Cardiac Inflight Incapacitations of U.S. Airline Pilots: 1995–2015

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INTRODUCTION: Inflight medical incapacitations are rare events that can result in the loss of lives and aircraft. The potential for an in-flight medical event deserves the attention of certification authorities. Cardiac emergencies are among the most common serious events. The primary focus of this study was to examine whether the proportions of pilots with reported cardiac conditions could be used to identify those who had inflight medical incapacitations.

METHODS: The Civil Aerospace Medical Institute Inflight Incapacitation Registry was searched to identify airline pilots with a cardiac history and an inflight medical event between 1995 and 2015. The Federal Aviation Administration's Decision Support System was searched for airline pilots without an inflight medical event. The cardiovascular history of incapacitated pilots was then compared to that of airline pilots without incapacitation events.

RESULTS: Although a significantly greater proportion of airline pilots with cardiac events had pacemakers than a control group with the same cardiac history who did not have inflight events, no significant difference was found in the proportions of other markers of cardiac health.

CONCLUSION: The proportions of airline pilots with identified cardiac conditions could not be reliably used to identify which pilots had inflight incapacitations.

KEYWORDS: airline, pilot, inflight, medical, incapacitation, cardiovascular, events, risk factors.

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For some time, it was believed that the first accidents attributed to pilot inflight medical incapacitation occurred in 1911; however, after reviewing these cases, Parmet and Underwood-Ground attributed them to pilot error. Therefore, the date of the first aircraft accident ascribed to pilot inflight medical incapacitation is still unknown.[23]

Inflight medical incapacitation has been given various definitions by different researchers. Leighton-White defined incapacitation as any condition that renders a pilot incapable of performing inflight duties.[15] Martin-Saint-Laurent et al. characterized it as a situation that prevents a pilot from performing normal or emergency operations and described a partial incapacitation as a temporary circumstance that distracts the pilot's attention.[18]

Although overt incapacitation would most likely be noticed by other crewmembers, a subtle event may not be detected, especially during takeoff or landing, since extraneous communication in the cockpit is discouraged at these times.[17] In addition, if flight duties are assumed by other crewmembers at these times, they are often unreported.[22]

The most common categories of medical complaints among airline crews include loss of consciousness, gastrointestinal, and neurological and cardiac events. Cardiac and neurological complaints comprise the more serious emergencies, requiring either aircraft diversions or the need of ground-based medical assistance. Among these, cardiac emergencies are the most common.[8,9]

Comparing results between review papers that have examined air carrier inflight incapacitation rates is often difficult because of the manner in which they have been reported. For example, one study reported an airline pilot inflight medical event rate of 0.058 per 100,000 flying hours in a review of airline

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pilot incapacitation from 1993 to 1998.[7] In contrast, another study found that there were 16 events per year from 1965 to 1981.[4]

Inflight incapacitation can result in the loss of lives and aircraft.[1,6,13] Fortunately, few U.S. airline inflight medical incapacitation events have resulted in aircraft accidents. One review of inflight medical incapacitations and impairments of U.S. airline pilots found that 2 out of 50 events resulted in an accident over a 6-yr period,[6] while another study disclosed that in 5 cases, the death or preceding incapacitation of the pilot was the direct cause of an accident, resulting in a total of 147 fatalities from 1961 to 1968.[2]

In addition to aircraft accidents, medical events have led directly to inflight pilot fatalities. A study of inflight medical events between 1993 and 1998 reported four pilot fatalities related to their incapacitating event. All four deceased pilots died because of cardiac events. Three of the four deaths resulted from myocardial infarctions (MIs), while one was the result of a cardiac dysrhythmia.[7]

Airline pilots receive periodic health risk assessments because inflight incapacitation can be so devastating in terms of lives and aircraft lost.[1,6,13] The assessment of the risk of an inflight incapacitating event during a finite time period is crucial to the determination of an individual's fitness to fly.[10] Existing aviation medical standards place a great deal of emphasis on the cardiovascular status of the pilot. The current approach of most aeromedical certification authorities to determine the level of cardiovascular risk, including first-class medical certificate applicants over 35 yr old in the United States, relies primarily on a medical history and annual electrocardiogram (ECG) and, if warranted, follow-up includes an exercise ECG.[19,24]

One of the main purposes of flight crew aeromedical standards is to reduce the probability of an inflight incapacitation event.[2] The objective of aeromedical standards worldwide is to minimize the risk of incapacitation by maintaining high standards, which can screen out pilots with a significant risk of incapacitation.[21] As a result of these rigorous medical selection standards, airline pilots are normally healthier than the general population.[14,16,17] This is especially true for cardiovascular and cerebrovascular diseases, which are important causes of inflight incapacitation.[5,6,17] However, although the present rigorous medical standards greatly reduce the probability of an inflight medical event, routine medical examinations cannot accurately predict inflight incapacitations.[15]

The primary focus of this study was to examine whether the proportions of pilots with identified cardiac conditions could be used in practice to identify pilots who had inflight cardiac incapacitations.

METHODS

The Civil Aerospace Medical Institute (CAMI) Incapacitation Data Registry is an internal Federal Aviation Administration (FAA) data system that contains detailed medical, toxicological, physical, and human factors data on over 1000 U.S. pilots, including more than 500 airline pilots, who experienced inflight medical events from 1993 to present, in a Microsoft Access® database. The registry was searched for airline pilots who experienced an inflight medical incapacitation between 1995 and 2015. Search criteria included subject identification number, FAA applicant identification number, age, gender, medical class issued, recent and total flight times, medications, category of incapacitation, date of event, and pathology codes assigned by the FAA prior to and after an inflight medical event.

The term "incapacitated" referred to a pilot who could not perform any of their crew duties, or who could perform some of their assigned duties with degraded performance. Documented medical conditions were associated with pathology codes assigned by the FAA. Pathology codes are alphanumeric codes for medical conditions and relevant procedures assigned to an individual airman as part of their permanent medical record.

The Decision Support System (DSS) is an internal FAA Oracle® data warehouse, which is part of the Medical Support System, containing more than 23 yr of longitudinal medical certification data that has been matched to aircraft accident data, permitting the scientific study of aeromedical decision-making processes. The DSS was searched for all airline pilots between 1995 and 2015 and previously documented medical conditions were associated with pathology codes assigned by the FAA. Search criteria included: applicant identification number, gender, medical class issued, pathology codes assigned by FAA, age, and date at the time of pathology code assignment.

Airline captains are required to have an airline transport (ATP) rating. The FAA's requirements for an ATP rating are to be at least 23 yr of age, possess a commercial pilot's certificate with an instrument rating, and have at least 1500 h of total flight time. First officers were not required to have an ATP rating until August 1, 2013.[12] For the purposes of this study, airline pilots were defined as pilots who were between 23 and 64 yr of age and held either a first- or second- class medical certificate and an ATP rating, or held a first-class medical certificate with an ATP or a or second-class medical certificate with a commercial pilot's certificate, instrument rating, and a minimum of 1500 h of total flight time prior to July 31, 2013.

After applying these criteria to a search of the DSS, a control group of 195,730 U.S. airline pilots who did not have an inflight medical incapacitation was identified. A subset of 70,283 pilots with previously identified cardiac pathology who did not have an inflight medical incapacitation was also identified.

In addition, a search of the Incapacitation Data Registry revealed that 173 U.S. airline pilots were found to experience some form of inflight medical incapacitation. Age matching was accomplished by pairing each of the 173 incapacitated pilots to all available control group pilots who were the same age in the same year as the incapacitated pilot for all medical conditions and procedures. The number obtained was then multiplied by 1000 and divided by the total number of control pilots of the same age in the year of the event:

$$\frac{1{,}000 \times \text{Number of Controls with the Cardiac Condition or Procedure}}{\text{Total Number of Control Pilots of the Same Age in the Same Year}}$$

This produced a group of 173,000 controls, with 1000 controls for each incapacitated pilot.

The resulting contribution for each incapacitated pilot was summed to obtain the number of age-adjusted control pilots for each category of cardiac pathology or procedure of interest for all incapacitated pilots. This method of matching incapacitated pilots to control pilots who were the same age in the same year (i.e., 59 in 2002), rather than simply matching ages without regard for the year of the event, accounted for any potential changes that may have occurred in both medical science and aeromedical certification standards over time.

The proportions of specific cardiovascular conditions such as hypertension, coronary artery disease, and myocardial infarctions, as well as related cardiovascular procedures, including stent placement and coronary artery bypass surgery, were compared between incapacitated pilots and airline pilots of the same age, with the same pathology, who did not experience an inflight incapacitation.

Descriptive and inferential statistics were performed using SPSS (Version 24) with alpha levels of 0.05. A two-tailed *t*-test was used to compare the age of airline pilots with cardiac incapacitations to the age of airline pilots who experienced other categories of inflight medical incapacitations. Chi-squared tests were used to compare the difference in the proportions of men to women between the incapacitation group and the control group. A Z-test was used to compare the proportions of cardiovascular disease for pilots with cardiac inflight events and noncardiac events with the same age groups for U.S. men in the general population from 2011 through 2015. Fisher Exact tests were used to compare proportions of incapacitated airline pilots with a history of coronary artery bypass surgery, an MI, or a cardiac pacemaker to airline pilots with the same cardiac pathology who did not have inflight events.

RESULTS

There were 195,730 U.S. airline pilots identified between 1995 and 2015 who did not have an inflight incapacitation. Of these 188,998 were men and 6732 were women. Of these 195,730 airline pilots, 70,283 had been diagnosed with some form of cardiovascular disease (CVD) and assigned cardiac pathology codes by the FAA.

Between January 1, 1995, and December 31, 2015, 173 U.S. airline pilots experienced some form of inflight medical incapacitation. Of the incapacitated pilots, 4 were women and 169 were men. Their ages ranged from 25 to 63 yr with a mean and SD of 47 $\pm$ 9.5 yr. First-class FAA medical certificates were held by 162, and 11 held second-class certificates. Of the 173 inflight medical incapacitations, 23 were cardiac events.

There were 150 U.S. airline pilots who suffered noncardiac inflight medical incapacitations during the study period; 4 were women and 146 were men. Their ages ranged from 25 to 62 yr with a mean age of 46 $\pm$ 9.6 yr. There were 139 pilots who held first-class medical certificates, while 11 held second-class certificates.

Of the 173 pilots who experienced inflight medical incapacitations during the study, 23 had cardiac-related events. All 23 were men and all held a first-class medical certificate. Their ages ranged from 34 to 63 with a mean age of 53 $\pm$ 6.2 yr. Their flight time in the preceding 6 mo ranged from zero to 541 h with a mean of 325 $\pm$ 140 h, and total flight time varied from 2800 to 28,000 h with a mean of 16,288 $\pm$ 6148 h.

The mean age of the 23 pilots with cardiac inflight medical events was 53.2 $\pm$ 6.2 yr. This was significantly greater than the mean of 46.4 $\pm$ 9.6 yr for the 150 pilots that experienced noncardiac events ($t = 4.55$, df = 40.35, $P < 0.001$). The age range for the pilots with cardiac inflight medical events was 47 to 59 yr, while that of the noncardiac group was 34 to 56 yr of age. The proportions of cardiac deaths from 2011 to 2015 for U.S. men ages 47 to 59 (corresponding to the cardiac event group) and ages 34 to 56 (corresponding to the noncardiac event group) were compared. The proportion of cardiac deaths was significantly greater in the 47 to 59 yr age group of U.S. men than the 34 to 56 yr age group ($Z = -187.9$, $P < 0.05$), confirming that our results were similar to what was found in the general population; that the older age group experienced a greater proportion of cardiac pathology.[3] **Table I** contains summary data for the 23 pilots who had cardiac inflight incapacitation events.

There were 30 pilots with noncardiac inflight events and 8 pilots with cardiac inflight events who had been assigned cardiac pathology codes prior to their events. Airmen may be granted a time limited, special issuance (SI) medical certificate by the FAA CAMI Aerospace Medical Certification Division (AMCD) when it is evident a pilot has a medical condition that makes them ineligible for a regular medical certificate under Title 14, Part 67 of the Code of Federal Regulations. Of the 23 incapacitated pilots, 3 had been granted SIs: one for atrial fibrillation; another for myocardial infarction, a coronary artery bypass surgery, angina pectoris and hypertension; and a third for apical hypertrophic cardiomyopathy, premature atrial contractions, and bradycardia.

Inspection of Table I reveals that 9 of the 23 incapacitated pilots died as a result of their inflight event. One of the nine deceased pilots had been issued a SI medical certificate for myocardial infarction, coronary artery bypass surgery, angina pectoris, and hypertension. Of the 23 incapacitated pilots, 14 survived their inflight event. Two of the surviving pilots had previously been issued a SI medical certificate: one for atrial fibrillation and another for apical hypertrophic cardio-myopathy, premature atrial contractions, and bradycardia.

Prior to their event, 15 of the 23 pilots who experienced cardiac inflight incapacitations, including 6 of the 9 deceased pilots, were either not on any cardiac medications, had not been evaluated for cardiac medical conditions or related procedures, or both. In 7 cases, cardiac pathology codes were added to the pilot's FAA permanent medical history file after their inflight event.

Proportions of incapacitated airline pilots with preidentified cardiovascular conditions of particular importance to aerospace medicine were compared to proportions of airline pilots with the same conditions who did not have inflight medical events. Cardiovascular conditions included hypertension,

Table I. Summary Data for Pilots Who Had Cardiac Inflight Incapacitating Events.

AGE	SI	DECEASED	CONDITIONS/PROCEDURES PRIOR TO EVENT	CONDITIONS/PROCEDURES POST EVENT	CARDIAC MEDS PRIOR TO EVENT	CARDIAC MEDS POST EVENT	LAST 6 MONTHS FLIGHT TIME (h)	TOTAL FLIGHT TIME (h)
34	N	N		CVD < 49% occlusion			400	2800
47	N	N		MI, Angioplasty with stent, CVD with AP	Atorvastatin		200	7863
48	N	Y					400	5600
48	N	N		Pericarditis			541	14,503
48	N	N	MVP, AF, HTN		Aspirin		118	15,770
48	N	N	HTN				300	9000
51	N	Y					327	16,076
51	Y	N	AFI	AF with rapid ventricular response	Sotalol Hydrochloride, Warfarin, Atorvastatin		0	11,500
51	N	N		PSVT			400	17,500
52	N	N		Angioplasty with stent			400	19,000
53	N	Y					341	21,732
55	N	N	HTN		Telmisartan	Toprol	0	11,300
56	N	Y					450	17,750
56	N	N					420	20,000
56	Y	Y	MI, CABG, AP, HTN		Amlodipine, Aspirin, Atorvastatin, Carvedilol, Altace, Ezetimibe		440	23,800
57	N	N		MI			200	18,000
57	N	Y					300	15,660
57	N	Y	AF, Bradycardia		Aspirin, Flecainide, Metoprolol		480	28,000
57	N	N		MI, Angioplasty with stent, CVD with AP	Atorvastatin		350	18,950
58	N	N					274	19,576
60	N	Y	HTN		Lisinopril, Pravastatin		400	25,000
61	Y	N	AHCM, PACs, Bradycardia		Atorvastatin, Warfarin		350	15,250
63	N	Y					405	20,000

Abbreviations: Y (Yes), N (No), SI (Special Issuance), CVD (Cardiovascular Disease), MVP (Mitral Valve Prolapse), HTN (Hypertension), PSVT (Paroxysmal Supraventricular Tachycardia), AP (Angina Pectoris), CABG (Coronary Artery Bypass Graft), AF (Atrial Fibrillation), AHCM (Apical, Hypertrophic Cardiomyopathy), PACs (Premature Atrial Contractions).

coronary artery disease, and myocardial infarctions. Related cardiovascular procedures included stent placement, implanted pacemaker and coronary artery bypass surgery. The medical conditions and procedures were documented in the DSS by pathology codes assigned by the FAA AMCD.

The proportion of the 173 incapacitated pilots with a history of either coronary artery bypass surgery ($P = 0.01$) or myocardial infarction ($P = 0.01$) was greater than the proportion of all airline pilots with the same cardiac histories who did not have inflight events. In addition, there was no significant difference in the proportions of incapacitated pilots with a history of occlusions of greater than 50% of a coronary artery, a history of stent placement, or a pacemaker when compared to the proportion of all airline pilots with these histories who did not have inflight events. Interestingly, airline pilots without inflight events had a significantly greater proportion of hypertension requiring medication ($\chi^2 = 24.59$, df = 1, $P < 0.0001$) and cardiac pathology in general ($\chi^2 = 20.50$, df = 1, $P < 0.0001$) than incapacitated pilots.

DISCUSSION

We found that inflight incapacitations are rare events, affecting less than 0.1% of U.S. airline pilots. Cardiac inflight events were even more infrequent, involving only 0.01% of airline pilots; however, they are serious situations that can result in injuries, fatalities, and loss of aircraft.[1,6,13] Therefore, the potential for an inflight medical event deserves the attention of the aerospace medical community and, specifically, certification authorities.

Unfortunately, using proportions of pilots with preassigned medical conditions defined by FAA pathology codes could not be used to reliably identify which pilots would have inflight cardiac incapacitations. Although a significantly greater proportion of the 23 pilots with inflight cardiac events had pacemakers than the age adjusted airline pilot control group ($P = 0.02$), this was based on a single incapacitated pilot having a pacemaker. There was no significant difference in the proportions of hypertension requiring medication, coronary artery occlusion greater than 50%, a history of a myocardial infarction, coronary artery bypass surgery, or stent placement when adjusted for age.

Airline pilots without inflight events had a significantly greater proportion of hypertension requiring medication and cardiac pathology in general than incapacitated pilots. This is an interesting finding. When Mills found that pilots who did not have aircraft accidents had more hypertension requiring medication than pilots who had accidents, he proposed that hypertension was protective, in that airmen who are conscientious enough to discover and treat their condition may have a similar orientation to flight safety issues such as filing flight

plans and double checking fuel levels.[20] Similar logic applied here could imply that pilots who report their hypertension to their Aviation Medical Examiner, and are subsequently regularly followed, are less likely to develop more serious CVD that may lead to a future cardiac event inflight.

Fortunately, the FAA has standardized procedures for the disposition of CVD cases. Applications for all classes of medical certificates with an established medical history or clinical diagnosis of an MI, angina pectoris, cardiac valve replacement, permanent cardiac pacemaker implantation, or CVD that has required treatment require an FAA decision and cannot be granted by the airman's Aeromedical Examiner (AME). Recovery time and required documentation before a medical certificate can be issued vary by the class of medical certificate applied for and the CVD category.[11] These rigorous procedures may have resulted in our finding of an age-adjusted inflight cardiac incapacitation rate of only 13.3/100,000 pilots in this study.

CONCLUSIONS

In summary, we found that identification of pilots at risk for an inflight cardiac incapacitation could not be reliably accomplished by comparing the proportions of incapacitated pilots with preassigned cardiac pathology codes to the proportion of all airline pilots with the same cardiac pathology codes who did not have an inflight event. We felt that if the proportions we evaluated were to be used as indicators of potential inflight cardiac events, we would need to rely on more than a single proportion, especially since only a very small fraction (0.04%) of all airline pilots studied were flying with implanted pacemakers.

It should be stressed, however, that current FAA aeromedical certification procedures require extensive diagnostic testing to evaluate potential risk after a cardiovascular event. Based on this assessment, a decision is made whether the pilot can be safely certified. This often results in a SI medical certificate which requires follow-up with close medical supervision and periodic re-evaluation. These protocols are not employed to predict which pilots will have a future inflight cardiac event. Although the lack of a significant difference in the proportion of most cardiac-related pathology codes between pilots suffering cardiac-related incapacitations and an age adjusted airline pilot control group with the same cardiac history suggests that FAA aeromedical management of pilots with known cardiac conditions is sufficient to ameliorate the risk of incapacitation in those pilots.

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REFERENCES

1. Billings CE. Human factors in aircraft incidents - results of a 7-year study. Aviat Space Environ Med. 1984; 55:960–965.
2. Buley LE. Incidence causes and results of airline pilot incapacitation while on duty. Aviat Space Environ Med. 1969; 40:64–70.
3. Centers for Disease Control and Prevention. Underlying causes of death. [Accessed on March 27, 2017.] Available from: https://wonder.cdc.gov.
4. Chapman PJ. The consequences of in-flight incapacitation in civil aviation. Aviat Space Environ Med. 1984; 55:497–500.
5. De Stavola BL, Pizzi C, Evans S, Evans A, dos Santos S. Cause-specific mortality in professional flight crew and air traffic control officers: findings from two UK population-based cohorts of over 20,000 subjects. Int Arch Occup Environ Health. 2012; 85(3):283–293.
6. DeHart RM. Coronary heart disease: an expensive Air Force problem. Aviat Space Environ Med. 1980; 51(9 Pt. 2):1057–1063.
7. DeJohn C, Wolbrink A, Larcher J. In-flight medical incapacitation and impairment of U.S. airline pilots: 1993 to 1998. Washington, DC: Federal Aviation Administration; 2004.
8. DeJohn CA, Wolbrink A, Larcher J. Inflight medical incapacitation and impairment of airline pilots. Aviat Space Environ Med. 2006; 77(10):1077–1079.
9. Dowdall N. Is there a doctor on the aircraft - top 10 inflight emergencies. BMJ. 2000; 321(7272):1336–1337.
10. Evans S, Radcliffe S. The annual incapacitation rate of commercial pilots. Aviat Space Environ Med. 2012; 83(1):42–49.
11. Federal Aviation Administration. Guide for Aviation Medical Examiners. [Accessed on May 23, 2018]. Available from: https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/ame/guide/.
12. Federal Aviation Administration. Pilot Certification and Qualification Requirements for Air Carrier Operations. Federal Aviation Notice N 8900.225. July 10, 2013.
13. Froom P, Jochanan B, Gross M, Ribak J, Lewis B. Air accidents pilot experience and disease related inflight sudden incapacitation. Aviat Space Environ Med. 1988; 59:278–281.
14. Huster KM, Muller A, Prohn MJ, Nowak D, Herbig B. Medical risks in older pilots: a systematic review on incapacitation and age. Int Arch Occup Environ Health. 2014; 87(6):567–578.
15. Leighton-White RC. Airline pilot incapacitation in flight. Aerosp Med. 1972; 43(6):661–664.
16. Linnersjö A, Brodin L, Andersson C, Alfredsson L, Hammar N. Low mortality and myocardial infarction incidence among flying personnel during working career and beyond. Scand J Work Environ Health. 2011; 37(3):219–226.
17. Mantziari L, Styliadis C, Kourtidou-Papadeli C, Styliadis I. Arrhythmias, sudden cardiac death and incapacitation of pilots. HIPPOKRATIA. 2008;12(Suppl 1):53–58.
18. Martin-Saint-Laurent A, Lavernhe J, Casano G, Simkoff A. Clinical aspects of inflight incapacitations in commercial aviation. Aviat Space Environ Med. 1990; 61(3):256–260.
19. McLoughlin DC. Aircrew periodic medical examinations. Occup Med (Chic Ill). 2003; 53(1):11–14.
20. Mills W. The association of aviator's health conditions, age, gender, and flight hours with aircraft accidents and incidents. [Doctoral dissertation.] University of Oklahoma, Norman, OK; 2005.
21. Mitchell S, Evans A. Flight safety and medical incapacitation risk of airline pilots Aviat Space Environ Med. 2004;75(3):260–268.
22. Mohler SR, Booze C. US fatal GA accidents due to cardiovascular incapacitation 1974–1975. Aviat Space Environ Med. 1978; 49(10):1225–1228.
23. Parmet AJ, Underwood-Ground KE. Reported in-flight incapacitation: the early birds of 1911. Aviat Space Environ Med. 1987; 58(3):276–278.
24. Wirawan IMA, Aldington S, Griffiths R, Ellis C, Larsen P. Cardiovascular investigations of airline pilots with excessive cardiovascular risk. Aviat Space Environ Med. 2013; 84(6):608–612.