Pneumocephalus and Neurosurgery in Rotary Aircrew

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BACKGROUND: Pneumocephalus secondary to trauma or tumors can have varied symptom severity. It is important to recognize and quantify pneumocephalus for medical evacuation and treatment. This case presents current recommendations for travel in the literature and how they are applicable in returning to flying duties after neurosurgical interventions.

CASE REPORT: This is the case of a Naval aircrew member who developed an osteoma and subsequently periorbital emphysema and pneumocephalus. This required medical evacuation from a remote territory, a team surgical approach, and later testing to allow him to return to flight duties in rotary aircraft.

DISCUSSION: A search of the literature did not reveal any previous cases of civilian or military flight crew having returned to flying duties after pneumocephalus or neurosurgery. Barometric chamber testing was performed post-operatively to provide clearance. Literature review revealed mixed advice on when one can safely fly commercially after neurosurgery and may be applicable in a case series of medical evacuation or future clearance in returning to flight duties.

KEYWORDS: flight, dura, osteoma, Navy, helicopter, aircrew, pilot.

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Pneumocephalus rarely presents separate from trauma or surgery; however, there are numerous case reports of it occurring in association with osteomas, involving penetration of the sinuses and intracranial invasion. In our review we were only able to find one previous case report of a sneeze resulting in the combination of pneumocephalus and orbital emphysema, but no reported cases associated with an osteoma diagnosis as the source. In addition, we could find no cases with any flight crew returning to flying status after a cerebrospinal fluid leak (CSF) or pneumocephalus involving either trauma or neurosurgery.

Osteomas are relatively common, with an incidence of 0.4 to 1% and 3% on plain radiographs and sinus CT scans, respectively. They are the most common primary skull neoplasm and are benign growths; however, their extension in paranasal locations can cause potentially life-threatening orbital or intracranial complications.[3,5] The requirement for intervention, however, is rare, as only 5% of identified osteomas proceed to surgical intervention. Intradural extension is a rare complication and, when needed, dural repairs are usually completed with pericranium (fascia lata, galea), autologous muscle, or bone grafts, and human fibrin glues to prevent sinus and cranial communication.[5]

Pneumocephalus and aberrant connections from osteomas can lead to a broad range of complications, ranging from cellulitis and meningitis to herniation and death. A current literature search revealed varied recommendations against air travel following a diagnosis of pneumocephalus.[1,7,10] In this case, we are presenting a U.S. Naval aircrew member diagnosed with an osteoma and his subsequent course involving periorbital emphysema, pneumocephalus, and a CSF leak. He required commercial air transport to specialty care and has since successfully returned to an aviation career in rotary aircraft after simple testing to confirm tolerance of barometric pressure changes.

CASE REPORT

A 21-yr-old U.S. Naval rotary aircrew member presented with immediate onset of periorbital emphysema after blowing his nose. The patient also reported mild headache and a sensation of "water running down the back of my head" during rapid position changes in physical training. Physical exam revealed significant left ptosis, swelling, and crepitus involving the orbit without erythema (**Fig. 1**). Neurological exam was normal and extraocular movements were intact.

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Fig. 1. Patient presentation with left sided ptosis and periorbital emphysema. Photo by AWS2 Conrad Hass, HSC-25 Guam.

The patient had no history of trauma or sinus surgery, but had a history of seasonal allergic rhinitis. Subsequent CT scan revealed a 1.5 × 1.5 × 2.3 cm ethmoid osteoma and intracranial air (**Fig. 2**). The patient was evacuated by commercial air from a U.S. island territory to Naval Medical Center San Diego for a combined otolaryngology, neurosurgery, and ophthalmology intervention. The waiver authority was contacted at this time.

The resection was completed endoscopically via nasal and transcaruncular approach and occurred 3 wk after presentation. The tumor communicated with the orbit and frontal sinus, and intracranial invasion lead to a CSF leak requiring a multistaged repair. The repair consisted of a septal bone graft and biological polymers to obtain a seal. A septoplasty was also performed as a means to harvest graft material and to repair pre-existing septal deviation. At 2 mo postoperatively, a repeat functional endoscopic sinus surgery (FESS) was performed due to scarring. A short commercial flight at 4 wk and a transpacific flight at 12 wk after surgery were made without difficulty.

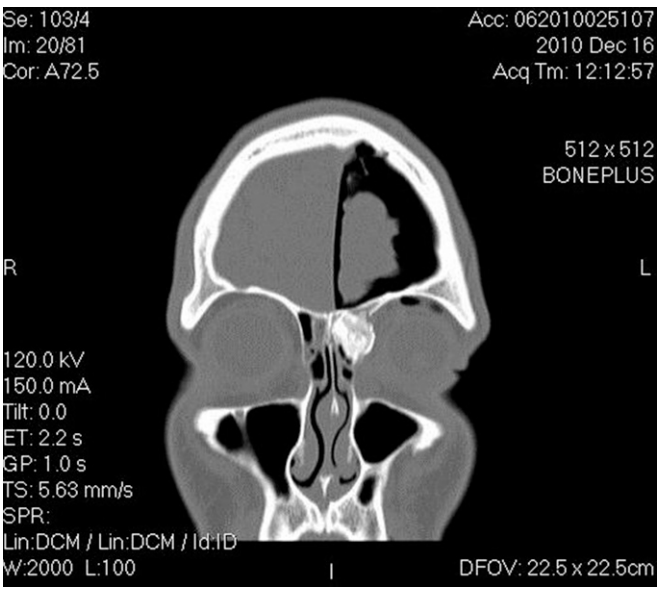

Fig. 2. Patient's computed tomography revealing pneumocephalus, periorbital air, and ethmoid osteoma. Naval Hospital Guam Radiology.

The patient had interval follow-up and was granted return to "Full Duty" status by all specialties at 6 mo. The additional evaluation to return to special duty and flying status included hypobaric testing. The patient remained asymptomatic after multiple "flights" up to a maximum of 18,000 ft (5486 m) performed in the hypobaric chamber. He was returned to flying duties with a verbal clearance from the waiver authority and a local Board of Flight Surgeons at 8 mo, and the waiver was officially complete 1 yr from presentation. To date the patient has suffered no sequelae while in performance of duties in the rotary community. He has flown a total of 540 h since the operation and been forward deployed both on ship and land. He has made more than 20 excursions to greater than 10,000 ft (3048 m) in an unpressurized cabin since returning to flying duties.

DISCUSSION

We were unable to locate any prior work reporting a neurosurgical patient returning to flying status following osteoma-related pneumocephalus. A literature search revealed only one case report of a commercial pilot returning to flying status after a cochlear implant. In that case, there was no disruption of the skull or dura. In a similar case, close follow-up of a pilot with a vestibular schwannoma was maintained until the pilot was grounded after becoming symptomatic.[6]

The primary concern for patients with any penetration of the skull is for the potential expansion of trapped air with the changing pressures associated with air travel. The current recommendations result in a widely varied standard and are based on rare case reports as well as anecdotal theories. Recommendations include labeling the diagnosis as an "absolute contraindication" to air travel, recommending only low-level flights, or neurosurgeons making no recommendations against flying after surgery.[1,7,10]

Standard flight profile and pressurization technology allows cabin pressure to be maintained below 8000 ft (2438 m) above sea level, even at cruising altitudes. Estimates of volume expansion vary from 25 to 50% from sea level to 8000-9800 ft (2438-2987 m).[8] In a frequently cited theoretical analysis, the expansion of trapped air by 30% in volume at the standard 8000-ft (2438-m) cabin pressure is predicted by mathematical modeling. It is also postulated that intracranial pressure could increase up to 12 mmHg with 30 ml of intracranial air and that the rate of change may be as important as the altitude due to delayed variations in compliance and then outflow resistance.[2] These calculations demonstrate that routine barometric testing should exceed the threshold for significant symptoms with intracranial air. Despite the above information, however, there is no evidence evaluating the durability of a dural closure and

subsequent air travel identifying why recommendations are difficult to make in cases such as the one presented here.

A small retrospective study of aeromedical evacuation of 21 post-traumatic pneumocephalus patients offers the best clinical evidence related to the presented case. In this study, the subjects experienced no significant increases of intracranial pressure (other than transient changes less than 5 mmHg) or any neurological deficits during or after air travel. Two patients whose intracranial pressure was monitored via an extraventricular drainage catheter did not demonstrate the increases due to air expansion as postulated by Andersson.[4] They concluded that further research is necessary, but pneumocephalus may not be an absolute contraindication against air travel, and instead consideration should be given to risks, mechanism of injury, time course and progression, and rate of altitude change in each individual patient. In other instances, it may be reasonable to delay transport and intervention when trauma and remote location are not issues. There are few cases of pneumocephalus associated with air travel and no cases of disability due to air travel and pneumocephalus or post-surgical status.[4,12] Patients with supratentorial craniotomy have been found to have air present 100% of the time for the first 2 postoperative days and 75% of the time at the seventh postoperative day. In the second postoperative week, 60% of patients still have air present on CT scan, 12% of which is rated as moderate to large.[11] It is not surprising to find that in the third postoperative week, air remains in 26% of CT scans because as little as 0.5 ml can be reliably identified on CT.[9,11] Despite this data, the amount of air that is of clinical significance has yet to be quantified.[4,7]

Pneumocephalus is common with any skull penetration and can remain for weeks. This can rarely include penetration by invading osteoma and, as in this instance; CT scan is an effective and reliable modality for identifying intracranial air. This is important to consider in acute aeromedical evacuation and, if possible, presence of air should be confirmed via CT scan and transport delayed until resolution of intracranial air in nonemergent cases (up to 3 wk). However, not all theoretical concerns have manifested in the limited clinical experience, so air travel with pneumocephalus may not be as dangerous as once believed. This case presents one more in the series, providing evidence of safe flight with potential pneumocephalus, and may be among the first cases reported of returning to flying duties after any neurosurgical intervention. The ability of this patient to return to aviation duties is encouraging in both aeromedical evacuation and returning others to active flight status in the future.

In this first case of an aircrew member returning to flight status, we have taken some simple steps toward ensuring flight safety. This included asymptomatic barometric chamber testing 6 mo after surgical resection of the tumor and correction of the dural defect. This provides good evidence that there will not be continued concerns for air or CSF leakage in flight and was sufficient for the waiver authority to permit return to active flight status. The early and frequent contact with the waiver authority likely increased the possibility of returning to flight status in this case. Being only one case with only 2 yr of follow-up, there is not yet any evidence of the rate of recurrence with repeated pressure changes. Also, a rapid decompression environment was not tested, so data is lacking in that situation as well. However, since there are so few reported cases of pneumocephalus associated with air travel, the likelihood of complications is low. The aircrew member also functions in a relatively normobaric environment in the rotary community, with relative pressure due to altitude rarely decreasing below that of a commercial airliner. This makes it a prudent first case for return to flight with possible application to fixed wing communities. A further case series or prospective study remains of value in resolving the mismatch between the theory of and clinical experience in pneumocephalus and air travel. This would potentially obtain objective data on the behavior of intracranial air and allow the possibility of other aircrew members or patients returning to active flight status after any neurosurgical intervention.

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