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16. Abstract

Incapacitation in the general aviation flight environment is a matter of utmost concern to the Federal Aviation Administration since the likelihood of accident is greater due to a lack of redundant pilot skills in most instances. The purpose of this study was to appraise the adequacy of medical standards in minimizing the risk of sudden incapacitation.

This study considered NTSB data and postcrash medical data received by the Medical Statistical Section of the Civil Aeromedical Institute (CAMI), Oklahoma City, Oklahoma, during the time period from 1975 to the present and other related literature to estimate the probability of incapacitation in general aviation.

Data for the years studied indicate that approximately 3 accidents per thousand (15 per 1,000 fatal accidents) are known to result from the incapacitation of the pilot for all causes. Results further suggest that the likelihood of incapacitation increases with age.

The occurrence of incapacitation for obvious medical reasons is less than would be expected based on general population morbidity/mortality data; however, the need for continued vigilance in certification and education regarding flying with known or suspected medical problems is emphasized.

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SUDDEN IN-FLIGHT INCAPACITATION IN GENERAL AVIATION

INTRODUCTION

The subject of incapacitation involving a crewmember in the flight environment has been of intense interest to the aviation medical community since the early days of aviation. This interest and concern for the possibility of sudden incapacitation have been the foundation for development of medical standards and the subject of much controversy concerning the implied dangers of allowing airmen with various medical problems to fly. Incapacitation in the general aviation flight environment is a matter of utmost concern to the Federal Aviation Administration (FAA) since the likelihood of accident is greater due to a lack of redundant pilot skills in most instances. This study of general aviation accident data was accomplished to address those ongoing interests and concerns based upon the latest information available.

MATERIALS AND METHODS

Review of the literature dealing with incapacitation was accomplished to include so-called "complete" versus "partial or subtle" incapacitation in the multi-crew airline environment as well as the usual single-crew general aviation environment. Additionally, general aviation accident records maintained by the FAA and the National Transportation Safety Board (NTSB) were referenced to provide background and basis for the material developed. The NTSB, of course, has the final responsibility for assigning the probable causes of civil aviation accidents. The FAA's Office of Aviation Medicine (OAM) is extensively involved in supporting the NTSB where possible, or when called upon, in conducting medical and human factor investigation of aviation accidents. The OAM is also interested in precrash and postcrash medical findings to verify the appropriateness of medical standards and identify environmental hazards to flight safety. Records maintained by the FAA have been referenced dating back to 1975 for purposes of this study. Estimates of the probability of sudden incapacitation and probability of accident given incapacitation in general aviation were developed based on literature, historical, and current FAA/NTSB findings.

RESULTS AND DISCUSSION

The definition of incapacitation may vary considerably based on the interest and perspective of the observer, the population being studied, and the likelihood of reporting. To be sure, any change in the ability of a flight crew member to function appropriately, whether due to physiological or psychological reasons, may be appropriately labeled incapacitation. This definition includes all possible disease states, as well as other temporary and traumatic causes of sudden incapacitation. Practically speaking, however, the most probable causes of incapacitation, in terms of likelihood of subsequent discovery in general aviation, are cardiovascular/cerebrovascular, alcohol, and drugs. Food poisoning and other gastrointestinal disorders, while representing an important cause of incapacitation in studies of multi-crew environments, are unlikely to be discovered in general aviation should a fatal accident ensue. Clearly, the most important cause of sudden incapacitation or death among those diseases likely to be discovered in general aviation accidents is coronary heart disease. United States population mortality data further suggest that cerebrovascular disease

accounts for approximately 20% of all deaths due to cardiovascular disease. Alcohol and drug involvement in general aviation accidents, while fluctuating greatly over the years of the study, is currently found in 7.7% of accidents (1).

The implications of sudden complete, or even partial, incapacitation in the general aviation environment are likely to be more ominous since it is unlikely that a second qualified pilot would be on board, whereas incapacitation in the multi-crew commercial aviation environment has repeatedly been shown to result in a low probability of accident outcome (3,6,7). Records maintained by the NTSB show a total of 37 fatal general aviation accidents due to incapacitation in the United States from 1959 to 1965; approximately 6 known cases per year (8). A breakdown of more recent NTSB data for all causes of pilot incapacitation is provided in Table 1. From 1975 to 1982 the total number of accidents where incapacitation was recognized equaled 92. Thirty-six of these cases were due to cardiovascular conditions (approximately 5 per year). Alcohol and a variety of other reasons ranging from pesticide poisoning to fire in the cockpit were cited as causes of incapacitation in the other cases (8). These known cases of incapacitation are no doubt a conservative estimate of accidents involving incapacitation given that trauma, fire, and inattention to detail mask medical factors involvement in some accidents.

Autopsy studies conducted by FAA have found an average of 5 cases per year involving cardiovascular incapacitation with an autopsy rate of 38%, or 13 cases per year when extrapolated to the entire fatal general aviation accident population (2). As in the Framingham follow-up and other general population studies, this study also indicates a higher probability of cardiovascular incapacitation with age (see Figure 1) (4). The overall likelihood of complete cardiovascular incapacitation, based on extrapolated values, is 1.6 recognized cases per 100,000 airmen per year, or 0.037 cases per 100,000 hours flown in general aviation (1 incapacitation per 2,683,629 hours flown). These estimates, of course, assume an accident outcome for each case of incapacitation, a reasonable assumption for the cases indentified in this instance.

Chapman has documented a cardiovascular incapacitation rate resulting in accident of 1 per 8,307,082,800 (0.000012 per 100,000 hours flown) from International Air Transport Association data (3). He further reports this rate to be at least 10 times better than is required by Airworthiness Criteria (European Joint Airworthiness requirements and Federal Aviation Regulations) for comparably vital aircraft systems. Obviously, the multi-crew environment is much safer than general aviation by comparison.

Earlier FAA studies also indicate a prevalence of severe coronary artery disease in some 5% of autopsied general aviation pilots in command for the years 1975 through 1977 (4).

How many of these latter victims were either partially or completely incapacitated by their disease is unknown from autopsy or other findings, representing an important point to ponder.

Tunstall-Pedoe describes an approach involving the application of age-specific mortality data to estimation of incapacitation among pilots. He also observes that a nonfatal attack can be disabling, thus rendering the pilot incapable of performing the coordinated activity required by flying (9). Conversely, it is well known that many people have carried on normal activity for some time while experiencing a heart attack. Keele found 30% of cases studied to have continued normal activities while experiencing cardiac pain (5).

Utilizing the age distribution of known incapacitation over the 8 years of the study to distribute the 13 cases per year of incapacitation estimated by the 1975-77 FAA Autopsy Study yields the rates contained in Table 2.

Clearly, the older age groups experience higher rates and contribute more to the total cardiovascular incapacitations expected in general aviation annually. While estimates of incapacitation are subjective at best, these findings emphasize, as have other studies, the need for special medical scrutiny of older age groups.

It is important to recognize the relative importance of incapacitation to accident causation. During the 8 years involved in this study, a total of 30,447 general aviation accidents occurred, of which 5,163 involved one or more fatalities. All known causes of incapacitation amount to 92 cases for a rate of 3 accidents per thousand and 15 accidents per thousand fatal accidents due to incapacitation. Even based on the higher estimated incapacitation rates contained in Table 2, recognized medical factors still only account for 2% of all fatal accidents. It is known from other studies that only half of sudden death victims have overt disease. However, the impact of evolving medical certification criteria should be closely monitored for adverse trends since we also know that sudden death occurs about nine times more frequently among the same age groups with overt cardiovascular disease (4). At present, it seems likely that greater impact could be achieved by convincing airmen not to fly when experiencing any symptoms which might affect performance.

SUMMARY

Accident rates for cardiovascular incapacitation are low compared to other factors known to contribute to general aviation accidents. Older age groups experience higher incapacitation rates and contribute more to the total incapacitations expected in general aviation. Greater education efforts concerning the importance of medical fitness in the aviation environment are likely to be more productive in reducing medical factors involvement in general aviation accidents than are stricter medical criteria.

Table 1

General Aviation Aircraft Accidents
Involving Pilot Incapacitation (All Causes)
1975 - 1982

Year	Total Accidents	Fatal Accidents	Known Accidents Involving Incapacitation	
			Total	Fatal
1975	3,995	633	19	18
1976	4,018	658	14	12
1977	4,079	661	11	7
1978	4,216	719	11	8
1979	3,818	631	6	5
1980	3,590	618	13	11
1981	3,500	654	10	9
1982*	3,231	589	8	7
TOTAL	30,447	5,163	92	77

*Last year for which complete data are available.

Source: National Transportation Safety Board; Washington, D.C.

Table 2

Estimated Annual Rates of
Cardiovascular Incapacitation in General Aviation

Age	Estimated Frequency	Mid-year Population	Cardiovascular Incapacitation Annualized Rate/100,000	Expected Cardiovascular Incapacitation
20-29	0	280,676	0	0
30-39	11.5	238,083	0.6	1.4
40-49	28.9	166,550	2.2	3.7
50-59	23.1	104,236	2.8	2.9
60 +	40.4	24,497	20.6	4.9
TOTAL	104.0	814,042	1.6	13.0

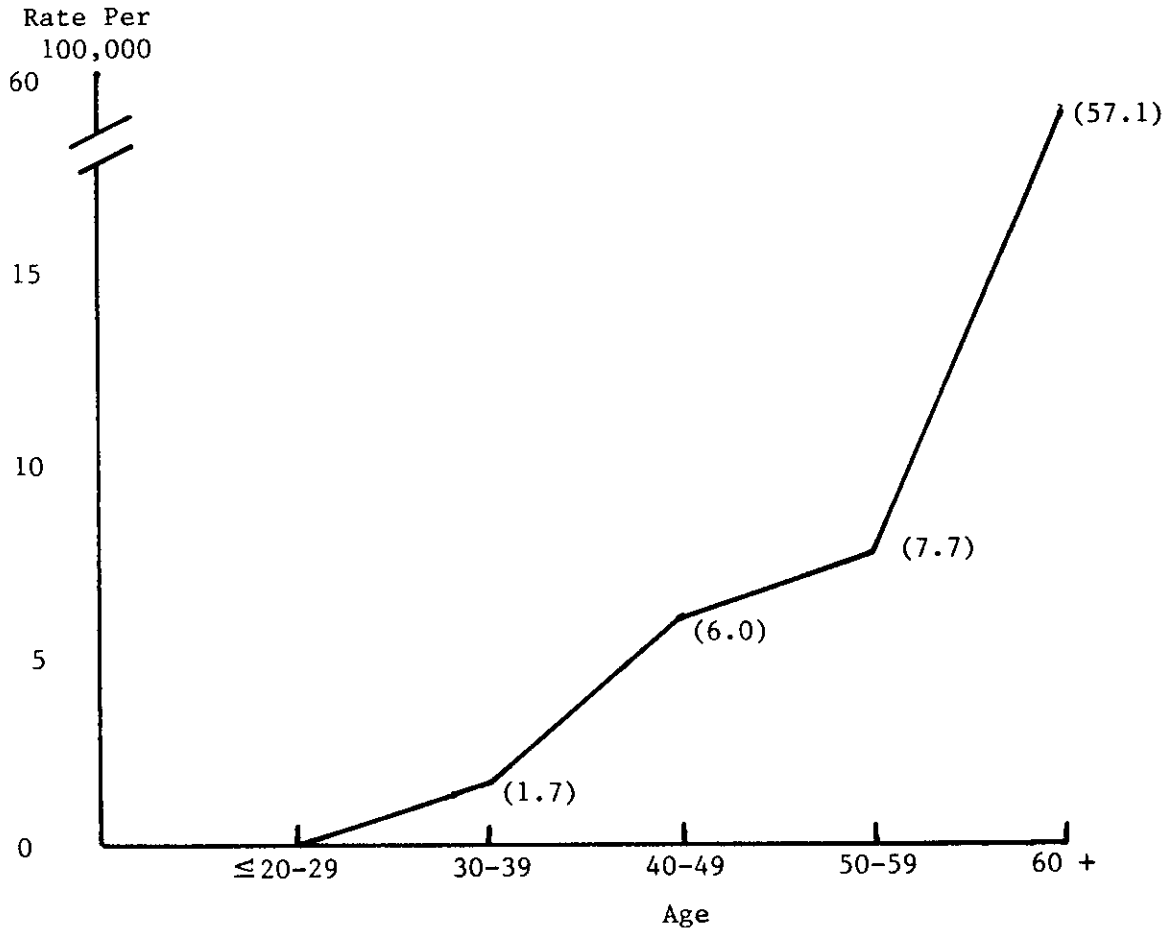

FIGURE 1. KNOWN CARDIOVASCULAR INCAPACITATION AMONG GENERAL AVIATION PILOTS BY AGE GROUP 1975 - 1982

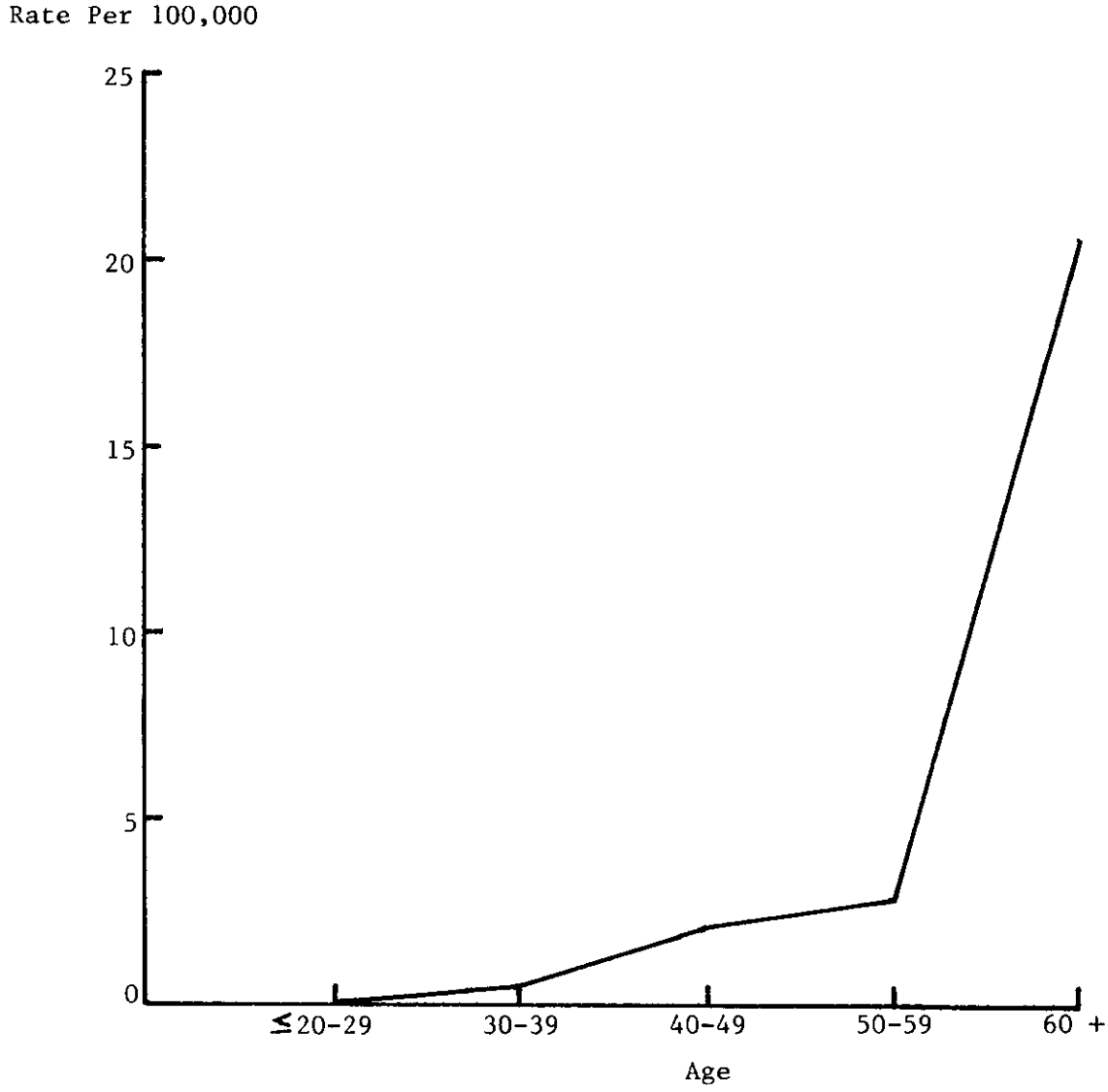

FIGURE 2. ESTIMATED ANNUAL RATES OF COMPLETE CARDIOVASCULAR INCAPACITATION IN GENERAL AVIATION BY AGE GROUP

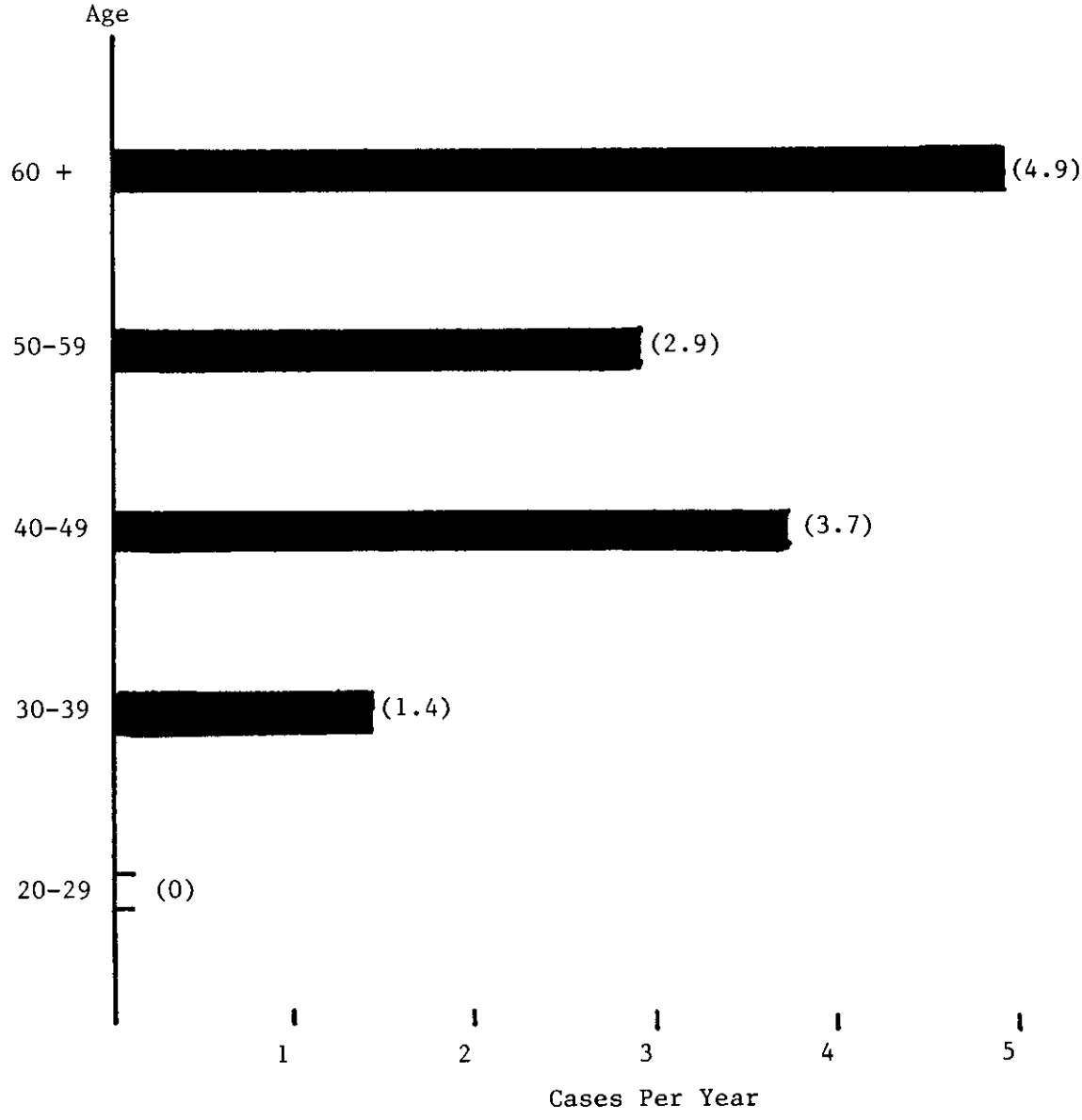

FIGURE 3. EXPECTED ANNUAL CARDIOVASCULAR INCAPACITATIONS BY AGE GROUP

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