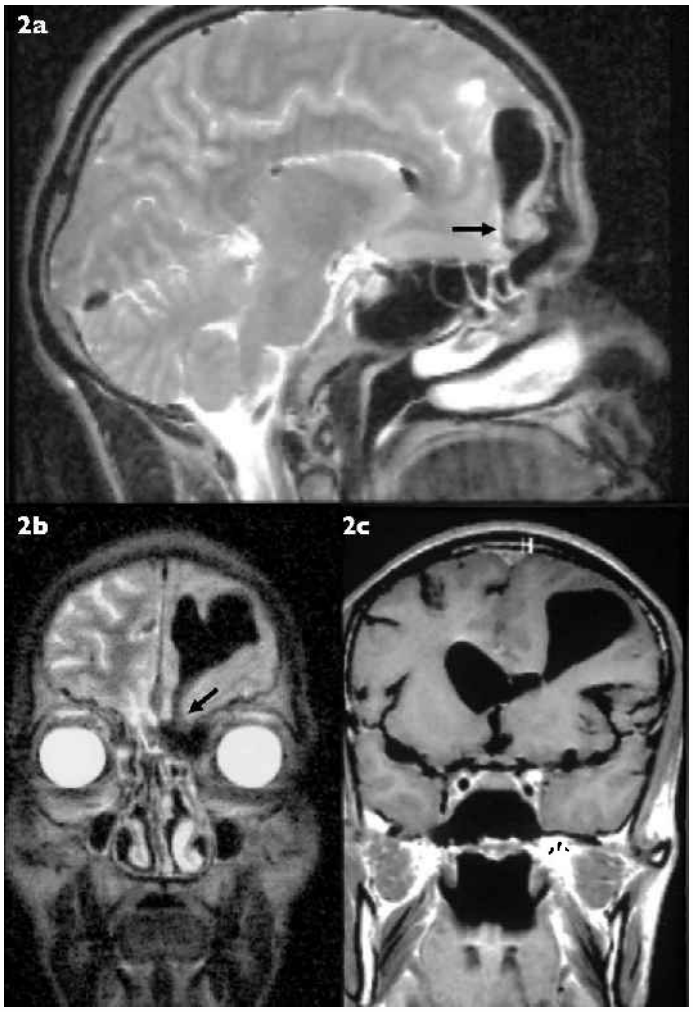

Fig. 2 (a) Sagittal and (b) coronal T2-weighted images show the communication of the pneumatocele to the left frontal sinus (arrows). (c) Contrast-enhanced coronal T1-weighted image shows no significant enhancement of the pneumatocele.

Fig. 3 Contrast-enhanced CT image shows rim-enhancing confluent abscesses in the right parietal lobe with small pockets of gas within the brain abscess.

IMAGE INTERPRETATION

An intraparenchymal air-filled cavity is seen in the left frontal lobe and communicating with the frontal horn of left lateral ventricle (curved arrow). Depressed fracture of the left frontal bone (white arrow) and an air-fluid level in the third ventricle (black arrowhead) are seen in the more caudal image. Pockets of free gas in the subarachnoid space outlining the sulci in the non-dependent areas are noted (Fig. 1). These findings were confirmed on sagittal and coronal MR images (Fig. 2).

DIAGNOSIS

Post-traumatic intracerebral pneumatocele.

CLINICAL COURSE

On the same day of admission, the patient underwent left frontal craniotomy. An air-filled cavity was found in the left frontal lobe which appeared contused.

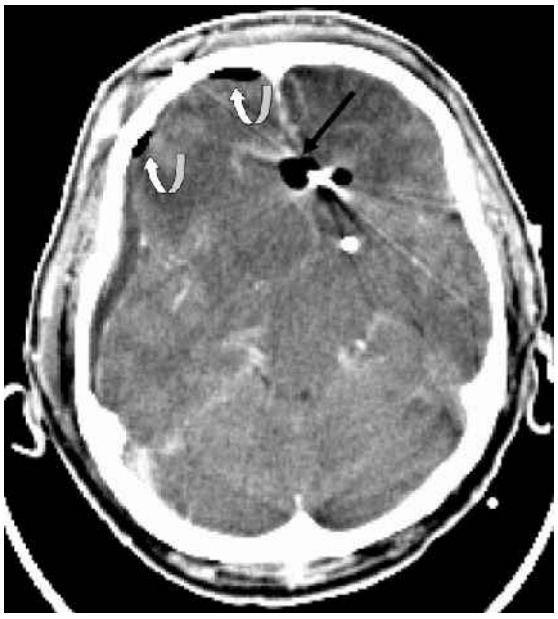

Fig. 4 Contrast-enhanced CT image shows pockets of gas at the operated area (black arrow) and in the subarachnoid space in the right frontal region (curved arrows), in a postoperative case of surgical clipping of an aneurysm.

The cavity communicated with the left frontal sinus through a 4 mm defect in the dura mater. No pus was found. Decompression of the pneumatocele and repair of the dura defect were performed. The left frontal bone fracture was reduced. He made excellent postoperative recovery with resolution of symptoms. Cultures of cerebrospinal fluid (CSF) were negative for any growth. CT done on the fifth postoperative day showed resolution of the pneumatocele, and the patient was discharged with no neurological deficits. The patient was asymptomatic at the last follow-up two years after surgery.

DISCUSSION

Intracerebral pneumatocele or aerocele is a well-delineated gas collection within the brain substance.[1] Pneumatoceles may result from head trauma, infection (Fig. 3) and surgery (Figs. 4 & 5) involving the skull base, erosion from skull base tumours, radiotherapy, and is rarely spontaneous.[2-7] Intracerebral pneumatoceles can be classified, based on their location, as frontal, occipital, or petrosal.[8] Frontal pneumatoceles are the commonest and their pathogenesis is well understood.[1,9] The higher incidence of frontal pneumatoceles is due to close opposition of the meningeal layers to the cranium and brain, while the widened subarachnoid space over the posterior ethmoid and sphenoid sinuses separates the brain from the sinus, and fractures in these regions usually lead to rhinorrhoea.

Traumatic pneumatocele occurs when a defect from fracture, erosion or surgery transgresses the pia and arachnoid mater in the same region as the dura mater. Air is forced under pressure into the brain when

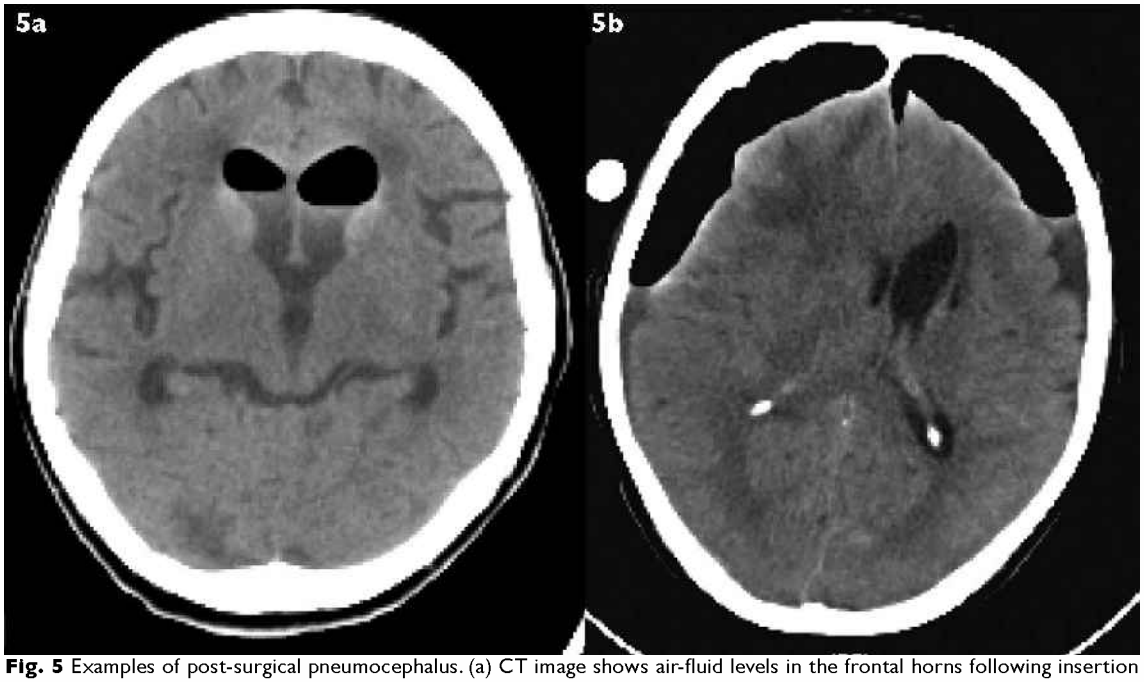

Fig. 5 Examples of post-surgical pneumocephalus. (a) CT image shows air-fluid levels in the frontal horns following insertion of an intraventricular shunt. (b) In another case, CT image shows air in the subarachnoid space in the bilateral frontal regions, following craniotomy for evacuation of a right frontal haematoma.

high pressure well beyond the intracranial pressure is generated in the sinuses by coughing, straining and sneezing.[1,2] Air can get trapped in the brain by a check valve mechanism by fragments of bone, dural flap, foreign bodies, sinus mucosa and granulation tissue, and a simple collapsible fistulous track can also behave as a valve.[1,9] Air is toxic to neurons, causing further damage to the already-compromised parenchyma, and this leads to cerebral oedema surrounding the air and evolves into encephalomalacia. The cycle is repeated, giving rise to larger air collection. Additionally, the whole process is aided by expansion of air at body temperature and ease of dissection of air along the white matter tracts.[8]

Clinically, patients present with findings of raised intracranial pressure, such as irritability, headaches, restlessness, delirium and coma. Personality changes, psycho-organic changes, aphasia, seizures, rhinorrhoea, hemiparesis and hemiplegia have also been reported.[3,10] CSF rhinorrhoea is the most common clinical sign in these patients.[2] The pneumatocele may enlarge till it produces mass effect or expansion of the cavity into a ventricular system, giving rise to rhinorrhoea,[2] and usually by that time there is increased intracranial pressure. Intermittent rhinorrhoea can be accompanied by gas entry audible to patients as "water gurgling in a bottle" or a "shaking coconut" sound.[8] Late presentation is more common and is due to the initial track occlusion by soft tissue swelling, preventing air entry.

On imaging, a pneumatocele is usually rounded or oval in configuration, measuring on average 3–4 cm in diameter[11,12] and surrounded by brain parenchyma. It is usually found in a location abutting the frontoethmoid sinuses, and a funnel may be visualised connecting the cavity to the sinus. The cavity may have air-fluid level when it communicates with the ventricular system. CT is the study tool of choice for confirming the diagnosis of intracranial pneumocephalus.[13] Gas appears hypodense on CT and appears hypointense on both T1-weighted and T2-weighted MR images. MR imaging, with its advantage of multiplanar imaging, may potentially demonstrate the fistulous track, as was demonstrated in our case. Although not as sensitive as CT for the detection of a small amount of gas, MR imaging can still demonstrate small pockets of intracranial gas. MR imaging is also more sensitive for demonstration of small focal or mild post-traumatic parenchymal injuries, as compared to CT. An important differential diagnosis is an abscess containing gas-producing bacteria, in which mottled gas collection is usually seen and an enhancing rim may be seen with contrast administration. The clinical history under such circumstances should be of help in differentiating the two. The potential complications include tension pneumocephalus, infection of the cavity, and possibly meningitis. When the cavity expands, causing mass effect and midline shift, it is termed tension pneumocephalus, and urgent decompression is necessary.[2,3]

Treatment of intracerebral pneumatocele is to correct an obvious defect, if one exists, and always to repair tension pneumocephalus. Conservative measures allow 85% of small meningeal tears to seal within a week.[14] Methods to facilitate healing of the dural defect include keeping the head elevated, avoiding increased intracranial pressure, and prophylactic antibiotics to prevent meningitis. Consideration should be given to the use of anticonvulsants. Cessation of previous rhinorrhoea is not a sure sign that the tear has sealed and that pneumocephalus cannot recur. Although most meningeal tears heal spontaneously, some do not and for such cases, surgical repair is necessary.[15] In conclusion, we have described a case of post-traumatic intracerebral pneumatocele and its MR imaging appearances. It is important to recognise pneumatoceles on imaging, as surgical management is indicated in most of the cases.

ABSTRACT

A 36-year-old man presented with cerebrospinal fluid rhinorrhoea after head injury in a road traffic accident three weeks prior to presentation. Magnetic resonance (MR) imaging demonstrated a hypointense cavity in the left frontal lobe communicating with the frontal horn of the left lateral ventricle, consistent with an intracerebral pneumatocele. The fistulous track communicating with the frontal sinus was demonstrated on the sagittal and coronal images. The patient underwent surgical decompression of the cavity and repair of the dural defect and fracture of the frontal bone. Postoperatively, the patient made excellent recovery. An intracerebral pneumatocele should be recognised on MR imaging, as potential complications include tension pneumocephalus and meningitis, and surgical treatment is indicated in most of the cases.

Keywords: cerebrospinal fluid rhinorrhoea, intracerebral pneumatocele, magnetic resonance imaging, post trauma

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REFERENCES

1. Bhimani S, Virapongse C, Sabshin JK, Sarwar M, Paterson RH Jr. Intracerebral pneumatoceles: CT findings. Radiology 1985; 154:111-4.
2. Mendelsohn D, Hertzanu Y. Intracerebral pneumatoceles following facial trauma: CT findings. Radiology 1985; 154:115-8.
3. Orebaugh SL, Margolis JH. Post-traumatic intracerebral pneumatocele: case report. J Trauma 1990; 30:1577-80.
4. Betz H, Prager P. Spontaneous pneumatocele during radiation of a giant meningosarcoma. Neuroradiology 1981; 22:159-61.
5. Johnson D, Tan L. Intraparenchymal tension pneumatocele complicating frontal sinus osteoma: case report. Neurosurgery 2002; 50:878-9.
6. Añorbe E, Aisa P, Saenz de Ormijana J. Spontaneous pneumatocele and pneumocephalus associated with mastoid hyperpneumatization. Eur J Radiol 2000; 36:158-60.
7. Markham JW. The clinical features of pneumocephalus based upon a survey of 284 cases with report of 11 additional cases. Acta Neurochir (Wien) 1967; 16:1-78.
8. Courville CB. Traumatic intracranial aerocele. Bull Los Angeles Neurol Soc 1943; 8:97-117.
9. Dandy WE. Pneumocephalus (intracranial pneumatocele or aerocele). Arch Surg 1926; 12:949-82.
10. Jelsma F, Moore DF. Cranial aerocele. Am J Surg 1954; 87:437- 51.
11. Eaglesham DC. Radiological aspects of intracranial pneumocephalus. Br J Radiol 1945; 18:335-43.
12. Taveras JM, Wood EH. Diagnostic Neuroradiology. 2nd ed. Baltimore: Williams and Wilkins Publishers, 1977: 1060-1.
13. McIntosh BC, Strugar J, Narayan D. Traumatic frontal bone fracture resulting in intracerebral pneumocephalus. J Craniofac Surg 2005; 16:461-3.
14. Goldmann RW. Pneumocephalus as a consequence of barotrauma. JAMA 1986; 255:3154-6.
15. Mincy JE. Posttraumatic cerebrospinal fluid fistula of the frontal fossa. J Trauma 1966; 6:618-22.

SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
Multiple Choice Questions (Code SMJ 2007011A)

	True	False
Question 1. Regarding intracerebral pneumatoceles:		
(a) Most commonly, they occur secondary to trauma or surgery involving the skull base.	☐	☐
(b) Traumatic pneumatoceles result when a defect from a fracture transgresses dura mater, but the pia and arachnoid mater are intact.	☐	☐
(c) Higher incidence of pneumatoceles in the frontal region is due to close opposition of meningeal layers to the skull base and brain.	☐	☐
(d) Patients with intracerebral pneumatoceles may give a history of audible "water gurgling in a bottle" with changes in posture.	☐	☐
Question 2. Regarding intracerebral pneumatoceles:		
(a) Pneumatoceles form when air gets trapped in the brain by a check-valve mechanism.	☐	☐
(b) The expansion of pneumatocele is aided by expansion of air at body temperature.	☐	☐
(c) Most of the patients with pneumatoceles present very early.	☐	☐
(d) The most common clinical sign is CSF rhinorrhoea.	☐	☐
Question 3. Regarding intracerebral pneumatoceles:		
(a) The most important potential complication of pneumatocele is haemorrhage.	☐	☐
(b) The most important differential diagnosis is a brain abscess.	☐	☐
(c) During conservative management of intracerebral pneumatoceles, cessation of rhinorrhoea is a reassuring sign that the meningeal tear has sealed and pneumocephalus will not recur.	☐	☐
(d) Tension pneumocephalus, a complication of pneumatocele, is managed conservatively.	☐	☐
Question 4. Regarding imaging appearances of gas in the brain:		
(a) Hypodense on CT.	☐	☐
(b) Hyperintense on T2-weighted MR images.	☐	☐
(c) Hypointense on T1-weighted MR images.	☐	☐
(d) Intracranial free gas is usually seen in non-dependent parts.	☐	☐
Question 5. The following features may be seen with CT/MR imaging in a case of intracerebral pneumatocele:		
(a) Air-fluid levels in ventricles.	☐	☐
(b) Small pockets of free gas elsewhere in the cranium.	☐	☐
(c) A fistulous track connecting the cavity to a paranasal sinus.	☐	☐
(d) Thick enhancing rim of the pneumatocele in the post-contrast images.	☐	☐

Doctor's particulars:

Name in full: _____

MCR number: _____ Specialty: _____

Email address: _____

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(1) Log on at the SMJ website: **www.sma.org.sg/cme/smj** and select the appropriate set of questions. (2) Select your answers and provide your name, email address and MCR number. Click on "Submit answers" to submit.

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(1) Answers will be published in the SMJ January 2008 issue. (2) The MCR numbers of successful candidates will be posted online at **www.sma.org.sg/cme/smj** by 15 January 2008. (3) All online submissions will receive an automatic email acknowledgment. (4) Passing mark is 60%. No mark will be deducted for incorrect answers. (5) The SMJ editorial office will submit the list of successful candidates to the Singapore Medical Council.

Deadline for submission: (November 2007 SMJ 3B CME programme): 12 noon, 25 December 2007