Attention-Deficit/Hyperactivity Disorder and Fatal Accidents in Aviation Medicine

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BACKGROUND: Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder with symptoms of inattention and/or hyperactivity-impulsivity that interfere with functioning and/or development. ADHD occurs in about 2.5% of adults. ADHD can be an excluding medical condition among pilots due to the risk of attentional degradation and therefore impact on flight safety. Diagnosis of ADHD is complex, which complicates aeromedical assessment. This study highlights fatal accident cases among pilots with ADHD and discusses protocols to detect its presence to help to assess its importance to flight safety.

METHODS: To identify fatal accidents in aviation (including airplanes, helicopters, balloons, and gliders) in the United States between the years 2000 to 2015, the National Transportation Safety Board (NTSB) database was searched with the terms ADHD, attention deficit hyperactivity disorder, and attention deficit disorder (ADD).

RESULTS: The NTSB database search for fatal aviation accidents possibly associated with ADHD yielded four accident cases of interest in the United States [4/4894 (0.08%)]. Two of the pilots had ADHD diagnosed by a doctor, one was reported by a family member, and one by a flight instructor. An additional five cases were identified searching for ADD [5/4894 (0.1%)]. Altogether, combined ADHD and ADD cases yielded nine accident cases of interest (0.18%).

DISCUSSION: It is generally accepted by aviation regulatory authorities that ADHD is a disqualifying neurological condition. Yet FAA and CASA provide specific protocols for tailor-made pilot assessment. Accurate evaluation of ADHD is essential because of its potential negative impact on aviation safety.

KEYWORDS: ADHD, ADD, aeromedical assessment, fitness to fly, accident.

Laukkala T, Bor R, Budowle B, Sajantila A, Navathe P, Sainio M, Vuorio A. *Attention-deficit/hyperactivity disorder and fatal accidents in aviation medicine*. Aerosp Med Hum Perform. 2017; 88(9):871–875.

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder with symptoms of inattention and/or hyperactivity-impulsivity that interfere with functioning or development. Several inattentive or hyperactive/impulsive symptoms present prior to age 12, in two or more settings, and symptoms interfere with or reduce the quality of social, academic, or occupational functioning are descriptive for ADHD according to The American Psychiatric Association Diagnostic and Statistical Manual-5 (DSM-5).[5] In WHO's International Classification of Diseases, version 10 (ICD-10), attention deficit hyperactivity disorder and attention deficit disorder without hyperactivity are coded separately.[15]

ADHD occurs in most cultures in about 5% of children and 2.5% of adults. In the context of aeromedical assessment, ADHD is a particularly complex diagnosis.[8] Currently no biological marker(s) is diagnostic for ADHD.[5] Pharmacological treatments with stimulants (e.g., methylphenidate, dexamphetamine) have issues surrounding short half-lives and effects on the recognition of fatigue.[4,10] Noradrenaline reuptake inhibitors are another pharmacological treatment option. Alternatively, adults can opt for a psychological approach according to the NICE Guidelines.[10]

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This manuscript was received for review in May 2017. It was accepted for publication in June 2017.

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DOI: https://doi.org/10.3357/AMHP.4919.2017

It is generally accepted by aviation regulatory authorities worldwide that ADHD is a disqualifying neurodevelopmental condition for a pilot. This restriction applies especially if an individual is taking prescribed medications to manage symptoms, as there can be possible deleterious effects on an individual's perceptive, motor, and cognitive functions. All or some of these effects can ultimately affect flight safety. While there is extensive literature on the effects of ADHD, including problems with attentional processing, impulse control, executive function, memory, visual-spatial function, and emotional state, there is comparatively little on approaches to and methods of assessment for ADHD, particularly for pilots. ADHD has been associated with traffic accidents, but medication seems to alleviate the risks.[3] However, all studies are not similar and, also, gender differences may apply.[3,9] This study highlights fatal accident cases among pilots with ADHD, discusses protocols to detect its presence, helps assess its importance to flight safety, and briefly explores pharmacological treatments.

METHODS

To identify fatal accidents in aviation (including airplanes, helicopters, balloons, and gliders) in the United States between January 1, 2000, to December 31, 2015, the National Transportation Safety Board (NTSB) database was searched (search date April 2, 2017).[11] The interactive search machine was used, allowing input of certain search terms and preconditions. To identify the medical conditions, the search terms "ADHD," "attention deficit hyperactivity disorder," and "attention deficit disorder" were chosen. The medical requirements for these medical conditions of different aviation authorities from the United States,[7] Australia,[1] and Europe[6] were compared.

RESULTS

Fatal general aviation accidents found with the search term "ADHD" (8 accident reports) or "attention deficit hyperactivity disorder" (10 accident reports) or "attention deficit disorder" (ADD; 12 accident reports) were analyzed further. Further analysis yielded altogether nine accident cases of interest. The prevalence of ADHD and/or ADD cases of all the fatal accident cases was estimated to be 0.18% in the United States between the years 2000 to 2015.

The NTSB database search for fatal general aviation accidents related to ADHD from 2000 to 2015 yielded four reports with a probable ADHD diagnoses. Two pilots were diagnosed with ADHD by a psychiatrist or a family doctor; in one case a family member confirmed ADHD with medication treatment, and in one case a flight instructor conveyed that the pilot told him of ADHD medication use (however, a family member provided a different account) (**Table I**). During their latest aeromedical assessments, three pilots had not shared all relevant information with their Aeromedical Examiners (AMEs), and one pilot was a student pilot, medical unknown/none. One of the deceased was reported to have multiple vehicle accidents on his driving record and traffic violations, e.g., for speeding.

In the search for ADD, five accidents with a pilot with possible ADD were identified (**Table II**). One of these pilots had a history of noncompliance with the U.S. Federal Aviation Administration (FAA) regulations. Another pilot had reported mild inattentiveness, diagnosed by a psychiatrist. Neuropsychological evaluation had been normal. In two cases, medical treatment was not required at the time.

Aviation authority policies generally disqualify pilots with ADHD as it is considered a neurological condition affecting flight safety. Rarely, a pilot with ADHD can be medically

Table I. Fatal Accidents in Aviation in the United States from 2000–2015 Among Pilots with Possible ADHD.[#]

NTSB CAUSE OF ACCIDENT	POSTMORTEM TOXICOLOGY	ADHD DIAGNOSIS	DECEASED AGE/GENDER	ACCIDENT CASUALTY/YEAR
Student pilot's improper handling of the airplane pilot's controls for undetermined reason and the inadequate supervision of the flight instructor. Contributing factor was the weather condition.	Bupropion*	Flight instructor: conveyed pilot medication for ADHD. Family member said the medication was used for smoking cessation.	43 yr/male	1 fatal & 1serious/2002
Pilot incapacitation due to fatigue.	Amphetamine, doxylamine	Diagnosed ADHD (psychiatrist, lisdexamfetamine medication prescribed)	54 yr/male	1 fatal/2008
Student pilot's failure to maintain adequate airspeed. Contributing factors: decisions to attempt a flight not qualified for; ignored weather conditions; and impairment due to prescription medication and alcohol.	Amphetamine; Alcohol	Diagnosed ADHD (family physician)	21 yr/male	1 fatal/2009
Technical reason: contributing pilot's decision to fly at a low altitude, poor long-term engine maintenance, and ADHD contributing to the decision-making.	Methylphenidate	Family member confirmed regular use of ADHD medication for his ADHD	18 yr/male	1 fatal/2013

[#] If an accident report was in both ADHD and ADD searches, it is reported only once.
* In specimen of deceased student pilot.

Table II. Fatal Accidents in Aviation in the United States from 2000–2015 Among Pilots with Possible ADD.*

NTSB CAUSE OF ACCIDENT	POSTMORTEM TOXICOLOGY	ADD DIAGNOSIS	DECEASED AGE/GENDER	ACCIDENT CASUALTY/YEAR
The pilot's failure to maintain aircraft control; a factor was pilot's diverted attention to over-flying a residence.	Sertraline, pseudoephedrine	Family member: ADD	Not available/ female	1 fatal/2000
The pilot's failure to maintain clearance from the power line.	Methylphenidate, desmethylvenlafaxine, venlafaxine	Pilot had reported mild inattentiveness, diagnosed by a psychiatrist. Neuropsychological evaluation had been normal. FAA: possible ADD. Not allowed to fly when using methylphenidate	61/male	1 fatal/2009
The pilot's failure to maintain aircraft control and altitude while maneuvering after takeoff.	Metoprolol	Primary care records, ADD, depression, and anxiety with prescription medications and ENT surgery	49/male	1 fatal/2009
The pilot's failure to maintain a wings-level attitude prior to impacting high vegetation and terrain during the off-field landing (glider accident).	Ethanol, methanol, propranol, acetaminophen, amphetamine	Information from a family member and a physician; ADD and amphetamine medication, anxiety and clonazepam medication	62/male	1 fatal/2010
The non-instrument-rated pilot's decision to continue visual flight into instrument meteorological conditions, which resulted in his loss of aircraft control and the resultant overstress and in-flight breakup of the weight-shift-control aircraft.	Paroxetine methylphenidate, caffeine, and acetaminophen	Medical records; diagnoses of attention deficit disorder and depression. No medical, sport pilot	45/male	1 fatal/2014

* If an accident report was in both ADHD and ADD searches, it is reported only once.

qualified only if special and detailed individual evaluation is carried out. The FAA[7] and Civil Aviation Safety Authority (CASA)[1] provide detailed protocols to help AMEs assess fitness to fly (**Table III**). The European Aviation Safety Agency refers to general neurological instructions and does not have any specific protocol for the evaluation of pilot applicants with ADHD or suspected ADHD.[6]

DISCUSSION

This study reports fatal aviation flight accidents associated with ADHD and ADD in the NTSB database in the years 2000–2015. While serious incidents are rare, some issues arise from this study. AMEs assessing pilots with a possible ADHD or ADD rarely had all relevant medical information when assessing these pilots' fitness to fly. As a limitation of this study, it is important to note that, during the 15-yr time frame, there have been some changes in diagnostic assessments. Also, it is possible that enlarging the NTSB database search to individual medications might identify some ADHD-related accidents. Our search was limited to the mentioned diagnostic entities for this study.

The American Psychiatric Association DSM-5,[5] in addition to the ICD-10,[15] is generally considered to be the gold standard when undertaking an ADHD assessment. A reliable assessment is likely to be arrived at by considering a wide range of clinical, historical, and collateral reports. In addition, the results of specialist neurocognitive testing are valuable for estimating the severity of the symptoms. There is, however, no single, accepted, precise clinical measure of ADHD, nor are there agreed clinical norms for pilots on most neuropsychological tests. Assessment may be time-consuming, costly, and also require access to specialists, such as a neuropsychologist, who may be in limited supply.

A mental status examination is core to an assessment of ADHD. Clinical history, school and academic performance records, work and conduct reports, as well as self- (and family) reports will likely be included in the assessment. As with many areas of clinical medicine, and particularly in neurodevelopmental disorders, a person's background history, baseline or normative functioning, and corroborating information are as important as the clinical assessment. In aviation, additional and unique sources of information may be sought in order to improve the reliability and validity of the assessment, including: 1) pilot training records from flight school; 2) simulator and line performance records; 3) colleague feedback regarding erratic behavior, carelessness in carrying out procedures, or following checklists; 4) unusual utterances, disregard for or 'bending' of standard operating procedures and rules; 5) inattention or impulsivity in training or line operations; 6) fidgeting; 7) poor social timing in dialogue such as interrupting or calling out answers; 8) misplacing things; 9) police conduct records (e.g., a caution or charge of driving under the influence, driving accidents, substance misuse, criminal or public disorder or misconduct transgressions), and 10) aggressive or threatening behavior, unusual or concerning behavior or 'antics' in social situations, especially down route away from the eyes of more senior airline managers or family; and 11) behavior in and attitude toward annual pilot medical checks, among other sources.

Table III. Aeromedical Assessment of ADHD and Fitness to Fly.

	AUTHORITY	
	CASA	**FAA**
Effect of ADHD	Ill-considered action	May produce cognitive deficits that can make an airman unsafe
	Restlessness	
	Impaired multitasking and situational awareness	
Documents	Instructor questionnaire	Aviation experience
	Employment and education history	Employment and education history
	Legal/traffic infringements	Legal/traffic infringements
Criteria	In full remission	Individual evaluation
	No safety-relevant medication	
	Absence of symptoms at least 6 mo after treatment completed	
Tests	No specified test requirements	Welsher Adult Intelligence Scales
		Trail Making Test
		Executive function test
		Pacet Auditory Serial Addition Test
		Continuous performance test
		Tests of verbal and visual memory
		Test of language
		Psychomotor and personality test
Drug testing	Not in protocol	Drug test within 24 h after neurocognitive testing

CASA = Civil Aviation Safety Authority, Australian Government.
FAA = Federal Aviation Administration, United States.

When assessing for ADHD, none of these factors should be used solely to make a diagnosis due to the heterogeneity of neuropsychological profiles, and the validity of any observations or reports may be diminished in the absence of a neuropsychological assessment.[10] It is especially relevant in ADHD assessment as the signs and symptoms may be subclinical.

Findings from the assessment will help to determine the presence and severity of the condition and, therefore, the implications for the pilot's medical license and career. Most aviation regulatory authorities determine outcome on a case-by-case basis, although in general the use of psychostimulant medications disqualifies a pilot.

An ADHD assessment should predominately focus on a pilot's childhood and school years; signs are usually visible in childhood and by teenage years and almost certainly by entry into flight school. Previously undetected ADHD may manifest during pilot training due to the significant cognitive, social, perceptive, and motor demands made on trainee pilots, and thus attention should be paid to initial training. Therefore, presentation of ADHD may be expected to be to the AME when the first student pilot medical certificate is sought or when questions are raised with the AME about a student pilot by the flight school.

Pilot self-reporting is a crucial source of information, whether it is the pilot's reflection or description of his/her own difficulties, or disclosure about having a prescription for ADHD medication, currently or in the past. Urine drug screening for ADHD medications is sometimes used in an assessment. If urine drug screening is carried out on site, it has limited sensitivity compared with quantitative laboratory testing.

Neuropsychological tests can be used for assessing executive function, although caution should be applied in drawing firm conclusions in the absence of a detailed clinical history and information from reported risk and false negatives.[2] Assessment of nonexecutive tasks should also be undertaken, including multiple neuropsychological domains. Subtests may measure visual information processing and reaction time, among other parameters. Batteries of online neuropsychological tests, such as CogScreen (www.cogscreen.com) and CANTAB (www.cambridgecognition.com), are extensively used in the United States and the United Kingdom. IQ test batteries are sometimes used, although they may not be sufficiently sensitive to specific deficits. There may be a tendency for people with ADHD to generally perform worse on IQ tests, especially the timed subtests, due to impulsivity and distractibility.[8] The FAA core test battery used to evaluate ADHD and review cases is both detailed and comprehensive and covers at least 11 domains, which requires familiarity with numerous general psychometric and specialist neuropsychological measures. It includes a range of subtests, including those for executive function, processing speed, working memory, visual memory, continuous attention, language, psychomotor performance, personality, and mathematical ability. The battery may, however, be beyond the resources and expertise of clinicians in some jurisdictions.[7]

Given the high heritability of ADHD (at 76%, with most studies reporting values >60%), viable genetic diagnostic testing would appear promising.[12] Several candidate genes have been suggested, but the current candidate genes and even large genomic scan data lack strong positive predictive value. The ability to use genetic testing for ADHD diagnostics is still limited,[16] and ADHD gene tests are not in clinical use.

Randomized controlled trials show short-term benefits of stimulants (e.g., methylphenidate, dextroamphetamine) and noradrenaline reuptake inhibitors such as atomoxetine in ADHD.[2,10,13] Stimulants are generally first-line pharmacological treatments according to ADHD guidelines. Documented side effects such as headache, loss of appetite or upset stomach, sleeplessness, and emotional symptoms, as well as slightly

elevated blood pressure, especially in aviation preparations with short half-lives, may be impractical indicators.

A large U.S. national cohort study of patients with ADHD ($N = 2{,}319{,}450$) revealed a lower risk of motor vehicle accidents in both genders in the months when receiving ADHD medication.[3] Another meta-analysis gave overall relative risk of 1.23 for drivers with ADHD when controlled with mileage.[14]

The analysis of selective literature on ADHD showed that drivers with ADHD have more adverse driving outcomes, but individuals are affected differently by ADHD.[9] ADHD patients are often involved with violations of speed limitations and increased number of road accidents, and appropriate medication may diminish symptoms.

ADHD increases the risk in road traffic accidents at least when untreated, which poses the question: what level of risk is acceptable for aviation? Both FAA and CASA require documents related to legal and traffic infringements. This requirement is important, but how useful official reports are in practice is somewhat unclear. Minor crashes are less documented as compared to serious traffic accidents.[9] It is also evident that official accident reports focus on traffic rules violations and not necessarily on other features of unsafe driving. Similar limitations apply to aviation investigations.

Having "blanket rules" in any decision-making process is difficult because they may not apply equally and, in some cases, it might be safe to fly. Therefore, there is a need to have a detailed understanding of the context and the circumstances around any potential pilot with a diagnosis of ADHD. These assessments require both medical specialization and experience of aeromedical assessment and should, therefore, be conducted in aeromedical centers with professionals from different disciplines.

Information of ADHD diagnosis and treatment was rarely available when AMEs assessed fitness to fly for the accident pilots of this study. It is essential that all applicant pilot's medical information is available when considering a decision to allow unrestricted flying privileges. The exclusion process in aviation seems to work efficiently, but underreporting and underrecognition are possibilities. We emphasize the importance of accurate evaluation of ADHD from a good behavioral history, verification by assessment with comprehensive testing with established tests, overseen by multidisciplinary professionals, because of its potential negative impact on aviation safety.

ACKNOWLEDGMENTS

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