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Flying Blind: Aeromedical Certification and Undiagnosed Age-Related Macular Degeneration

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16. Abstract

Background: The love of flying seldom diminishes throughout a pilot's career. It is often the primary motivation for investing the time and expense necessary to attain and maintain a valid pilot license and medical certificate. However, a pilot's ability to meet the physical requirements for aeromedical certification may become compromised by advancing age or impairments. Individuals with physical limitations or the elderly in a number of states must pass a vision test to renew their driver's license. These individuals may resort to extraordinary measures to avoid losing the privilege of operating a motor vehicle and maintain a sense of independence. Similarly, pilots with physical limitations may attempt to circumvent the Federal Aviation Administration's aeromedical certification process in order to retain a valid medical certificate.

Case Report: In an investigation of a fatal accident the National Transportation Safety Board (NTSB) concluded that the aviation medical examiner who issued an airman medical certificate to a visually impaired pilot failed to perform the appropriate procedures to verify the validity of medical information provided by the pilot. The airman subsequently crashed his aircraft, resulting in his death and the deaths of five others onboard.

Conclusions: The NTSB report stated the pilot's "failure to maintain airplane control for an undetermined reason resulted in an inadvertent stall." The report also stated that "either the pilot's macular degeneration or his unrecognized coronary artery disease could have contributed to his failure to maintain control of the airplane." The potential debilitating effects associated with these and other serious health issues are discussed.

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Flying Blind: Aeromedical Certification and Undiagnosed Age-related Macular Degeneration

BACKGROUND

The Federal Aviation Administration (FAA) is responsible for regulating the safety of all civilian aviation activities in the United States for both commercial and general aviation. Civilian pilots must carry a current pilot license and medical certificate issued by the FAA to legally operate an aircraft in the United States. Airman medical certificates are valid for various time periods based on the class of certification obtained and the age of the airman at the time of issuance (1). The love of flying seldom diminishes throughout a pilot's career. It is often the primary motivation for investing the time and expense necessary to obtain and maintain a valid pilot license and medical certificate. However, a pilot's ability to meet the physical requirements for aeromedical certification may become compromised with advancing age.

It is never easy for a person to relinquish aspects of their independence or discontinue a beloved avocation, such as flying, due to physical limitations that may accompany injury or aging. Individuals with physical limitations or the elderly in a number of states must pass a vision test to renew their driver's license (2). Some of these individuals resort to extraordinary measures to avoid losing the privilege of operating a motor vehicle and maintain a sense of independence. Similarly, pilots with physical limitations may attempt to circumvent the FAA's aeromedical certification process in order to retain a valid medical certificate.

This paper describes an event in which an elderly pilot provided false information during a medical recertification exam and was later involved in a fatal accident. According to the National Transportation Safety Board (NTSB) the aviation medical examiner (AME), who issued the airman medical certificate, failed to perform the appropriate tests to verify the validity of the medical information (3). The airman subsequently crashed the aircraft he was piloting, which resulted in not only his death but the deaths of five innocent victims.

CASE REPORT

This case involves an 86-year-old airman, who first received his commercial pilot license in 1945 and last renewed his flight instructor certificate in 2007. On June 8, 2008, the pilot was flying a general aviation Cessna U206C, single-engine plane that crashed in Ballville Township, at the Fremont Airport, in northern Ohio. Witnesses reported the pilot appeared to lose control of the plane, which stalled before crashing in a field three-quarters of a mile east of the runway. A stall in fixed-wing aircraft is the point at which the wings fail to generate enough lift to keep the plane stable (4). The accident pilot and five passengers on-board the aircraft, ages 4 to 62 years, were killed (5).

The NTSB issued its final report on this fatal accident on April 16, 2010 (3). In the official report, the Board concluded that the crash was the result of the pilot's "failure to maintain airplane control for an undetermined reason resulted in an inadvertent stall." The NTSB also cited the airman's poor judgment in continuing to fly, despite being treated for wet macular degeneration that affected his vision. The Board further stated "the pilot's visual deficiency would have made it difficult for him to decipher the readings on cockpit instruments and to distinguish objects on the ground. This lack of visual acuity increased the likelihood that the pilot would fly at an inappropriate speed or altitude, thus increasing the chances of a stall." Furthermore, the report cited the AME who failed to document the pilot's eye condition.

A review of the accident pilot's medical records indicated that he had been treated for age-related macular degeneration (ARMD) in both eyes for two years. However, one year prior to the crash, the AME reported his vision to be 20/20 uncorrected for each eye and issued the pilot an FAA second-class medical certificate. (See Table 1 for the vision standards intended for the various FAA airman medical certificates.)

An autopsy found that the airman had severe coronary artery disease with "only a pinpoint lumen (opening) remaining distally of the left anterior descending coronary artery," which was not indicated by his medical records. The disease increases the chance of a heart attack or abnormal heart rhythm, which could result in impairment or incapacitation (6,7). However, if death had occurred within a few minutes to an hour of the impairment or incapacitation, there would be no postmortem evidence of the event.

The NTSB reported that "either the pilot's macular degeneration or his unrecognized coronary artery disease could have contributed to his failure to maintain control of the airplane." The Board could not conclusively determine

Table 1: FAA Vision Standards for Airman Medical Certificate by Class

Class of Certificate & Pilot Type	**First Class Commercial Pilot**	**Second Class Air Transport Pilot**	**Third Class Private Pilot**
Distant Vision	20/20 or better in each eye separately (Snellen equivalent), with or without correction.		20/40 or better in each eye separately, with or without correction.
Near Vision	20/40 or better in each eye separately (Snellen equivalent), with or without correction, as measured at 16 inches.		
Intermediate Vision	20/40 or better in each eye separately (Snellen equivalent), with or without correction at age 50 and over, as measured at 32 inches.		No requirement.
Color Vision	Ability to perceive those colors necessary for safe performance of airman duties.		

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whether either condition directly caused the accident. However, given the incompatibility of the pilot's vision deficiency with the safe operation of a motor vehicle and his awareness of this, the pilot displayed "extremely poor judgment" by continuing to fly, according to the NTSB report.

AVIATION ACCIDENT DETAILS

On the day of the accident, the pilot was providing rides in his single-engine, six-seat airplane at the airport that he owned and managed. Passengers purchased tickets for the rides in the airport office. The rides were given concurrently with a charitable "fly-in breakfast" event, which had been advertised in the local newspaper. According to a representative of the charitable organization, the air rides were a separate activity. The money collected for the air ride tickets was not given to the charity, and evidence indicates that the pilot retained the money.

The accident occurred on the fifth or sixth flight of the morning, about 30 minutes after takeoff. Moments before the crash, the plane was observed to be flying very slowly. One witness said it was "almost on the edge of a stall." According to the NTSB report, the witness heard the engine "throttle up" and saw the plane appear to "stall" with the left wing "dipping" as it "descended below the tree line." The accident site was about 0.75 mile east of the approach end of runway 27. Ground scarring and wreckage distribution covered a relatively small area, consistent with an accident due to an aerodynamic stall. Examination of the airplane by the NTSB revealed no mechanical anomalies that would have precluded normal operation.

Videotapes of previous flights and of the beginning of the accident flight indicated that the pilot was performing nonstandard takeoffs. Rather than beginning a normal climb after lifting off from the ground, the pilot would maintain an altitude just above treetop level until reaching the departure end of the runway, at which point he would initiate a steep pitch-up maneuver (i.e., a vertical deviation from horizontal flight) followed by a pushover maneuver (i.e., a return to level flight). In addition, a witness, who was also a pilot, reported that the accident pilot routinely performed a nonstandard maneuver called a "buttonhook turn" to align the airplane for final approach and landing. The maneuver involved flying the airplane at an altitude of about 300 feet above ground level perpendicular to the approach path and then executing a 270-degree turn to the final approach. These nonstandard departure and approach maneuvers may be due to the visual deficiency of the pilot who had difficulty seeing the instrument panel, runway, or any obstructions near the airport.

MEDICAL FINDINGS AND HISTORY

An NTSB review of the pilot's personal medical records indicated that he had been receiving treatment for ARMD in both eyes at least since April of 2006. The visual consequences that can occur as a result include difficulties in recognizing faces, reading, and driving. (See Table 2 for a more comprehensive list of ARMD signs and symptoms.)

The accident pilot's near visual acuity with the best possible correction was last noted to be 20/40, on May 13, 2007, for his better (left) eye. On that same date, his uncorrected distant visual acuities were noted to be 20/160 for his right eye and 20/100 for his left eye. Distant visual acuity with correction was last noted on April 8, 2008, to be just worse than 20/100 for each eye. On May 20, 2008, just three weeks before the fatal accident,

Table 2: Clinical Signs and Symptoms from Macular Degeneration
Central vision becomes dim, fuzzy, or less sharp
Reading requires more light than in the past
Difficult in seeing people's faces clearly
Blind spot develop in the central field of vision
Loss of central vision that does not go away or becomes worse over time
Vision loss may be severe and rapid with wet AMD compared to dry AMD
Distorted vision (i.e., *metamorphopsia*) - A grid of straight lines appears wavy and parts of the grid may appear blank (see Figure 2)
Color vision deficiency
Slow recovery of visual function after exposure to bright light
Contrast sensitivity loss

distant visual acuity without correction was last noted to be 20/200 for each eye.

ARMD treatments on the pilot's left eye included two laser photocoagulation treatments, 11 bevacizumab (Avastin) injections, and a final combined photodynamic therapy and bevacizumab injection on May 20, 2008. His records also note treatment of the right eye with laser photocoagulation on May 6, 2008. The pilot had been advised not to drive on at least two separate occasions (in October 2007 and January 2008) by his retinal specialist (8). (Note: If an individual is not following the instructions of their eyecare practitioner to discontinue flying, the healthcare provider can anonymously report a pilot who may be endangering himself and others by piloting an aircraft to the FAA at 1-866-TELL-FAA.)

In August of 2006, the accident pilot's personal medical records also indicated prostate cancer (radioactive seed implants) and a history of hyperglycemia (high blood sugar), with a hemoglobin A1C of 6.8% and blood glucose of 118 mg/dL. Although the accident pilot's A1C level was indicative of a diabetic condition (9), he did not have a known history of diabetic retinopathy or clinically significant macular edema. Additionally, there were no indications of heart disease in the personal medical records.

The pilot had not noted any conditions or treatments on his most recent application for an airman medical certificate, dated May 4, 2007, and had also specifically denied having "Eye or vision trouble except glasses" or having "Visits to health professional within last 3 years." His certificate had only the limitation "Must have available glasses for near vision." On the examination performed in conjunction with that application, his uncorrected distant vision was noted to be 20/20 in each eye separately and both eyes together, and his near vision was noted as corrected to 20/20 in each eye separately and both eyes together. These acuity measures were supposedly taken one week prior to the examination (May 13, 2007) by his retinal specialist when the airman's uncorrected distance vision was measured at 20/160 and 20/100 in his right and left eyes, respectively. The same AME had performed all associated airman medical certificate examinations from 1998. The FAA decertified the physician on January 28, 2009, for improper issuance of medical certificates.

As mentioned previously, the accident pilot continued to drive despite being advised by his retinal specialist not to on at least two separate occasions. According to state highway patrol and police department records, the pilot was involved in four traffic accidents from 1998 to 2008, with the most recent occurring on May 30, 2008, less than 10 days before the fatal aircraft accident. The accident report indicates that the pilot's vehicle was hit by another vehicle, near an intersection when he turned left in front of the oncoming vehicle. The pilot reported to the state highway patrol that he was southbound with the sun was glaring into his eyes, and he assumed that he had enough room to make the turn. He said that he saw the other vehicle when he was already into the turn. A witness to the accident stated that the distance between the pilot's vehicle and the other vehicle was 20-30 feet when the turn was made.

The passenger seated in the right front seat of the accident airplane was one of the accident pilot's former student pilots who purchased a ride in the airplane. He held a private pilot certificate but did not hold a current airman medical certificate. If the accident pilot had become incapacitated, it is possible this passenger could have taken control of the airplane. There was insufficient evidence to determine whether or not this passenger was manipulating the flight controls when the accident occurred.

The local FAA Flight Standards District Office had no records of any concerns raised or complaints about the pilot. Also, the FAA had no record of the pilot applying for a Letter of Authorization to conduct passenger-carrying flights for compensation or hire, which is required by 14 CFR part 91.147 for all passenger-carrying flights (10) not conducted under 14 CFR part 91.146 (flights for the benefit of a charitable, nonprofit, or community event) (11). Therefore, the FAA was unaware of, and provided no oversight of, the pilot's passenger-carrying flights.

MACULAR DEGENERATION CLINCIAL SEQUELAE AND TREATMENT

ARMD is the leading cause of visual loss in the United States' senior population (12,13). The condition causes deterioration and possible eventual loss of central vision. There are several risk factors for macular degeneration. Some of these risk factors cannot be modified, such as age (14), race (15), gender (15), or family history (16,17). Other risk factors can be reduced, such as smoking, poor diet, and sunlight exposure (12,18,19).

The most common type of ARMD is the "dry" form. In this type of macular degeneration, there is progressive thinning (atrophy) and deposition of waste products (drusen) in the retina. Although vision loss can occur, it is usually minimal and progresses slowly (12).

The "wet" form of macular degeneration is responsible for 10% of macular degeneration cases (12). In this condition, abnormal blood vessels grow beneath the retina. Leakage and bleeding from these abnormal vessels can destroy central vision (See Figure 1). Because the wet form of macular degeneration is often devastating, scientists have been searching for ways to prevent it from occurring. The Age-Related Eye Disease Study (AREDS) has shown that vitamin supplementation is important in slowing the progression of macular degeneration in patients with moderate dry macular degeneration or in patients with more advanced disease in one eye only (20,21). The importance of lutein and zeaxanthin supplements are being investigated in AREDS II, with results expected within the next five years. Other studies indicated the importance of carotenoids as an antioxidant resident of the retina (18).

Metamorphosia (distortion of vision) is usually the first symptom present when wet macular degeneration begins; thus, this symptom should be evaluated promptly (See Figure 2). Angiography is the diagnostic test of choice, which is performed by injecting a dye into the patient's vein and photographing it as it circulates through the vessels of the eye. The pattern of dye transmission and leakage identifies certain disease processes. Special digital cameras and computers are used to maximize the effectiveness of this test.

Drugs are used to treat advanced ARMD, including anti-VEGF (vascular endothelial growth factor) therapies such as Lucentis, Avastin, and Macugen. Many patients can achieve excellent results with a treatment schedule of anti-VEGF agents given at tailored dosing intervals to obtain the best combination of efficacy and safety (22). In addition, the use of such drugs, in combination with photodynamic therapy and thermal laser treatments, can bring about significant benefits in certain patients (23,24,25,26).

Despite best efforts, many ARMD patients are left with poor vision. For those patients, evaluation by a low-vision specialist can result in dispensing of special lenses and optical devices to enable patients to optimize their visual abilities (27).

When abnormal blood vessel membranes grow beneath the retina (i.e., chroidal neovascularization), there are three main types of laser treatment that are used to eliminate these membranes. Conventional (hot) laser treatment coagulates blood vessel membranes (28). The procedure is painless and takes a relatively short time to perform. The vision in the area of treatment is permanently altered, and recurrence of vessel growth is common. Photodynamic therapy, or "cold" laser, involves the intravenous injection of Visudyne, a light-sensitive drug, which accumulates in the blood vessel membranes (29,30). A low-intensity laser is then applied to the retina activating the drug and closing the blood vessel membrane. Patients must avoid sunlight or other bright light for a few days following the procedure, as severe sunburn can occur. There is no significant damage to normal tissue, but the blood vessels tend to re-open, and repeated treatments are often necessary. Transpupillary thermotherapy, or "warm" laser, may be useful in certain patients with blood vessel growth beneath the central macula (31). The laser warms the abnormal blood vessel membrane by several degrees, but not enough to cause a burn. This membrane may reform and require repeat treatments in some patients. Although specialists consider this treatment to be promising, it has not yet been proven effective in a clinical trial.

CLINICAL CONSIDERATIONS OF THIS ACCIDENT

AMEs should be aware that pilots may attempt to falsify information or manipulate test results to maintain their certification status. The AME in this report did not properly validate the applicant's visual performance measurements. Even with memorization of target optotypes or squinting the eyes to improve test scores, the validity of acuity measurements could be confirmed by other means. These include: direct viewing of the macula area of the retina with an ophthalmoscope, performing a monocular color vision test (32), or completing a simple glare test using a penlight or window as the glare source while performing visual acuity measurements (32). Although falsification of the airman medical application form may result in fines of up to $250,000, imprisonment up to five years, and revocation of medical and all pilot certificates (FAR 67.403), this did not deter the accident pilot from lying or misrepresenting medical data in order to keep flying. The fact that this pilot knew he had an eye condition that resulted in central vision loss, which would not allow him to meet the applicable FAA vision standards, suggests that he knew he was flying illegally.

Accidents are often the result of multiple factors; consequently, it is unlikely that central visual acuity loss from the ARMD was the only contributing factor in this accident. For example, the accident pilot's borderline diabetic condition may have adversely affected his attentiveness and cognition compromising his judgment (33,34,35,36). Diabetes can also result in vision problems, including reduced contrast sensitivity (37,38,39), increased color vision deficiency (40,41), glare sensitivity (39), visual field defects (42,43), and macular edema, i.e., fluid collection that may result in blurred vision (43,44,45,46,46,47), which can increase photostress recovery time (48,49). Furthermore, ARMD can also result in color vision problems (27,32,40), glare sensitivity (27,50,), increased recovery time from exposure to bright lights (32,49), reduced contrast sensitivity (50,51), and visual field loss (50). Reduced visual acuity from macular degeneration may additionally affect the pilot's eye-hand coordination (27) and contribute to his failure to maintain control of the aircraft. Although not evaluated in this case, prior research has shown that reduced contrast sensitivity and visual field loss are better predictors for increased risk of vehicle accidents (52,53). His undiagnosed coronary artery disease could have resulted in angina (chest pain) and numbness or loss of feeling in the arms, shoulders, or wrists and could have been detrimental to a pilot flying a plane. Unfortunately, since there were no survivors, exactly which factors contributed to this accident may never be known.

CONCLUSIONS

In summary, the NTSB determined the probable cause of this accident was the pilot's failure to maintain control of the airplane for an undetermined reason, which resulted in an inadvertent stall. Contributing to the accident was the pilot's "poor judgment" in continuing to fly with a severe visual deficiency. The pilot's visual deficit would have made it difficult for him to decipher the readings on cockpit instruments and to distinguish objects on the ground. This lack of visual cues increased the likelihood that the pilot would fly at an inappropriate speed or altitude, thus increasing the chances of a stall. In addition, his AME failed to accurately assess and report the pilot's visual deficiency. Inexplicably, normal eye test results were reported by the AME (including 20/20 uncorrected vision), and the pilot was issued a second-class medical certificate. Other limitations resulting from the ARMD, coronary artery disease, and diabetes may have also contributed to the accident. Regardless of all the contributing factors in this accident, a visually impaired individual was allowed to fly an aircraft illegally, resulting in an accident that cost him his own life and the lives of five innocent victims.

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