Intracerebral pneumatocele presenting after air travel

Raman C. Mahabir, M.D., M.Sc., Artur Szymczak, B.Sc., and Garnette R. Sutherland, M.D., F.R.C.S.(C)

Department Neurosurgery, The University of Calgary and the Foothills Medical Centre, Calgary, Alberta, Canada

In this report the authors discuss a patient who experienced symptoms of an acute right frontal, intraparenchymal pneumatocele while on an airplane descending to an international airport. This rare complication of an ethmoid sinus osteoma that eroded upward through the dura mater is described along with a literature review. A persistent headache and inappropriate behavior consistent with a frontal lobe syndrome brought the patient to clinical and imaging evaluation, which revealed a large right frontal lobe pneumatocele and an associated ethmoid sinus osteoma extending upward into the frontal lobe. Through a right frontal craniotomy, the air cavity was evacuated, the osteoma partially excised, and the dural defect closed using a vascularized pericranial flap. Postoperatively, the patient made an unremarkable recovery. For patients with air sinus osteomas extending into the cranial cavity, air travel or other barotrauma may result in a life-threatening tension pneumatocele.

Key Words • air travel • cerebrum • parenchymal lesion • pneumatocoele • osteoma

Osteomas are common and appear in approximately 0.25% of all routine sinus radiographs. They usually arise at the junction of the ethmoid and frontal bones and grow very slowly within the sinus cavity. Pneumocephalus was first reported as a complication of osteoma of the paranasal sinuses by Cushing3 in 1927. The literature is now replete with cases of air within a dura-based cavity; however, there is only one previous documented case of intraparenchymal air. In that case, an osteoma breached the dura mater but the cause of the introduction of air was unclear.

In the present report we discuss the acute development of a right frontal intraparenchymal pneumatocele in a passenger on an airplane descending to an international airport.

Case Report

History. This 68-year-old man presented to the emergency department complaining of headache, confusion, nausea, and vomiting. He had noted the onset of symptoms as a passenger on an airplane descending to Heathrow Airport. The patient described the sudden onset of a severe pan-cranial headache. Attributing the symptoms to his first air travel experience or a flulike illness, the patient boarded a transatlantic flight. His symptoms progressed to a more severe headache as well as nausea with four episodes of vomiting in flight. Again ascribing the symptoms to air travel or flu, he did not seek medical attention for another 2 days. During this time, his family noted increasingly strange behavior such as forgetfulness, wearing his shirt backward, and making statements out of keeping with his character and personality.

The patient recalled experiencing “terrible” headaches approximately 30 years ago. These headaches were non-thalamic, had a frequency of three to four per year, and were relieved by acetylsalicylic acid and sleep. The headaches ceased more than 10 years prior to his present problem.

Examination. The patient’s recent medical history was not significant. His only medication was hydrochlorothiazide for hypertension. At the physical examination the man was drowsy, although oriented to time, place, and person. He had no cranial nerve or extremity deficit.

Computerized tomography scans of the brain revealed a large air collection (5.6 × 5.5 × 6.5 cm) in the right anterior frontal lobe, which caused a significant mass effect. A calcified mass in the ethmoid sinus was also visualized (Figs. 1 and 2). The diagnosis of pneumatocele secondary to osteoma of the ethmoid sinus was established. To define the lesion and dural defect more clearly, MR images were obtained. On both T1- and T2-weighted images the mass in the ethmoid sinus appeared hypointense with evidence of calcification. The midline was shifted by 1.3 cm (Fig. 3).

Operation. Surgical treatment consisted of a bicoronal scalp incision with dissection to isolate a vascularized periosseal flap. A right frontal craniotomy allowed an extradural exposure of the osteoma and dural defect. The osteoma was resected completely from the intracranial compartment and partially from the ethmoid sinus. The pia arachnoid, which was adherent to the osteoma, was dissected off the bone by performing a microsurgical procedure. The defect in the dura mater was repaired using periosteum, which was not reinforced by laying the vascularized pericranial flap along the floor of the right anterior cranial fossa.

Postoperative Course. Two days after the operation CT scanning revealed partial reexpansion of the right frontal lobe (Fig. 4). There were no postoperative complications and the patient’s symptoms resolved. He was discharged from the hospital on the 2nd postoperative day. In a follow-up telephone interview, the patient stated that he had returned safely home with no recurrence of symptoms during air travel. At the 6-month follow-up MR imaging session reexpansion of the right frontal lobe demonstrated.

Brain imaging provides the ability to detect as little as 0.5 cm3 of air. Air has an extremely low attenuation coefficient (1000 HU) and, therefore, appears as a region of very low density that is surrounded by a white rim. The hyperintensity peripheral to the air collection is consistent with ischemia. Brain imaging provided the best demonstration of the pneumatocele (Fig. 3). The pneumatocele was best visualized on a coronal T2-weighted image. The midline was shifted 1.3 cm (Fig. 3).

Brain imaging provided the best demonstration of the pneumatocele. The pneumatocele was best visualized on a coronal T2-weighted image. The midline was shifted 1.3 cm (Fig. 3).

Abbreviations used in this paper: CT = computerized tomography; MR = magnetic resonance.
Intracerebral intraparenchymal pneumatocele

Reexpansion of the frontal lobe was found with only focal encephalomalacia persisting (Fig. 5).

Discussion

Brain imaging provides the ability to detect as little as 0.5 cm³ of air. Air has an extremely low attenuation coefficient (≈1000 HU) and therefore, appears as a region of very low density that is surrounded by a white rim. The presence of air in the cranial cavity can be attributed to a gamut of causes, including traumatic, neoplastic, infectious, iatrogenic, and spontaneous origins. Aside from surgery, trauma is the most common cause, with 7 to 9% of patients with head injury demonstrating intracranial air. Isolated pneumocephalus most often clinically presents as florid agitation delirium, decreased level of consciousness, and frontal lobe syndrome, with the exception of spontaneous pneumocephalus in which symptoms are most often mild.

Pneumocephalus generally develops because there is a discontinuity of the skull base through which air enters the cranial cavity. In the absence of gas-forming organisms, two mechanisms have been proposed to rationalize this. The first requires a cerebral spinal fluid leak. The resultant development of a relatively negative intracranial pressure can create a sufficient vacuum to introduce air into the cranium. This mechanism will cause air to be distributed along the cisterna and leptomeningeal space. The second mechanism, and the likely basis in our case, consists of a valve mechanism. In the presence of positive endotympanic pressure...

J. Neurosurg. / Volume 101 / August, 2004

FIG. 1. Preoperative nonenhanced coronal CT scans revealing a large air collection in the right anterior frontal lobe that is associated with ventricle compression, a midline shift, and subfalcine herniation. The osteoma is apparent (center and right).

FIG. 2. Preoperative nonenhanced axial CT scans further clarifying that the air is intraparenchymal and the osteoma extends upward from the ethmoid sinus into the frontal lobe.

FIG. 3. Axial T₁-weighted (left), T₂-weighted (center), and fluid-attenuated inversion-recovery (right) MR images demonstrating a hypointense mass in the ethmoid sinus as well as an air collection measuring 6.7 × 4.8 × 6.3 cm in the right frontal lobe. There is a significant midline shift and the hyperintensity peripheral to the air collection is consistent with ischemia.
sures (example nasal blowing, coughing, sneezing, or a Val- 
salva maneuver), air can be forced from pneumatic cavities 
to the endocranium. When the endocranial pressure exceeds 
the pressure in the pneumatic cavity, the valve will close, 
preventing egress of the entrained air. This air will normal-
ly be distributed in the extradural space. In our case, pre-
operative imaging and intraoperative findings confirmed the 
presence of intraparenchymal air. An osteoid osteoma had 
eroded through the anterior cranial fossa and dura mater. We 
propose that this event occurred years before presenta-
tion. The patient’s history of episodic severe headaches 
may have been associated with pneumocephalus and in-
flammation. At the time of surgery, adhesions were evident 
among the osteoma, dura mater, and arachnoid. Therefore, 
the pneumatocele may have been preexisting and acutely 
exacerbated by the barotrauma. The arachnoid adhesions 
likely prevented the air from entering the subdural com-
partment. The patient’s history of episodic severe headaches 
may have been associated with pneumocephalus and in-
flammation. At the time of surgery, adhesions were evident 
among the osteoma, dura mater, and arachnoid. Therefore, 
the pneumatocele may have been preexisting and acutely 
exacerbated by the barotrauma. The arachnoid adhesions 
likely prevented the air from entering the subdural com-
partment. Two previous cases of air travel (barotrauma)–induced 
spontaneous pneumocephalus have been documented in the 
literature. In both cases, the air was confined to the sub-
dural compartment. Neither of these cases was associated 
with a neoplasm.

Prompt decompression of intracranial air is the initial 
treatment of symptomatic pneumocephalus. The principles of 
subsequent treatment parallel those for a cerebrospinal 
fluid leak with meningitis. It is of fundamental importance 
to identify the communication to the pneumatic cavity, if 
present, and seal it, thereby decreasing the possibility of re-

currence.10

Conclusions

This is a rare complication of osteoma eroding into the 
cranial vault. For patients with air sinus osteomas extending 
into the cranial cavity, air travel or other barotrauma may re-

Fig. 5. Six-month follow-up axial T1-weighted (left) and T2-
weighted (right) images demonstrating resolution of the pneu-
matocoele and reexpansion of the frontal lobe. Focal encephalomalacia is 
noted in the right anterior frontal lobe.

References

1. Canavan L, Osborn RE: Dural sinus air without head trauma 
or surgery: CT demonstration. J Comput Assist Tomogr 15: 
526–527, 1991
pneumocephalus in an elderly patient. Age Ageing 29:365–367, 
2000
3. Cushing H: Experiences with orbito-ethmoidal osteomata having 
intracranial complications, with report of 4 cases. Surg Gynecol 
Obstet 44:721–742, 1927
4. Johnson D, Tan L: Intraparenchymal tension pneumatocele com-

Fig. 4. Postoperative nonenhanced axial CT scans demonstrating partial reexpansion of the right frontal lobe and a 
crease in the midline shift. Air now extends into the subdural compartment.

10. Wu CT, Lee ST: Delayed spontaneous tension pneumocephalus 
of acute traumatic intracranial pneumocephalus. A retrospective 
9. Vallejo LA, Gil-Carcedo LM, Borras JM, et al: Spontaneous pneu-
mocephalus of an otogenic origin. Otolaryngol Head Neck Surg 
121:662–665, 1999
8. Siegel W, Hackel H: Prognosis, incidence and management of 
acute traumatic intracranial pneumocephalus. A retrospective 
6. Osborn AG, Daines JH, Wing SD, et al: Intracranial air on com-
5. Markham JW: The clinical features of pneumocephalus based up-
on a survey of 284 cases with report of 11 additional cases. Acta 
Neurochir 16:1–78, 1967
4. Johnson D, Tan L: Intraparenchymal tension pneumatocele comp-
licating frontal sinus osteoma: case report. Neurosurgery 50: 
878–880, 2002
3. Cushing H: Experiences with orbito-ethmoidal osteomata having 
intracranial complications, with report of 4 cases. Surg Gynecol 
Obstet 44:721–742, 1927
pneumocephalus in an elderly patient. Age Ageing 29:365–367, 
2000
1. Canavan L, Osborn RE: Dural sinus air without head trauma 
or surgery: CT demonstration. J Comput Assist Tomogr 15: 
526–527, 1991

Conclusions

This is a rare complication of osteoma eroding into the 
cranial vault. For patients with air sinus osteomas extending 
into the cranial cavity, air travel or other barotrauma may re-

Fig. 5. Six-month follow-up axial T1-weighted (left) and T2-
weighted (right) images demonstrating resolution of the pneu-
matocoele and reexpansion of the frontal lobe. Focal encephalomalacia is 
noted in the right anterior frontal lobe.

References

1. Canavan L, Osborn RE: Dural sinus air without head trauma 
or surgery: CT demonstration. J Comput Assist Tomogr 15: 
526–527, 1991
pneumocephalus in an elderly patient. Age Ageing 29:365–367, 
2000
3. Cushing H: Experiences with orbito-ethmoidal osteomata having 
intracranial complications, with report of 4 cases. Surg Gynecol 
Obstet 44:721–742, 1927
4. Johnson D, Tan L: Intraparenchymal tension pneumatocele comp-
licating frontal sinus osteoma: case report. Neurosurgery 50: 
878–880, 2002
5. Markham JW: The clinical features of pneumocephalus based up-
on a survey of 284 cases with report of 11 additional cases. Acta 
Neurochir 16:1–78, 1967
6. Osborn AG, Daines JH, Wing SD, et al: Intracranial air on com-
8. Siegel W, Hackel H: Prognosis, incidence and management of 
acute traumatic intracranial pneumocephalus. A retrospective 
9. Vallejo LA, Gil-Carcedo LM, Borras JM, et al: Spontaneous pneu-
mocephalus of an otogenic origin. Otolaryngol Head Neck Surg 
121:662–665, 1999
10. Wu CT, Lee ST: Delayed spontaneous tension pneumocephalus 
cased by radon exposure of the skull base. Br J Neurosurg 13: 
214–216, 1999

Manuscript received September 16, 2003. 
Accepted in final form April 2, 2004. 
Address reprint requests to: Raman C. Mahabir, M.D., De-
partment of Surgery, Foothills Medical Centre, 1403 29th Street 
N.W, Calgary, Alberta, T2N 2T9, Canada. email: raman_chaos@ 
hotmail.com.

S

cveral recent reports regarding a unique syndrome 
characterized by the following features have appeared in 
the neurological journals: a combination of invol-
untary movement. This 43-year-old man presented to our hospital with mild 
left hemiparesis that had appeared 2 weeks previously 
and was then referred to us from the Department of Internal 
Medicine because of a suspected intracerebral hematoma 
and an uncontrolled blood glucose level had not been checked prior to admis-
S

cellaneous recent reports regarding a unique syndrome 
characterized by the following features have appeared in 
the neurological journals: a combination of invol-
untary movement. This 43-year-old man presented to our hospital with mild 
left hemiparesis that had appeared 2 weeks previously 
and was then referred to us from the Department of Internal 
Medicine because of a suspected intracerebral hematoma 
and an uncontrolled blood glucose level had not been checked prior to admis-

Abbreviations used in this paper: 
CT = computerized tomography; DW = diffusion-weighted; Hb = hemoglobin; MR = magnetic 
resonance.

J. Neurosurg. / Volume 101 / August, 2004