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Aeromedical Aspects of Findings From Aircraft-Assisted Pilot Suicides in the United States, 1993-2002

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16. Abstract All aviation accidents are tragic, but few are more avoidable than aircraft-assisted suicide. Aircraft-assisted suicide may precipitate as a result of clinical depression, marital or financial difficulties, or numerous other problems. While aircraft-assisted suicide attempts almost always result in pilot fatalities, they also have the serious and unfortunate potential to cause collateral damage to property and life. Our laboratory was interested in evaluating the epidemiological, toxicological, and aeromedical findings from pilots involved in aircraft-assisted suicides. Case histories, accident information, and the declaration of suicide as the probable cause in the aviation accidents were obtained from the National Transportation Safety Board (NTSB). Toxicological information was obtained from the Civil Aerospace Medical Institute's Bioaeronautical Sciences Research Laboratory. Other relevant information was obtained from medical certification data systems. Over the 10-year period, 1993-2002, there were 3648 fatal aviation accidents. Of these, the NTSB determined that 16 were aircraft-assisted suicides, 15 were from intentional crashing of an aircraft, and 1 due to a student pilot exiting the aircraft while in-flight. All 16 aircraft were operated as general aviation. All pilots involved in these aircraft-assisted suicides were male, with a median age of 40 (range 15-67) years. The pilot was the sole occupant of each aircraft that was intentionally crashed. Toxicological findings for 7 of the 14 pilots for which test specimens were available were negative for disqualifying substances, whereas 4 contained ethanol at various levels, 2 were found positive for benzodiazepines, 1 positive for marijuana, 1 positive for cocaine, and 1 positive for venlafaxine. None of the airmen had reported intake of these substances during their medical certification process. These limited data indicate that 50% of accidents classified by the NTSB as aircraft-assisted pilot suicide involve at least one, if not more, disqualifying drug(s). However, based on the few cases conclusively attributed to suicide, death by the intentional crashing of an aircraft appears to be an infrequent and uncommon event.					
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AEROMEDICAL ASPECTS OF AIRCRAFT-ASSISTED PILOT SUICIDES IN THE UNITED STATES, 1993-2002

INTRODUCTION

All aviation accidents are all tragic, but few are more avoidable than aircraft-assisted suicide. Aircraft-assisted suicide may precipitate as a result of depression, domestic difficulties, or numerous other problems. While aircraft-assisted suicide attempts almost exclusively result in pilot fatality, they also have the serious and unfortunate potential to cause collateral damage to property and life. Other reports on aircraft-assisted suicide have been published;^{7,12} however, none have been published over the time period 1993-2002 concerning aircraft-assisted suicide in the United States. Our laboratory (Bioaeronautical Sciences Research Laboratory) was interested in evaluating the epidemiological and toxicological findings from pilots involved in aircraft-assisted suicide over these years.

METHODS

All information pertaining to case history, accident information, and probable cause(s) of aviation accidents were available through the National Transportation Safety Board (NTSB). Our laboratory gathered medical and toxicological information on all civil aviation fatalities that were determined by the NTSB to result from aircraft-assisted pilot suicide. The NTSB's database can be accessed online at www.nts.gov/ntsb/query.asp. Other information related to the incident and the airmen's medical certification were obtained from the Civil Aerospace Medical Institute's (CAMI's) Decision Support System (DSS) and Aerospace Medical Certification System, including the Document Information Workflow System, which records aeromedical information and flight experience, as reported by the pilot (on an FAA Form 8500-8) to the aviation medical examiner (AME) at the time of the medical examination that is part of the medical certification process.⁴ CAMI's Forensic Toxicology Research Laboratory analyzes postmortem specimens collected from pilots involved in civil aviation accidents.^{1,5} Toxicological information for each suicide case was obtained from CAMI's toxicology database.²

Case Histories

Case 1

A 45-year-old pilot was arrested and charged with lewd and lascivious conduct with a minor. He was released on bail 1 day later, which was 3 days prior to the accident.

Hours before the accident, the pilot met with a friend, and they drove around while consuming alcohol. The friend later told investigators the pilot was making comments pertaining to the intentional crashing of his airplane. Shortly after meeting with his friend, the pilot, the sole occupant of a Piper PA-46-310, was fatally injured in an aviation accident. The accident occurred at 0111 hrs. The pilot was found to have ethanol levels of 175 and 117 mg/hg in the lung and muscle, respectively. These impairing levels of ethanol are considerably above the FAA's legal limit of 40 mg/dL ethanol in a pilot's blood. The NTSB determined the probable causes of the accident to be ethanol impairment and pilot suicide.

Case 2

A 38-year-old pilot was experiencing emotional distress stemming from recent public accusations of an extramarital affair and subsequent harassment. These actions led to an order of protection for the accuser. Details surrounding the alleged affair and subsequent harassment were released to the local media, prompting the pilot's wife to leave and take their child with her. A coworker told investigators that the pilot attempted suicide twice following his wife's departure, once in a closed garage with a running car and once in an airplane, both times deciding not to complete the act. Four days after the 2 unsuccessful suicide attempts, the pilot was fatally injured when the Piper PA-28-180 he was flying collided with terrain shortly after takeoff. Witnesses observed the airplane taxi towards the runway at a "faster than normal" speed. Following takeoff, witnesses saw the airplane dive vertically towards the runway from an altitude of 300-400 feet. The accident occurred at 0030 hrs. The accident investigators found no evidence of aircraft mechanical problems. Toxicological examination of the pilot's remains revealed no disqualifying substances. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 3

A 20-year-old pilot was found guilty in a jury trial of operating a "pyramid scheme." According to friends, the pilot "did not feel he could go to jail, and since this was his second offense for this particular crime, (the pilot) felt that if convicted he would spend some years in jail." Approximately 30 minutes after the guilty verdict, the pilot rented a Cessna 152. An employee at the airport said

the pilot “seemed somewhat snobbish and in a hurry.” Shortly after takeoff, the airplane was observed flying low and making a circle over the base of a mountain near the airport. The plane was then observed flying straight into the mountain, killing the pilot. The accident occurred at 1515 hrs. A toxicological examination found 1 ng/mL tetrahydrocannabinol (the active compound in marijuana) in the pilot’s blood. Furthermore, tetrahydrocannabinol carboxylic acid (an inactive metabolite of tetrahydrocannabinol) was found at 6 and 15 ng/mL in the blood and urine, respectively. While the presence of tetrahydrocannabinol in the blood indicated the pilot used marijuana, an illegal substance, the blood concentration determined suggests that there was little cognitive impairment at the time of the accident. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 4

A 32-year-old pilot was experiencing marital difficulties. The pilot and his spouse had a violent argument that resulted in police intervention. The police removed the wife and child from the residence and took them to her parent’s home for the night to ensure their safety. The pilot called his in-laws’ home numerous times that night. He continued to call the next day and left a message on their answering machine. The message indicated that he wanted to “see my son one last time” and “say goodbye to my son.” Following the call, the pilot signed and had notarized all of the vehicle titles and left them on the table for his wife. The pilot then rented a Cessna 150K, and shortly after departure, witnesses observed the aircraft flying erratically. The airplane then crashed in a steep nose-down attitude, killing the pilot (sole occupant). The accident occurred at 1158 hrs. Following the accident, the pilot’s wife told authorities that her husband had often talked about suicide. The accident investigators found no evidence of aircraft mechanical malfunction. Toxicological examination revealed no drugs in the pilot’s system. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 5

A 38-year-old pilot was involved in a fatal hit-and-run automobile accident resulting in the police issuing a warrant for his arrest. Two days later, the pilot gained access to a Cessna 182E. The pilot departed and immediately climbed above an altitude of 21,000 feet. Air traffic control (ATC) made contact with the pilot, at which time he indicated that he was out of fuel and requested an approach. The controller advised the pilot of a nearby airport, but he declined and stated, “I prefer water.” Communications continued for 20 minutes, during which time the pilot continued to request a

water landing. The pilot made numerous ominous statements to ATC such as, “All things considered, I think that would be the best place to go” and “As you might have guessed, I have not had a good day...I’m going swimming tonight.” The airplane crashed into an ice-covered reservoir in a nose-down attitude, penetrating the ice and submerging all but the tail of the aircraft. The accident occurred at 0117 hrs. The pilot was found to have ethanol levels of 64 and 77 mg/dL in his blood and vitreous humor, respectively. These findings indicate that the pilot was above the FAA’s legal ethanol limit and was likely impaired. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 6

A 67-year-old pilot was reportedly depressed over the recent death of his mother and his own deteriorating health. The pilot departed the airport in a Cessna 172N. The pilot’s girlfriend contacted the operator, who in turn contacted ATC expressing concern about a potential suicide attempt. However, airport officials were unable to prevent the pilot’s departure. A lifeguard reported seeing an airplane complete a loop, level off, and then dive vertically into the ocean, killing the pilot (sole occupant). The accident occurred at 1352 hrs. A hand-written will, dated the day before the accident, was found. There was no evidence of aircraft mechanical malfunction. A toxicological examination found ethanol in the pilot’s system. However, it was determined upon further investigation that the ethanol present was a result of postmortem microbial ethanol production and was not present due to ethanol consumption. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 7

A 26-year-old pilot and some friends had been consuming alcoholic beverages at a restaurant, after which the pilot was driven home. Approximately 45 minutes after his return home, the pilot told his roommate that he was going for a walk. Approximately 15 minutes later, the pilot attempted to gain access to the flight line where he was employed as a flight instructor; however, the computer security system would not grant him access due to the late hour. He scaled an 8-foot fence and gained unauthorized access to a Piper PA-44-180. The pilot was given clearance for takeoff and began his flight. Approximately 15 minutes into the flight, he requested clearance to land. The airplane was observed at a higher than normal altitude for landing, and when questioned by ATC about this, the pilot responded “This will be my final landing.” Witnesses observed the airplane descend at a steep angle and high rate of speed and impact the

runway. The accident occurred at 2323 hrs. A note found by the pilot's roommate following the accident said, "I do not want to live." There was no evidence of aircraft mechanical malfunction. Toxicological examination of the pilot found intoxicating amounts of ethanol. Ethanol was identified in the urine at 141 mg/dL, and in the brain and muscle at 103 and 97 mg/hg, respectively. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 8

A 41-year-old pilot's marriage proposal was turned down by his girlfriend. The following day, the pilot took a Cessna 172M for a flight. The operator at the airport observed the pilot taxiing at excessive speeds and contacted ATC, requesting that they ask the pilot to return to the ramp; however, the pilot had already departed. A short time later, witnesses observed the airplane flying at an altitude of 200-300 feet, then "descend at an increasing speed" and nose dive into a field adjacent to the church where his girlfriend was attending services. The accident occurred at 1125 hrs. There was no evidence of aircraft mechanical malfunction. Toxicological examination found diazepam (Valium®), a benzodiazepine, at a concentration of 28 and 74 ng/g, in the kidney and liver, respectively. Nordiazepam, an active metabolite of diazepam, was also found at a concentration of 69 and 134 ng/g in the kidney and liver, respectively. These substances are disqualifying and would have legally prevented this pilot from operating an aircraft. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 9

A 40-year-old pilot, with a history of substance abuse, was being sought by police in connection with a recent arson. He had previously been convicted of first-degree arson. The pilot told a friend that he was going on a trip and needed a ride to the airport. Upon arrival, he left an envelope in the friend's car and told him not to open it until after his departure. Once the pilot entered the airport, the friend opened the envelope and found two documents: power of attorney transferring all property to the pilot's brother and a letter entitled "message in a bottle." The pilot rented a Cessna 172S, took off from the airport, and a short time later a witness observed the aircraft rocking back and forth and stated, "The aircraft was no more than 10 feet off the water." The witness also said that the airplane was on a collision course with a boat, forcing the boat's captain to take evasive measures. Other boats in the area had similar reports. The pilot then made a distress call that was relayed to the appropriate authorities by a passing Boeing 747. Approximately an hour after the distress call, the Coast Guard found the

pilot's body floating in the water. The accident occurred at approximately 1832 hrs. After recovery of the aircraft and a thorough investigation, it was determined that there was no evidence of mechanical malfunction. A toxicological examination found cocaine, benzodiazepines, and ethanol in the pilot's body. Cocaine was identified in the blood at 5 ng/mL. A cocaine metabolite, benzoylecgonine, was found at 113 ng/mL and 215 ng/g in the blood and liver, respectively. Cocaethylene, a compound formed from the co-administration of cocaine and ethanol, was identified in the liver at 31 ng/g. Diazepam, nordiazepam, temazepam, and oxazepam were found in the blood at 57, 76, 143, and 1 ng/mL, respectively, and in the liver at 1011, 1504, 758, and 492 ng/g, respectively. Ethanol was found in the blood at 42 mg/dL. These findings indicate that the pilot had used cocaine, diazepam, and ethanol within hours of his flight. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 10

A 22-year-old pilot was conducting touch-and-go operations in a Piper PA-44-180. During routine communications with the local ATC, the pilot gave the controller a phone number and told the controller, "After all of this...that's the people that you can contact...we'll be at a full stop this time." The pilot further stated, "...tell my family and friends that I love them very much." On short final, the pilot pulled straight up and appeared to stall at approximately 1000 feet. The airplane then descended at a steep angle and impacted the runway. The accident occurred at 1933 hrs. There was no evidence of aircraft mechanical malfunction. A toxicological examination found no disqualifying substances in the pilot's system. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 11

A 43-year-old pilot was served a restraining order at his place of residence and escorted off his property. The following morning, the pilot, in a Socata TB-20, departed the airport on a local flight. According to witnesses, the airplane made 4 circular patterns over the pilot's residence then dove directly into the house. The accident occurred at 0737 hrs. No evidence of mechanical malfunction was discovered when the aircraft was evaluated. Unfortunately, due to the severity of the accident and the ensuing fire, no toxicological examination was possible. No persons on the ground were injured. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 12

A 40-year-old pilot was a suspect in a criminal investigation when authorities entered his home and seized

records and his computer. That evening, the pilot obtained the keys to a Cessna 152 that he was not scheduled or authorized to fly. Additionally, he was not certified to fly at night. A witness said the pilot entered the aircraft with no preflight inspection, taxied directly to the runway, and took off with no pre-takeoff checks or engine run-up. Within two minutes of takeoff, the airplane crashed into a mountainside at 2158 hrs. The accident investigators found no evidence of aircraft mechanical malfunction. Toxicological examination found no drugs in the pilot's system. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 13

A 15-year-old student pilot was told by his flight instructor to pre-flight a Cessna 172R. However, the student pilot, without an instructor, untied the airplane, boarded it, started the engine, and, without clearance, took off. There was no communication between the pilot and ATC. A Coast Guard helicopter intercepted the aircraft and signaled the pilot to land. The aircraft continued its course and crashed into an office building. The accident occurred at 1703 hrs. A suicide note was found on the pilot's body. No persons on the ground were injured. Accident investigators found no evidence of aircraft mechanical malfunction. Postmortem toxicological examination found no evidence of drugs. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 14

A 54-year-old pilot was being treated by a psychotherapist for severe depression. The pilot departed the airport in a Cessna 172K and approximately 30 minutes after takeoff, witnesses observed the aircraft flying "abnormally low" and then fly straight into a mountain. The accident occurred at 1558 hrs. During the ensuing investigation, the pilot's therapist told investigators that the pilot had stated, "If he killed himself, he would do it in a plane, and crash it with only himself in it." The NTSB found no evidence of aircraft mechanical malfunction. Toxicological examination revealed the antidepressant, venlafaxine, and its metabolite, desmethylvenlafaxine, in the blood at 446 and 1462 ng/mL, respectively. These compounds were also identified in the pilot's urine at 3018 and 34,102 ng/mL, respectively. Based on the drug concentration, the volume of distribution (6.8 L/kg) for venlafaxine, and the pilot's weight, it appears that the pilot was taking the maximum therapeutic dose of 225 mg per day, which may be accompanied by significant side effects. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 15

A 43-year-old pilot was the subject of an on-going criminal investigation. Local authorities were told by numerous people that the pilot had threatened to kill himself by deliberately crashing an airplane before he would go to jail. Two days before motions were to be heard in court, the pilot rented a Cessna 152. The pilot did not conduct a preflight inspection, but rather got into the airplane and sat motionless for approximately 15 minutes. He then started the engine and again sat motionless for another 15 minutes. The pilot then taxied to the runway and departed the airport. Approximately 1 hour after departure, the airplane disappeared from radar. The aircraft crashed with a nose-down angle in a field. The accident occurred at approximately 0820 hrs. The accident investigators found no evidence of aircraft mechanical malfunction. Toxicological examination found no drugs in the pilot's system. The NTSB determined the probable cause of the accident to be pilot suicide.

Case 16

A 47-year-old student pilot scheduled an instructional flight in a Cessna 152 to evaluate how his ears would feel at altitude following a recent ear surgery. Once at an altitude of 9500 feet, the pilot opened the left window. Near the end of the scheduled flight, the pilot asked the flight instructor to fly the airplane so he could "check his ears." During a subsequent slow turn, the pilot asked the instructor to increase the angle of the bank. The instructor ultimately increased the turn to a 45-degree bank, at which point the instructor heard "a noise that sounded like ... the seat belt hitting the side of the plane." The instructor turned just in time to see the pilot exiting the aircraft. The incident occurred at 1344 hrs. Investigators found no problems with the aircraft cabin door or the restraint system. Friends of the pilot revealed a history of "ongoing treatment for depression and a recent intent to take his own life by using an aircraft." A suicide note, left in the pilot's car, stated "I'm tired of being depressed. I've been this way for almost 2 months. I'm about ready to do anything to stop feeling this way." The pilot was also the target of a federal investigation. Biological specimens from the pilot were not submitted to CAMI for toxicological examination. The NTSB determined the probable cause of the accident to be pilot suicide.

RESULTS AND DISCUSSION

Epidemiological and Toxicological Aspects

The NTSB is the primary federal agency responsible for investigating civil aviation accidents. The NTSB is also responsible for determining the probable cause(s) of

an aviation accident. During the course of an aviation accident investigation, it may be difficult to differentiate between a suicidal and an unintentional aviation accident, when considering that the circumstances surrounding such accidents can be virtually indistinguishable. The NTSB's determination of suicide as the probable cause of an aviation accident is assigned only when there is strong supporting evidence for such a claim, such as a suicide note, a witness, or suicidal ideation. Therefore, aircraft-assisted suicides are likely under-reported; however, for the purpose of this study we examined only general aviation fatalities that were reported by the NTSB as suicide.

Compared to other types of suicide, aircraft assisted suicide is unique in that it is almost always successful. Over the 10-year period, 1993-2002, there were 3648 fatal general aviation accidents, 15 of which were reported by the NTSB as being suicide as the probable cause. Additionally, 1 pilot suicide was reported that did not result in an aviation accident (case 16). Therefore, aviation accidents as a result of pilot suicide are rare events, accounting for 0.41% of all fatal general aviation aircraft accidents (15 of the 3648). The pilot suicide that did not result in an aviation accident was not included when deriving this statistic. A previous study by Ungs¹² evaluating aircraft-assisted suicide in the United States over the years 1979-1989 found that 0.17% (10 out of 5929) of all fatal general aviation accidents were conclusively attributed

to suicide. While the actual number of aircraft-assisted suicides has gone up from 10 over an 11-year period to 16 over a 10-year period, an increase of 76%, the total number of general aviation accidents has substantially decreased from 5929 to 3648 over the time periods studied, a decrease of 32%. The frequency of suicide by year from 1992 - 2003 is presented in Table 1. Five of the 16 (31%) aircraft-assisted suicides occurred in 2002, while no cases were identified in 1996 or 1999.

All 16 "suicide flights" were operated as general aviation, 14CFR Part 91. The aircraft used in these suicides were predominantly single-engine (14 of 16), fixed-landing gear (13 of 16) aircraft, and consisted of 11 Cessna, 4 Piper, and 1 Socata. All of the pilots involved in these aircraft-assisted suicides were male, with a median age of 40 years (range 15-67). The pilot was the sole occupant in all of the suicides involving aircraft accidents. Epidemiological aspects of the suicide pilots involved in the current study were similar to those found by Ungs.¹² Ungs reported that all of the aviation-assisted suicides were operated under general aviation flight rules, and that all the suicide victims were male, with a median age of 36 (range 29-87).

Precursors to suicide have been well documented.¹¹ Common suicide precursors include psychological problems, substance misuse, domestic issues, and legal problems, as can be seen in the case histories discussed

Table 1. Comparison of aviation-assisted suicides versus total fatal general aviation accidents per year (1993-2002).

Year	Aviation-assisted suicides	Fatal general aviation accidents*
1993	1	401
1994	1	404
1995	3	413
1996	0	361
1997	1	350
1998	2	364
1999	0	340
2000	2	345
2001	1	325
2002	5	345
TOTAL	16	3648

*Numbers obtained 12/04 from www.nts.gov/aviation/Table10.htm

Table 2. Suicide pilot's state of mind prior to the accident.

Case #	Domestic Stress/Difficulties	Criminal Stress/Trouble	Depression	Prior Talk/Thoughts of Suicide	Prior Attempt at Suicide	Left Suicide Note/Letter	Summary of Events Leading to Suicide
1	-	Y	-	Y	-	Y	Father of 4; arrested; worried about jail; lewd behavior w/minor
2	Y	-	-	-	Y	-	Negative publicity; order of protection; extramarital affair
3	Y	Y	-	-	-	-	Worried about jail; found guilty of pyramid scheme
4	Y	-	-	Y	-	-	Fight with spouse; police intervene
5	-	Y	-	-	-	-	Fatal Hit & Run; warrant for arrest
6	-	-	Y	Y	-	*	Mother's death; worried about deteriorating health & FAA license
7	-	-	-	-	-	Y	Spent previous night drinking
8	Y	-	-	-	-	-	Marriage proposal declined
9	-	Y	Y	Y	-	Y	Criminal history; suspect of arson
10	-	-	-	-	-	-	Undetermined
11	Y	-	-	-	-	-	Restraining order; escorted away from home
12	Y	Y	-	-	-	-	Subject of criminal investigation; estranged from adopted daughter
13	-	-	-	-	-	Y	Undetermined
14	-	-	Y	Y	-	-	Under therapy for severe depression
15	-	Y	-	Y	-	-	Undergoing criminal investigation
16	-	-	Y	Y	Y	Y	Ongoing treatment for depression

* A hand-written will was found, prepared the day before the pilot's suicide.

above and in Table 2. Based on available NTSB data, the majority of the 16 suicides occurred between the hours of 1200 and 0800 ($n = 13$), most frequently on Monday ($n = 6$), and in the fall or winter seasons ($n = 11$). Ten of the 16 airmen (63%) had thought of suicide, talked about suicide, attempted suicide before, and/or left a suicide note. Specifically, 7 of the 16 victims had expressed recent thoughts of suicide, 5 left a suicide note, and 2 had previously attempted suicide (1 twice before). Also, 13 of the 16 victims (81%) had experienced domestic problems (46%), criminal issues (46%), and/or depression (31%) just prior to their suicide. Table 2 summarizes these results.

All 16 airmen were medically certified for flight operations sometime in their flying career: 1 – 30 years, median = 6, as measured by the length of time between their first medical certification to the date of the incident. Three of the airmen, cases 1, 15, and 16, had allowed their medical certification to lapse, where the time span between their medical certification exam to the date of the suicide was 67, 49, and 302 months, respectively. The remainder of the airmen had current medical certification and, therefore, were operating within the FAA's aeromedical certification regulations at the time of the accident. Each airman was in good general health as of their last medical certification. Nine of the 16 airmen were granted "clear" (unrestricted) certification. Five of the 6 "limited" certifications were due to the requirement of corrective lenses. Definitive information regarding the "limited" certification of one airman (Case 2) was not available, but may have been related to a Statement of Demonstrated Ability (SODA), though we could not ascertain the nature or degree of the impairment. Likewise, the "Special Issuance" certification granted to one airman (Case 6) was likely due to cardiovascular problems, as discussed below.

At the time of their flight certification medical examination, one airman (Case 5) reported having "problems with hay fever/allergies." Another airman (Case 8) reported his military discharge for medical reasons but provided no details as to the date of the discharge or its cause. However, aeromedical personnel had noted benign essential hypertension in 1992 and 1997 and acquired deformities of the forearm, excluding fingers, also in 1997. One airman reported "other illness" (Case 4) and 3 reported "admission to a hospital" (Cases 8, 9, and 12), but provided no details. An airman (Case 7) reported his appendix had been removed and corrective surgery of a broken jaw, both occurring around 1995. One airman (Case 6) reported "heart/vascular trouble" and "admission to a hospital." This report was confirmed by further medical intelligence, prompting the pathology codes for angina pectoris in 1994 and acute myo-

cardial infarction in 1985. The coroner confirmed this by noting evidence of advanced coronary artery disease and myocardial infarction on autopsy. Other pathology included 2 cases of alcohol dependence with DUI/DWI conviction (Case 9 twice and Case 10 once). Six of the airmen reported visiting a health professional within the last 3 years for treatment of conventional problems (flu, hay fever, checkup, back injury, etc).

All 16 airmen exhibited a normal field of vision during their medical examination and 15 "passed" their color vision test (1 missing data point). Their resting (sitting) systolic blood pressure averaged 122 ± 8 mmHg; resting diastolic blood pressure averaged 76 ± 6 mmHg; and their resting heart rate averaged 70 ± 8 bpm. The AMEs medical examination, as described in Form 8500-8 and recorded in DIWS, noted no abnormalities or comments regarding the self-report items, except for noting scars and tattoos for 5 of the airmen.

Nine of the airmen were private pilots with single-engine land rating. Four airmen were commercial pilots with both single- and multi-engine land rating. Flight experience, i.e., total flight hours and flight hours in the last 90 days and 30 days, is presented in Table 3. The majority of the suicides were initiated while maneuvering (6 of 16) or during the descent (7 of 16) phase of operation.

Toxicological findings for 7 of the 14 airmen for which test specimens were available were negative for disqualifying substances (specimens were not available for Cases 11 and 16). Positive toxicological findings included 4 ethanol positives, 2 positive results for benzodiazepines, 1 positive result for marijuana, 1 positive result for cocaine, and 1 positive result for venlafaxine. None of the airmen reported intake of these disqualifying substances during their medical certification process or thereafter. Indeed, the 2 airmen undergoing depression therapy had not reported it to their AME, and only 3 of the 16 airmen (19%) reported taking medications of any kind. Toxicological findings for these 3 cases were negative for disqualifying substances. Table 4 describes these results.

Each of the 4 ethanol-positive values were above the FAA cutoff of 40 mg/dL. In fact, 2 of the pilots tested positive for ethanol above 100 mg/dL, indicating significant impairment. The benzodiazepines identified in 2 of the cases were diazepam and some of its biologically active metabolites (nordiazepam, temazepam, and oxazepam). Diazepam is prescribed mainly as an antianxiety agent and a muscle relaxant. Therefore, the presence of diazepam and its various metabolites suggests possible cognitive impairment. One of the cases that tested positive for diazepam (Case 4) also tested positive for ethanol and cocaine, as well as cocaethylene, an active

Table 3. Flight experience of suicide pilots.

Case #	Age	Class of medical certification	Pilot license	Airplane ratings	Total flight time (h)	Flight time, last 90 days (h)	Total flight time, last 30 days (h)
1	45	3*	Private	SEL†	1915	45	20
2	38	2	Private	SEL	320	3	2
3	20	3	Private	SEL	55	-	-
4	32	3	Private	SEL	164	5	5
5	38	3	Private	SEL	500	-	-
6	67	3	Commercial	Multi- & SEL	5550	171	54
7	26	2	Flight instr., commercial	Multi- & SEL	984	1	1
8	41	3	Private	SEL	148	30	4
9	40	1	Private	SEL	200	-	-
10	22	1	Flight instr., commercial	Multi- & SEL	1203	-	-
11	43	3	Private	SEL	1476	35	15
12	40	3	Student	None	94	-	-
13	15	3	Student	None	19	-	-
14	54	2	Flight instr., commercial	Multi- & SEL	4676	-	-
15	43	2*	Private	SEL	85	-	-
16	47	2*	Student	None	-	-	-

*Medical certificate lapsed

†Single-Engine Land

cocaine metabolite formed from the co-administration of cocaine and ethanol. One victim was found positive for tetrahydrocannabinol (Case 3), the active compound in marijuana, as well as tetrahydrocannabinol carboxylic acid, an inactive metabolite of tetrahydrocannabinol. However, in view of the low level of tetrahydrocannabinol, it was likely that this compound had little direct affect on the pilot's mental processes. One victim had the antidepressant, venlafaxine, and its active metabolite, desmethylvenlafaxine, in his blood at 446 and 1462 ng/mL, respectively. Steady-state therapeutic blood concentrations of these 2 compounds are typically about 180 and 320 ng/mL, respectively, following 6 days of a 150 mg daily dose.¹⁴ The concentrations found in case 14 were significantly higher than therapeutic levels following a typical dosage. These concentrations, in conjunction with the volume of distribution for these compounds, suggest that

the pilot was taking at least the maximum dose of 225 mg per day. The side effects of venlafaxine - including anxiety, nervousness, insomnia, mania, hypomania, seizures, and suicide attempts - increase with dosage, and, therefore, may have affected the pilot's mental faculties. This pilot had not reported using this drug even though he had been in therapy for severe depression. According to the NTSB Accident Report, "The pilot's wife said that he was being treated for depression. A psychotherapist reported that the pilot had been seeing her for approximately 2.5 months, twice a week, for severe depression. She said he was also taking anti-depressant medication."

Each of the compounds found in these 7 aviation accident victims have the potential to impair both judgment and physical ability. These disqualifying substances may have contributed to the events that led to these fatal accidents.

Table 4. Postmortem toxicology findings and self-reported medications.

Case #	Self Report: During Medical Certification Process [*]	Toxicological Analysis/ Disqualifying Substance Present	Substance Amount
1	None [67]	Ethanol	175 mg/hg, lung; 117 mg/hg, muscle
2	None [<1]	None	N/A
3	None [13]	Tetrahydrocannabinol-THC (marihuana) THC carboxylic acid	1 ng/mL, blood 6 ng/mL, blood; 15 ng/mL, urine
4	"1 med", unspecified [20]	None	N/A
5	None [8]	Ethanol	64 mg/dL, blood 77 mg/dL, vitreous humor
6	None [12]	None [†]	N/A
7	None [8]	Ethanol	141 mg/dL, urine; 103 mg/hg, brain 97 mg/hg, muscle
8	None [14]	Diazepam (Valium [®]) Nordiazepam	28 ng/g, kidney; 74 ng/g, liver 69 ng/g, kidney; 134 ng/g, liver
9	None [16]	Ethanol Cocaine Benzoylecgonine Cocaethylene Diazepam Nordiazepam Temazepam Oxazepam	42 mg/dL, blood 5 ng/mL, blood 113 ng/mL, blood; 215 ng/g, liver 31 ng/g, liver 57 ng/mL, blood; 1011 ng/g, liver 76 ng/mL, blood; 1504 ng/g, liver 143 ng/mL, blood; 758 ng/g, liver 1 ng/mL, blood; 492 ng/g, liver
10	None [10]	None	N/A
11	None [17]	N/A*	N/A
12	None [10]	None	N/A
13	Isotretinoin (Accutane [®]), unspecified dosage [2]	None	N/A
14	None [16]	Venlafaxine (Effexor [®]) Desmethylvenlafaxine	446 ng/mL, blood; 3018 ng/mL, urine 1462 ng/mL, blood; 34,102 ng/mL, urine
15	Ranitidine (Zantac [®]), daily, unspecified dosage [49]	None	N/A
16	None [302]	N/A*	N/A

^{*} [] indicates the approximate number of months from last medical to suicide.

^{*} No specimens submitted for analysis.

[†] Postmortem microbial ethanol production.

Certification Aspects

The FAA's medical regulatory responsibilities, that consider public safety as paramount, are different from clinical medicine, where the physician-patient relationship takes precedence.⁹ However, that both have the health of the patient as a common factor, both rely on what an individual reveals in their medical self-report and both depend on what is found during the medical (history and physical) examination. The information gathered on the 16 suicide victims during the medical certification process could not have alerted AMEs of suicidal ideation. In retrospect, it is also doubtful that a psychological examination would have been helpful, as the majority of the accidents seem to have been triggered by events that occurred long after the medical certification process was completed (median 14 months). Further, since an AME's "regulatory" duties would generally not be appreciated by pilots that fear losing their certification, it is especially challenging for the physician to inspire a trusting physician-patient relationship - much less discern if a pilot may be suicidal or expect him to report issues or medications that would put his privilege to fly in jeopardy. Still, to develop potential suicide mitigation/prevention strategies, it is necessary to understand and recognize the stress factors contributing to a person taking his own life. Understanding suicide, as it relates to aviation safety, is a function of aeromedical research, including the integration of toxicology, bioinformatics, accident investigation, and the psychosocial disciplines. Recognizing these factors in a patient seeking medical certification for flight operations is an issue of training and the certification process itself.

According to Remick,¹¹ "there are no pathognomic markers of depression." Specific criteria an AME would address to identify major depression as a concern would include factors such as the individual's sleep pattern, interests, mood, level of energy, concentration, appetite, etc. However, a pilot seeking to be medically certified will typically present himself as happy and healthy, especially to the physician he believes whose job it is to restrict flying activities if found otherwise. Major depression is a significant risk factor for the development of coronary artery disease and stroke, compounding the medical certification assessment process. The most prevalent avenue for the treatment of depression is the use of Selective Serotonin Reuptake-Inhibitors (SSRIs); however, SSRIs have drawn high interest from the aerospace medical community in terms of their effects on psychomotor performance and the persistence of symptoms after weeks of receiving an adequate dose of these antidepressants.^{3, 6, 8, 10}

To address psychosocial issues, Yanowitch et al.¹³ proposed that "increasing pilot insight into the role of emotional and situational stress in accident causation" should lead to more effective accident prevention programs. They proposed the "psychosocial autopsy" approach, developed in 1955, by composing a "psychosocial reconstruction inventory, that attempts to answer the WHY of the accident. It includes a "retrospective portrait" of the victim in terms of lifestyle, as learned from family and friends. This approach implies the need for an aeromedical research scientist to be an integral component of the accident investigation team. Also, investigating the circumstances surrounding the accident would lead to improved security processes that could frustrate the efforts of the emotionally vulnerable pilot. Finally, the integration of this type of information with existing data from the NTSB and aeromedical certification databases, along with autopsy and toxicological reports, could advance the contribution of the bioinformatics sciences in the development of better avenues to aircraft accident prevention.

Unfortunately, while one could say that 100% of the victims were experiencing depression at the time of suicide, probably no one could have stopped their making the final suicidal choice. Witness the 2 victims who were apparently undergoing professional treatment for depression or the 8 cases where the victims discussed suicide with friends or family immediately prior to doing so.

CONCLUSION

Most of the "suicide" pilots had significant domestic/criminal difficulties at the time of their suicide. The limited data presented here indicate that 50% (7 out of 14) of all aviation-assisted pilot suicides, for which toxicological specimens are available for analysis, involve at least one, if not more, disqualifying substances, and 43% (6 of the 14) had potentially cognitive impairing levels of such substances in their system. During the medical certification process for the 16 suicide victims, no information gathered would have identified suicidal ideation. The majority of the suicides were likely triggered by events occurring long after the medical certification process had been accomplished. However, it must be stressed that pilot-assisted suicide appears to be an uncommon event, accounting for less than one-half of 1 percent of all fatal general aviation accidents. Also significant is the fact that, over the 10-year period of this study, no one other than the pilot was injured during the course of an aviation-assisted suicide.

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