

Clinical Record

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Air flight barotrauma and meningitis: causality seems real

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Abstract

Background. Barotrauma to the middle-ear cavity and paranasal sinuses is a relatively common flight-related health problem. Occasionally, it may result in severe mechanical or infectious intracranial complications; these have been rarely reported to date.

Objective. Four cases of acute bacterial meningitis following air travel are presented, and its pathogenesis is briefly described.

Conclusion. Neurological symptoms occurring after air flight should prompt proper investigation. Otitis media and sinusitis are common primary focuses of bacterial meningitis. Severe complications of air flight barotrauma may be underreported.

Introduction

Barotrauma to the middle-ear cavity and paranasal sinuses is a relatively common flight-related health problem. Infection subsequent to barotrauma results in otitis media and sinusitis, which can represent a primary focus of acute bacterial meningitis.

The infectious diseases department at the Hospital Na Bulovce in Prague is a tertiary centre providing medical care to infectious diseases patients, including central nervous system infections. In the period 2007–2018, we treated 278 episodes of acute bacterial meningitis. Four patients suffered from acute bacterial meningitis shortly after they travelled by flight. Their meningitis could be a direct consequence of flight barotrauma.

Case reports

Case one

A 67-year-old female from Mongolia arrived by flight in Prague, Czech Republic, in May 2007. She had high blood pressure controlled by captopril, and intermittent dyspepsia. Three days after arrival, she developed mental alteration and meningism.

Cerebrospinal fluid (CSF) analysis confirmed acute bacterial meningitis, with a polymorphonuclear count of 220 cells/mm³, protein level of 4.7 g/l and glucose CSF/blood ratio of 0.04; in addition, cultures were positive for *Streptococcus pneumoniae*.

Within a day, the patient became comatose. Computed tomography (CT) scanning of the head showed signs of brain oedema but no other pathology. Multiple organ dysfunctions further advanced the disease course. Despite complex intensive care, the patient died 5 days after admission.

Case two

A 78-year-old male from Australia arrived by flight in Prague in June 2011. His chronic co-morbidities included high blood pressure, bronchial asthma and prostatic hypertrophy, all controlled by medication. A day after arrival, he became disorientated, unable to walk, febrile, complained of headache and vomited. His Glasgow Coma Scale score was 8 on admission, with meningism.

A CSF test confirmed acute bacterial meningitis, with a polymorphonuclear count of 460 cells/mm³, protein level of 3.1 g/l and glucose ratio of 0.49. Both CSF and blood cultures were negative, as were the CSF polymerase chain reaction findings. Head CT demonstrated brain oedema and hypophyseal macroadenoma, with bone defects of the sellar bottom.

The disease course was complicated by seizures, acute renal insufficiency and polyneuromyopathy. With complex intensive care, the patient regained consciousness and was weaned from the ventilator. He started physiotherapy, and after 35 days he was repatriated to his home country.

Case three

A 38-year-old female from the UK arrived by flight in Prague in September 2011. In childhood, she had suffered from acute leukaemia, cured by bone marrow transplantation.

At the time of admission, she was being treated for high blood pressure, hypercholesterolaemia and mild bronchial asthma.

Seven years previously, she had suffered from meningitis due to *S pneumoniae*, with transient nasal CSF leakage during the episode of meningitis. No pathological intracranial communication had been diagnosed, and she had experienced no further leakage until two weeks prior to the current symptoms when she again noticed intermittent nasal discharge.

Two days after arrival, the patient became disorientated, with meningism and headache. Her Glasgow Coma Scale score was 12 on admission. Head CT showed no pathology. A CSF test confirmed acute bacterial meningitis, with a polymorphonuclear count of 11 300 cells/mm³, protein level of 5.5 g/l and glucose ratio of 0.02. Culture and polymerase chain reaction findings were positive for *S pneumoniae*. The disease course was favourable and she was discharged after two weeks.

Case four

A 61-year-old female from Australia arrived in Italy in August 2018. She was treated for high blood pressure and hypercholesterolaemia. In 2007 and 2014, she had undergone transnasal surgery of hypophysis because of a Rathke's cyst. Two days after arrival, she had complained of headache and cough. Oral cefuroxime and corticosteroids were prescribed for bronchitis, with some relief. A week later, she was admitted to the hospital in Prague for headache, fever and malaise.

Head CT findings were negative. Ceftriaxone was started because of high C-reactive protein levels and leucocytosis. Within a day, the patient became comatose, with a Glasgow Coma Scale score of 8, left-sided hemiparesis and meningism. A CSF test confirmed acute bacterial meningitis, with a polymorphonuclear count of 3616 cells/mm³, protein level of 4.5 g/l and glucose ratio of 0.11. Cultures were negative, but polymerase chain reaction findings for *S pneumoniae* were positive. A follow-up CT did not reveal any bone defect. Beta trace protein was not detected in the nasal discharge.

The disease course was complicated by cerebritis and abscess formation, and hemiparesis. With complex intensive care, the patient regained consciousness and was weaned from the ventilator. She started physiotherapy, and after 27 days she was repatriated to her home country.

Discussion

The pathophysiology of barotrauma can be explained by Boyle's law, which states that the volume of a gas varies inversely with its pressure. Normal atmospheric pressure is 760 mmHg. The commercial airline cabin air pressure is maintained at around 560 mmHg. The changing pressure and volume of gas in the middle-ear cavity equilibrates with the cabin air through the Eustachian tube and in the paranasal sinuses through the sinus ostium. During ascent, the atmospheric pressure decreases, and air in the cavity expands and escapes. During descent, the air pressure increases, and gas volume in the cavity decreases and air flows into the cavity. When the air passage is blocked because of obstruction, it may result in barotrauma.¹

The Eustachian tube can be obstructed with mucosal oedema caused by rhinopharyngitis or hypertrophic adenoid vegetation. Otic barotrauma is reported to occur mainly during descent, when the ball-valve effect does not let air pass

into the middle ear. Negative pressure in the cavity causes pain and mucosal oedema, and rarely tympanic membrane or round window membrane perforation.^{2,3} Oedema and sterile exudation causes serous otitis media called aerotitis or barotitis. Its symptoms are otalgia, tinnitus, vertigo and hearing loss. A study by Stangerup *et al.* found otoscopic signs of barotitis in 10 per cent of the adults and in 22 per cent of the children.⁴ The subsequent infection may cause acute or chronic bacterial otitis, which can lead to severe sequelae such as mastoiditis and meningitis.

Sinus barotrauma, also called aerosinusitis or barosinusitis, is less common, but tends to be more severe. It can occur during ascent or descent. The sinus ostium can be blocked by oedema, exudate, polyp, tumour, trauma and so on, intranasally or intrasinusly. The overpressure in the sinus during ascent results in mucosal oedema and rupture. The air and fluid content can dissect into surrounding tissues and dehiscences. This may lead to subcutaneous or orbital emphysema, pneumocephalus, meningitis, and trigeminal nerve dysfunction.¹ The negative intrasinus pressure during descent causes oedema and serous exudation; in severe cases, it can also result in mucosal bleeding, avulsion of the mucosa from the bone and submucosal haematoma.^{1,5} A superimposed infection may lead to bacterial sinusitis, which can be a primary focus of meningitis.

Direct extension of bacteria, per continuitatem, from the primary infectious focus in the middle ear, mastoid cells or paranasal sinuses, is one of two of the most common pathogenetic mechanisms of acute bacterial meningitis. In the majority of such cases, this is due to *S pneumoniae*; in contrast, meningitis originating from haematogenous seeding to the meninges is mostly caused by *Neisseria meningitidis*. Penetration of bacteria from the middle ear and sinuses to the intracranial space can be facilitated by preformed paths like bone defects and dural dehiscences. The air pressure changes during flight can further support the extension of infection.

- Ear or sinus barotrauma associated with air flight is relatively common
- Severe mechanical or infectious intracranial complications of barotrauma are rare
- Neurological symptoms following air flight should prompt proper investigation
- Otitis media and sinusitis are common primary focuses of bacterial meningitis
- Severe complications of air flight barotrauma may be underreported

In the literature, we found only four reported cases of acute bacterial meningitis that were likely to have resulted from air travel barotrauma. These were: a patient with spontaneous pneumocephalus and meningitis with a post-traumatic bone defect in the sphenoid sinus,⁶ a patient with bilateral subdural empyema and meningitis,⁷ and two patients with meningitis following air flight soon after vestibular schwannoma surgery.⁸

In our case series, despite no primary focus of infection determined by imaging or otorhinolaryngological findings, this diagnosis must be suspected. In three of the cases, the pathological communication between a sinus and intracranial space was either diagnosed or highly suspected based on a history of CSF leakage and hypophysis surgery.

Conclusion

Many people travelling by aeroplane likely suffer from ear or sinus barotrauma that is mild and resolves spontaneously. In a minority of cases, barotrauma can lead to severe mechanical or infectious intracranial complications. Therefore, headache and other neurological symptoms occurring after air travel should be taken seriously. It can be assumed that air travel associated meningitis and other intracranial complications are not so scarce, despite being rarely reported.

Competing interests. None declared

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