Cognitive Changes in a Commercial Pilot Secondary to an Olfactory Meningioma

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BACKGROUND: Olfactory meningiomas are typically benign, slow-growing intracranial tumors with subtle presentations that result in delayed diagnosis. To date, only a few published reports describe meningiomas in airmen. None specifically mention olfactory meningiomas or detail the associated presence of cognitive impairment.

CASE REPORT: This was a 55-yr-old commercial pilot with over 20 yr of flight experience who presented for a fitness-for-duty evaluation due to alarming performance at work and neurocognitive concerns. On examination, the patient had an odd affect and anosmia. Imaging showed a large, frontal, midline intracranial mass consistent with an olfactory meningioma.

DISCUSSION: Fitness-for-duty cases are often challenging and even more so when neurocognition is called into question. Symptoms may be subtle and gradual in onset, making recognition and diagnosis difficult. Dementia, alcohol or substance misuse/abuse, and psychiatric diagnoses are often the first conditions considered when evaluating new cognitive impairment in a pilot. This case highlights the importance of keeping a broad differential, including intracranial masses, conducting a thorough neurological examination, and the judicious use of brain imaging.

KEYWORDS: aviation, CNS tumor, fitness-for-duty, intracranial mass, subtle incapacitation.

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Brain tumors constitute a subtle cause of cognitive impairment. Meningiomas are typically histologically benign and often discovered incidentally on imaging.[2] They are the most common primary central nervous system (CNS) tumor in adults, accounting for over one-third of all CNS tumors.[12] Olfactory meningiomas, midline tumors arising from the cribriform plate dura in the anterior cranial fossa, account for approximately 10% of meningiomas overall.[1,3,12] Olfactory meningiomas are slow-growing tumors that present with a large tumor burden.[2] As a result, they are associated with a higher risk for irreversible visual and/or executive functioning impairment.[2] Olfactory meningiomas may also cause motor deficits and seizures, which ostensibly pose an aeromedical risk.[1,5,9]

In 1974, Hansen and McMeekin described one case of meningioma, discovered on autopsy, in a pilot who was fatally injured under visual flight rule conditions.[7] More recently, a small meningioma was discovered incidentally during the autopsy of one of two pilots involved in a fatal general aviation accident in 2018.[14] Two other cases in the literature describe pilots who initially presented with sensory symptoms that were ultimately attributed to meningiomas.[8,13] None of these cases were olfactory meningiomas. To the best of our knowledge, there are no published case reports of olfactory meningioma in a pilot.

CASE REPORT

A 55-yr-old male commercial pilot with over 20 yr of flight experience presented for a fitness for duty evaluation. In recent years, he primarily occupied the observer seat as a relief pilot and was now attempting to return to the position of first officer. During this transition, fellow pilots voiced concerns about the airman's performance, prompting a company conducted supervised flight. The instructor ultimately canceled the second leg of the flight after noting the pilot's missed radio calls, inability to locate route information, flap and landing gear overspeed events, staring out the window, and difficulty finding the airport bus pick-up despite familiarity with the airport. The airman was also noted as having an unkempt appearance. The pilot was then sent for remedial simulator training with similar

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feedback, noting that the pilot was late, unprepared, made multiple errors, and exhibited an overall odd behavior. At this time, the company elected for a fitness for duty evaluation which required the airman to travel domestically to another city where the aeromedical clinic was located.

On the day of his appointment, a severe storm blanketed the area. Although poor weather conditions along with unfamiliarity with the city made travel difficult, these factors should not pose any significant problems for a seasoned traveler such as this pilot. However, the airman struggled to get to his appointment despite having a smartphone and the clinic address. The pilot scheduled two different ride-shares and, after arriving at the wrong location a second time, called the clinic from a street corner but was unable to identify the cross streets. Ultimately a staff member was able to locate the pilot and personally transported him to the clinic.

On presentation, the airman exhibited tangential thinking and a bizarre, but primarily affable demeanor. This was punctuated by intermittent episodes of mildly aggressive or outright obnoxious behavior. At one point, the airman explained that he had not eaten in a day and a half because he had forgotten his wallet at home and managed to travel transcontinentally the day before using his company badge. Later, while escorting the airman to the laboratory for blood and urine collection, the clinic staff also observed the pilot briefly stumble without falling. Overall, it was noted that the airman lacked insight and appeared generally apathetic about the circumstances leading to his evaluation.

The airman denied any significant past medical, surgical, or family history. He also denied tobacco or recreational prescription drug use but reported a remote history of marijuana. He endorsed drinking approximately 12 beers/wk. CAGE questionnaire was negative. The airman also mentioned that he was in marriage counseling and that his distractibility and forgetfulness was irritating his wife.

Review of systems was positive for fatigue but otherwise unremarkable. Physical examination revealed mild instability with tandem gait and anosmia. To test his sense of smell, the airman was instructed to close his eyes while different odors (scented hand sanitizer and coffee grounds) were presented directly under his nose. He was unable to detect or identify either odor. Cognitive screening was conducted using the Montreal Cognitive Assessment and the airman scored 24 out of a total of 30 points (-1 point for language fluency, -5 points for delayed recall).

A broad differential diagnosis was considered, but the preeminent concerns were substance or alcohol abuse, new onset dementia, psychiatric illness, and CNS malignancy. Work-up included a computed tomography (CT) of the head which revealed a large ($6 \times 5.7 \times 4.6$ cm) midline frontal mass extending through the cribriform plates bilaterally. The mass was associated with mild cerebral and extensive vasogenic edema with mass effect on the frontal horns of the lateral ventricles and displacement of the anterior cerebral arteries (see **Fig. 1**). These findings were consistent with a diagnosis of olfactory meningioma.

Fig. 1. Axial computed tomography image of the pilot's olfactory meningioma.

The airman was escorted to the emergency department for hospital admission. The neurosurgery team was consulted and the patient was started on corticosteroids and levetiracetam for seizure prophylaxis. Magnetic resonance imaging (MRI) of the brain, with and without contrast, confirmed the size of the mass and noted reactive hyperostosis of the skull base. After a brief admission, the airman was discharged in stable condition, accompanied by his wife, to return home for definitive care.

The aeromedical disposition was immediate grounding due to an intracranial mass, use of high-dose steroids, and the airman's seizure risk. The airman underwent surgical resection of the olfactory meningioma. His postoperative course was complicated by a cerebrospinal fluid infection requiring an additional hospitalization. He has not returned to flying status at the time of this writing but is hopeful for a possible return in the future.

DISCUSSION

CNS tumors pose a rare but serious risk of sudden incapacitation secondary to seizures or acute intracranial hemorrhage.[1,2,9] Some studies suggest that there is an increase in CNS tumors among pilots.[4,6] Increased exposure of aircrew to ionizing radiation has been theorized as a risk factor. Although an exposure-response relationship has never been established with regards to brain tumors, ionizing radiation is considered a major environmental risk factor for CNS tumors, including meningiomas.[1,4]

As in our pilot, olfactory meningiomas present at a large size due to insidiously slow growth, resulting in subtle incapacitation from cognitive impairment that may go unrecognized for years.[1,3] This highlights the importance of maintaining a high index of suspicion for the development of brain tumors in airmen with subtle cognitive or behavioral changes.

Anosmia is often the first symptom and can therefore be an early indicator for an olfactory meningioma.[1–3] Unfortunately, like our pilot, many patients do not seek medical care for isolated anosmia and may not report this symptom without prompting. In practice, assessment of the first cranial (olfactory) nerve is often neglected due to perceived lack of clinical significance and lack of standardization in testing. Our pilot was simply asked to smell coffee and hand sanitizer and reported he could not smell either.

Federal Aviation Administration (FAA) Form 8500 does not address the assessment of smell. Despite this, aviation medical examiners should consider asking airmen if there have been any changes to their sense of smell, especially if testing of the first cranial nerve is omitted from the neurological exam. Notably, many conditions may cause temporary anosmia, including viral upper respiratory infections and seasonal allergies.[2] Persistent olfactory impairment may be the result of aging, damage from infectious diseases, or prior trauma; however, prolonged anosmia may also indicate a more serious CNS condition.[2]

When diagnosis is delayed, symptoms may progress from isolated anosmia to cognitive impairment and personality changes as increasing tumor burden displaces and compresses structures within the frontal lobes. The airman described in this case showed a gradual decline in his ability to safely perform flight duties despite years of experience, indicating prior capability. The pilot and his close contacts noted gradual changes in his cognition starting several years prior to presentation in our clinic. Although this pilot did not exhibit any vision changes, visual impairment may occur due to compression of the optic nerve and chiasm.[2,3,9] Vision changes can range from central scotomas and other visual field defects to a complete bilateral loss of vision.[10]

Airmen who present with an abnormal neurological examination and new cognitive changes should have brain imaging performed to rule out intracranial mass. Olfactory meningiomas have a characteristic appearance on both CT and MRI: a well-circumscribed, often calcified, midline mass adjacent to the dura at the cribriform plate. In many cases, there is infiltration into the cribriform plate.[1,3] Hyperostosis of the skull base can also be seen.[2] A head CT is typically the first imaging obtained due to ease and timeliness of access. MRI is often employed as part of the preoperative assessment. MRI with and without contrast is the preferred modality for assessing the extent of the tumor and invasion into adjacent structures.

Treatment of olfactory meningiomas most commonly involves surgical resection. Other treatment options include radiation and stereotactic radiosurgery.[1] Chemotherapy is an investigative treatment modality that may be used if the olfactory meningioma is not amenable to surgical resection or in cases of recurrence.[1] Prognosis is generally considered favorable in surgically amenable cases and mortality rates have improved with advances in surgical technique.[1,9] As seen with this pilot, patients may require preoperative high dose corticosteroids for the management of associated edema and most patients receive seizure prophylaxis.[3] For patients who present with preoperative vision changes or cognitive impairment, symptomatic improvement and even resolution have been shown to occur with surgery in some patients.[5,9] A retrospective review by Gazzeri et al. suggests that cognitive impairment due to giant olfactory meningioma may improve for up to 1 yr following surgical resection.[5]

Recurrence is dependent primarily on extent of resection and duration of followup.[9,15] Even with presumed complete gross resection of histologically benign meningiomas, recurrence rates may be unacceptably high for medical certification. Because of this, any tumor of the brain or meninges is often permanently disqualifying for military pilots. The recurrence rate of olfactory meningioma varies widely in the literature from as low as 5% to as high as 40%.[9,11] In a 24-yr retrospective review by Nakamura et al., the mean time of recurrence was 88 mo (range 47–175 mo).[9]

Zhang et al.[15] attempted to identify prognostic factors for recurrence in severe cases of olfactory meningioma with extension into the nasal cavity. They conducted a retrospective review of 43 cases with a 5-yr recurrence rate of 11.6% and identified the following five prognostic factors for recurrence: 1) age less than 45 yr at time of diagnosis, 2) soft tumor texture, 3) hyperostosis, 4) edematous changes measuring at least 20 mm, and 5) presence of a dural tail sign on radiological imaging.[15] Our pilot notably had two of these five factors: hyperostosis and edematous changes. Hyperostosis is an indication of reactive changes in the bone adjacent to the tumor. Zhang et al. postulated that edematous changes obscure the tumor margin, making it more difficult to identify intraoperatively, therefore increasing the likelihood of incomplete resection.[15]

A number of concerns must be addressed before considering posttreatment aeromedical recertification. The degree of improvement in vision, memory, concentration, and other cognitive functions will affect an airman's likelihood for medical recertification. Irreversible visual impairments would likely be disqualifying. Neurocognitive testing is essential prior to reconsideration of medical certification to assess for the presence of persistent cognitive impairment. The airman's postsurgical seizure risk and use of any anticonvulsants must also be assessed.

Our pilot had significant preoperative cognitive impairment that will require resolution prior to reconsideration of medical certification. He should also be seizure free and off all anticonvulsants for a period of years, ultimately determined by the FAA. At that time, he will require a complete neurological evaluation, including repeat MRI, EEG, neurocognitive testing, and a neurology consultation. We also recommend consultation with a neuropsychiatrist. Given the slow growth of olfactory meningiomas, if granted medical recertification, it is anticipated that our pilot would need periodic surveillance MRIs for the duration of his medical certification to monitor for recurrence.

Based on our experience, slow-growing intracranial tumors such as olfactory meningiomas may result in subtle cognitive incapacitation in airmen. In general, these tumors are often underdiagnosed or misdiagnosed until tumor burden is large and impairments may be irreversible. Aeromedical recertification for intracranial tumors must be addressed on a case-by-case basis. As the aerospace medical community encounters and reports more cases of airmen with olfactory meningiomas, risk factors for recurrence and aeromedically significant post-treatment sequelae will become clearer.

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