A chest radiogram showed a mild left subhilar infiltrate. Amylase transferase levels were mildly elevated, and a PPD skin test was negative. Treatment was changed to clarithromycin (250 mg b.i.d.), and 3 days later, his temperature decreased. Antibiotic therapy was continued for 10 days. Serology for \textit{Coxiella burnetii} phase II antigen (microimmunofluorescence) showed an increase of the IgG titer from <1 : 100 to 1 : 1600 and a biphasic pattern for the IgM titer (<1 : 100 to 1 : 800 and then 1 : 200). Serological tests for \textit{Mycoplasma pneumoniae}, \textit{Chlamydia pneumoniae}, \textit{Chlamydia psittaci}, \textit{Leptospira}, enterovirus, respiratory syncytial virus, adenovirus, influenza A and B viruses, hantavirus, Rift Valley fever virus, Sindbis virus, chikungunya virus, dengue virus, West Nile virus, and \textit{Legionella} urinary antigen were all negative. Because his cough and fatigue continued, doxycycline therapy was initiated for 10 days.

At his second visit, the index patient mentioned that a 32-year-old female employee had pneumonia unresponsive to cefuroxime axetil. A common source outbreak was suspected, and an inquiry was instituted. Q fever serology for the woman was strongly positive for IgM and IgG antibodies to \textit{C. burnetii} phase II antigen (titers of 1 : 2000 for both antibodies). Serologies for other agents of atypical pneumonia were negative. She was treated with doxycycline for 2 weeks, and her fever resolved rapidly.

The travel itinerary included a stop at the Masai Mara reserve. The 2 sick patients denied drinking unpasteurized milk. As far as they could recall, the only place that they had visited together was a tribal shack in the game reserve that was 2 × 3 m in size, made of cattle hides and straw, and covered with mud and/or manure. Inside the shack, the group observed 2 goats and a burning oven. Both patients recalled inhaling noxious fumes during that short visit and feeling sick the next day.

Because 4 other people entered the shack, a case-control investigation was carried out. Blood samples were obtained from all 6 people who entered the shack and from 17 travelers who visited other shacks. Some of the 17 travelers indicated that they had peeked into this particular shack. Serology revealed an additional asymptomatic case in those people who entered the shack and 1 asymptomatic case in those who did not enter the shack, but this patient admitted to having peeped into the shack. Entering the shack thus constituted a significant risk factor for contracting Q fever (RR, 8.5; \( P = .04 \), two-tailed Fisher’s exact test). After departing Kenya, none of the 3 travelers who entered the shack and were asymptomatic, nor the 17 who entered other shacks, became ill during a 6-week follow-up period.

Our investigation found that 4 (8%) of 50 safari travelers to Kenya contracted Q fever; 2 travelers developed overt infection, whereas 2 others developed asymptomatic illness. Information about the prevalence of \textit{C. burnetii} in Africa is scant [3, 4]. To our knowledge, this is the first report of an outbreak of Q fever acquired on this continent. The prevalence of antibodies to \textit{C. burnetii} among various ethnic populations in Kenya has ranged from 10% to 20% [5, 6]. \textit{C. burnetii} is transmitted to humans mainly via airborne dust. It is therefore conceivable that this cluster of cases occurred during exposure at the Masai shack. Either the shack or the 2 goats could have served as a source for transmission; furthermore, entrance to the shack was significantly associated with disease, which attests to the respiratory mode of transmission.

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**References**


**Pneumocephalus Due to Invasive Fungal Sinusitis**

Pneumocephalus is an accumulation of intracranial air that occurs when there is a connection between the intracranial space and the extracranial space. Rarely, tension pneumocephalus develops—an accumulation of air through a one-way valve that causes dramatic neurological deterioration. Two proposed mechanisms are a ball-valve effect—where air is pulled into the intracranial space during coughing, swallowing, or straining—and an inverted-bottle effect—where excessive leakage of CSF leads to negative intracranial pressure and replacement of fluid with air [1]. We present a unique case of pneumocephalus secondary to a fungal infection.

A 77-year-old man with a history of steroid-dependent autoimmune hemolytic anemia and myelodysplastic syndrome was admitted to the hospital with a 1-day history of altered mental status. He was somnolent and withdrew only from painful stimuli. His vital signs were stable except for a respiratory...
Figure 1.  

A. Head CT scan of a patient with pneumocephalus secondary to invasive fungal infection at time of admission. Marked pneumocephalus surrounds frontal lobes anteriorly. 

B. Smear of purulent material from patient’s frontal sinus that shows fungal hyphae (Paragon stain; original magnification, ×1000).
rate of 33. Physical examination demonstrated CSF rhinorrhea. There were no signs of head trauma.

The WBC count was 22,400/μL, hematocrit was 15.6%, and platelet count was 26,000/μL. A head CT scan revealed marked pneumocephalus surrounding the frontal lobes (figure 1A). There was no intracranial hemorrhage, mass lesion, or fracture.

The patient’s neurological status deteriorated, and he developed aspiration pneumonia. The family requested comfort care, and the patient subsequently died.

An autopsy confirmed massive pneumocephalus with compressive narrowing of the anterior cerebral. Destruction of the inner wall of the right frontal sinus by extensive fungal osteomyelitis allowed air to enter the cranium. The fungus was not grown in culture because of an inadequate specimen, but microscopic examination of purulent material from the frontal sinus showed septate hyphae of uniform width with dichotomous branches at 45° angles (figure 1B), findings consistent with *Aspergillus* species.

In 1967 Markham [1] evaluated 295 cases of pneumocephalus that dated back to 1884. The most common cause of pneumocephalus was trauma (74% of cases), followed by neoplasm (13%). Infection accounted for 9% of cases, and surgery accounted only for 4%; however, invasive neurosurgery is more common today. Three of the infectious cases resulted from sinusitis, whereas most of the infectious cases were due to chronic otitis media. Further review of the literature revealed several other cases related to otitis media [2] and a few due to meningitis caused by gas-forming bacteria [3]. To our knowledge, no cases of pneumocephalus secondary to invasive fungal infections have been reported.

*Aspergillus* is the most common cause of fungal sinusitis [4]. Other etiologies include *Fusarium* species, *Bipolaris* species, *Curvularia lunata*, *Pseudallescheria boydii*, *Rhizopus arrhizus*, *Cunninghamamella bertholletiae*, and several other sporadically identified fungi [5]. Invasive sinus aspergillosis occurs predominantly in immunocompromised patients but can occur in immunocompetent hosts [6]. Invasion into the brain is a well-documented complication of fungal sinusitis [7]. Although not previously documented, this complication may create a bone defect that sets the stage for the development of pneumocephalus.

The diagnosis of invasive fungal disease is difficult and requires histopathologic examination that demonstrates the characteristic hyphae. Invasive aspergillosis is very difficult to treat, even with amphotericin B and surgical intervention. The mortality rate associated with this condition is >50%, and is even higher when there is intracranial involvement [4, 7].

In conclusion, pneumocephalus is uncommon and is usually seen after head trauma or surgery. We present a unique case in which a frontal sinus infection, probably due to *Aspergillus* species, led to symptomatic or tension pneumocephalus. Although uncommon, infectious etiologies including fungal disease should be considered when pneumocephalus is discovered, especially in immunocompromised patients.

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