Technical Report Documentation Page

1. Report No. FAA-AM-78-38	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Cardiovascular Problems Associated with Aviation Safety		5. Report Date January 1976
		6. Performing Organization Code
7. Author(s) Eighth Bethesda Conference of the American College of Cardiology		8. Performing Organization Report No.
9. Performing Organization Name and Address American College of Cardiology Washington, D.C.		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DOT FA 74 WA-3447
12. Sponsoring Agency Name and Address Office of Aviation Medicine Federal Aviation Administration 800 Independence Avenue, S.W. Washington, D.C. 20591		13. Type of Report and Period Covered
		14. Sponsoring Agency Code FAA

15. Supplementary Notes
This Study was conducted inpart under Contract No. DOT FA 74 WA-3447

16. Abstract In April 1975, the American College of Cardiology held its Eighth Bethesda Conference on Cardiovascular Problems in Aviation Safety.

Perhaps the most meaningful purpose of this meeting was to make clear, in a structured fashion, the availability and pertinence of noninvasive and invasive methods of testing to ensure early identification of cardiovascular problems and, at the same time, qualify persons for aircrew service who heretofore would have been eliminated because of noncrucial abnormalities in the physical or laboratory examination.

It should be emphasized that this Conference was convened to identify the causes, clinical course and possible risks of cardiovascular disease in aviation medicine. The deliberations were made without concern for any political or regulatory agencies and do not reflect an official position of The American College of Cardiology. The recommendations set forth in this report are those of the Conference participants and reflect the present documented scientific opinion and positions of the conferees. The Conference made no effort to be concerned with operational or economic factors in regard to the recommendations and confined its conclusions to the scientific facts to protect pilots, passengers and civilian populations from the potential hazards of in-flight cardiovascular accidents.

17. Key Words Cardiology Cardiovascular	18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	206	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

79 03 2

CARDIOVASCULAR PROBLEMS ASSOCIATED WITH AVIATION SAFETY*

Eighth Bethesda Conference of the
American College of Cardiology
April 25 and 26, 1975, Washington, D. C.

PARTICIPANTS

LEONARD S. DREIFUS, M.D., F.A.C.C.
Lankenau Hospital
Jefferson Medical College
Philadelphia, Pennsylvania
CHAIRMAN

EZRA A. AMSTERDAM, M.D., F.A.C.C.
Section of Cardiovascular Medicine
University of California
School of Medicine
Davis, California

ARTHUR C. BEALL, JR., M.D., F.A.C.C.
Baylor College of Medicine
Houston, Texas

GEOFFREY BENNETT, M.D.
Board of Trade
Civil Aviation Department of Medicine
London, England

*The recommendations set forth in this report are those of the Conference participants and do not necessarily reflect the official position of the American College of Cardiology. This study was supported in part by Contract DOT FA 74 WA-3447 from the Federal Aviation Agency.

Address for reprints: Leonard S. Dreifus, M.D., The Lankenau Hospital, Lancaster and City Line Avenue, Philadelphia, Pa. 19151.

CHARLES A. BERRY, M.D.
University of Texas Health Science Center
Houston, Texas

STANLEY M. BIALEK, M.D.
Medical Consultant
Aircraft Owners and Pilots Association
Bethesda, Maryland

DAVID BRISTOW, M.D., F.A.C.C.
University of Oregon Medical School
Portland, Oregon

STANLEY K. BROCKMAN, M.D., F.A.C.C.
Jefferson Medical College
Philadelphia, Pennsylvania

ROBERT A. BRUCE, M.D., F.A.C.C.
University of Washington
School of Medicine
Seattle, Washington

GEORGE E. BURCH, M.D., F.A.C.C.
Tulane University
New Orleans, Louisiana

TIMOTHY N. CARIS, M.D., F.A.C.C.
Veterans Administration Hospital
San Antonio, Texas

EARL T. CARTER, M.D.
Mayo Clinic
Rochester, Minnesota

GEORGE F. CATLETT, M.D.
United Air Lines
Jamaica, New York

MELVIN D. CHEITLIN, M.D., F.A.C.C.
San Francisco, California

JOHN J. COLLINS, JR., M.D., F.A.C.C.
Peter Bent Brigham Hospital
Boston, Massachusetts

FRANCIS H. CORCORAN, M.D., F.A.C.C.
Naval Hospital
National Naval Medical Center
Bethesda, Maryland

ELIOT CORDAY, M.D., F.A.C.C.
University of California at Los Angeles
Los Angeles, California

NATHAN COUCH, M.D.
Peter Bent Brigham Hospital
Boston, Massachusetts

JAMES E. DALEN, M.D., F.A.C.C.
Peter Bent Brigham Hospital
Boston, Massachusetts

HAROLD T. DODGE, M.D., F.A.C.C.
Division of Cardiology
University of Washington
School of Medicine
Seattle, Washington

EPHRAIM DONOSO, M.D., F.A.C.C.
Mt. Sinai Hospital
New York, New York

HAROLD ELIASH, M.D.
Department of Medicine
S:t Gorans Sjukhus
Stockholm, Sweden

MYRVIN H. ELLESTAD, M.D., F.A.C.C.
Memorial Hospital Center
Long Beach, California

MARY ALLEN ENGLE, M.D., F.A.C.C.
The New York Hospital
New York, New York

DORIS J. W. ESCHER, M.D., F.A.C.C.
Montefiore Hospital and
Medical Center
Bronx, New York

CHARLES FISCH, M.D., F.A.C.C.
Indiana University School of Medicine
Indianapolis, Indiana

SAMUEL M. FOX, M.D., F.A.C.C.
George Washington University
School of Medicine
Bethesda, Maryland

EDWARD D. FREIS, M.D., F.A.C.C.
Veterans Administration Hospital
Washington, D. C.

ARNE FRYKHOLM, M.D.
Aviation Medical Section
Montreal, Quebec, Canada

GOFFREDO G. GENSINI, M.D., F.A.C.C.
St. Joseph's Hospital
Syracuse, New York

RAYMOND W. GIFFORD, JR., M.D., F.A.C.C.
Department of Hypertension and Nephrology
Cleveland Clinic
Cleveland, Ohio

CAPT. RODERIC W. GILSTRAP
Aeromedical Committee
Air Line Pilots Association
Incline Village, Nevada

MICHAEL S. GORDON, M.D., F.A.C.C.
University of Miami
Miami, Florida

ROBERT J. HALL, M.D., F.A.C.C.
Texas Heart Institute
Houston, Texas

DWIGHT E. HARKEN, M.D., F.A.C.C.
Harvard Medical School
Boston, Massachusetts

ROGER B. HICKLER, M.D., F.A.C.C.
Memorial Hospital
Worcester, Massachusetts

ARCHIE A. HOFFMAN, M.D., F.A.C.C.
Bethesda, Maryland

JOHN HOWITT, M.D., F.A.C.C.
Board of Trade
Civil Aviation Department of Medicine
London, England

HERBERT N. HULTGREN, M.D., F.A.C.C.
Palo Alto Veterans Administration Hospital
Palo Alto, California

J. O'NEAL HUMPHRIES, M.D., F.A.C.C.
The Johns Hopkins Hospital
Baltimore, Maryland

WILLIAM B. KANNEL, M.D., F.A.C.C.
National Heart Institute
Framingham, Massachusetts

SUZANNE B. KNOEBEL, M.D., F.A.C.C.
Indiana University Medical Center
Indianapolis, Indiana

NICHOLAS KOUCHOUKOUS, M.D., F.A.C.C.
University of Alabama School of Medicine
Birmingham, Alabama

MALCOLM C. LANCASTER, M.D., F.A.C.C.
USAF SAM (NG)
Brooks Air Force Base, Texas

LOUIS F. LeJACQ
American Journal of Cardiology
Yorke Medical Group
New York, New York

ROBERT I. LEVY, M.D., F.A.C.C.
National Heart & Lung Institute
National Institutes of Health
Bethesda, Maryland

WILLIAM LIKOFF, M.D.,F.A.C.C.
Hahnemann Medical College and Hospital
Philadelphia, Pennsylvania

HUGH McALLISTER, JR., M.D.
Department of Cardiovascular
Pathology
Armed Forces Institute of Pathology
Walter Reed Hospital
Washington, D. C.

PAUL L. McHENRY, M.D., F.A.C.C.
Department of Medicine
Indiana University Medical Center
Indianapolis, Indiana

KEVIN MICHAEL McINTYRE, M.D., F.A.C.C.
Veterans Administration Hospital
West Roxbury, Massachusetts

LT. COL. ROBERT R. McMEKIN
Armed Forces Institute of Pathology
Walter Reed Hospital
Washington, D. C.

HAROLD T. MANKIN, M.D., F.A.C.C.
Mayo Clinic
Rochester, Minnesota

GEORGE W. MANNING, M.D., F.A.C.C.
University Hospital
London, Ontario, Canada

BILL L. MARTZ, M.D., F.A.C.C.
Dow Chemical
Indianapolis, Indiana

DEAN T. MASON, M.D., F.A.C.C.
Section of Cardiovascular Medicine
University of California, Davis, School of Medicine
Davis, California

RICHARD L. MASTERS, M.D.
Air Line Pilots Association
Denver, Colorado

FRANCIS A. L. MATHEWSON, M.D., F.A.C.C.
Winnipeg, Manitoba, Canada

WILLIAM P. NELSON, M.D., F.A.C.C.
Chief, Cardiovascular Service
Fitzsimons General Hospital
Denver, Colorado

GORDON NORWOOD, M.D.
Federal Aviation Agency
Washington, D. C.

CAPTAIN HARRY W. ORLADY
United Airlines
Chicago, Illinois

LT. COL. FRANK PETTYJOHN, MC
U.S. Army Aeromedical Research Laboratory
Fort Rucker, Alabama

CHARLES E. RACKLEY, M.D., F.A.C.C.
University of Alabama Medical Center
Birmingham, Alabama

ROBERT L. REIS, M.D., F.A.C.C.
University of Kansas Medical Center
Kansas City, Kansas

WILLIAM C. ROBERTS, M.D., F.A.C.C.
Section of Pathology
National Heart & Lung Institute
National Institutes of Health
Bethesda, Maryland

DAVID C. SCHWARTZ, M.D., F.A.C.C.
Division of Cardiology
Children's Hospital
Cincinnati, Ohio

ARTHUR SELZER, M.D., F.A.C.C
Pacific Medical Center
San Francisco, California

RALPH SHABETAI, M.D., F.A.C.C.
University of Kentucky
School of Medicine
Lexington, Kentucky

THOMAS L. SHEFFIELD, JR., M.D., F.A.C.C.
Department of Medicine
University of Alabama School of Medicine
Birmingham, Alabama

DAVID H. SPODICK, MD., F.A.C.C.
Cardiology Division
Lemuel Shattuck Hospital
Boston, Massachusetts

BORYS SURAWICZ, M.D., F.A.C.C.
Department of Medicine
University of Kentucky
College of Medicine
Lexington, Kentucky

MORTON E. TAVEL, M.D., F.A.C.C.
Indiana University
Indianapolis, Indiana

COL. JOHN H. TRIEBWASSER
U.S. Air Force
Clinical Sciences Division
Brooks Air Force Base, Texas

HAROLD C. URSCHEL, JR., M.D., F.A.C.C.
Dallas, Texas

JOHN F. WILLIAM, JR., M.D., F.A.C.C.
Department of Medicine
University of Texas
Medical Branch
Galveston, Texas

LEROY A. WOLEVER, M.D.
Civil Aviation Medical Association
Las Vegas, Nevada

FOREWORD

INTRODUCTION TO THE CONFERENCE

LEONARD S. DREIFUS, M.D., F.A.C.C.
Director, Eighth Bethesda Conference, American College of Cardiology
Philadelphia, Pennsylvania

In 1965, the American College of Cardiology held its first Bethesda Conference on cardiovascular problems in aviation safety. Since this initial gathering, there has been a significant increase in the magnitude of stress in all phases of civilian and military aviation. It was appropriate that an in-depth reevaluation of these problems take place in 1975 in this Eighth Bethesda Conference. The rapid accumulation of new knowledge in aerospace medicine, combined with improved methods for identifying and treating cardiovascular disease, gave this Conference a new perspective. With the explosive increase in aviation requirements had come the necessity for further definition of the medical problems that may be encountered with regard to aircrew and passengers.

During this past decade, an abundance of information concerning the natural history of congenital and acquired cardiac disease has matured. We no longer restrict patients with cardiovascular disease to sedentary activity. Many persons may now qualify in the various categories of pilot training and aircrew status. It was the charge of this Conference to recommend the limitations as well as indications for admission or return to active flying status of persons with cardiovascular diseases. Improved methods of care and rehabilitation have offered so much to patients with cardiovascular disease that this reexamination appeared necessary.

Perhaps the most meaningful purpose of this meeting was to make clear, in a structured fashion, the availability and pertinence of noninvasive and invasive methods of testing to ensure early identification of cardiovascular problems and, at the same time, qualify persons for aircrew service who heretofore would have been eliminated because of noncrucial abnormalities in the physical or laboratory examination.

It should be emphasized that this Conference was convened to identify the causes, clinical course and possible risks of cardiovascular disease in aviation medicine. The deliberations were made without concern for any political or regulatory agencies and do not reflect an official position of The American College of Cardiology. The recommendations set forth in this report are those of the Conference participants and reflect the present documented scientific opinion and positions of the conferees. The Conference made no effort to be concerned with operational or economic factors in regard to the recommendations and confined its conclusions to the scientific facts to protect pilots, passengers and civilian populations from the potential hazards of in-flight cardiovascular accidents.

Finally, the Conference was concerned with the problems of the increasing role of insurance carriers and the legal implications of qualifying persons with known cardiac disease since subsequent accidents could result in catastrophic loss of life and increased liability to all parties involved.

KEYNOTE ADDRESSES

AVIATION CARDIOLOGY IN CANADA

GEORGE W. MANNING, M.D., F.A.C.C.
LT. COL. ROBERT THATCHER, M.D.
IAN H. ANDERSON, M.D.

Ottawa, Toronto and London,
Ontario, Canada

In Canada we have two aspects of aviation cardiology--military and civilian; the latter is subdivided into private civilian and commercial flying. In both instances the standards are rigid. This report summarizes what we in aviation cardiology are attempting to accomplish given the present state of knowledge.

MILITARY AVIATION CARDIOLOGY

The Central Medical Board of the Defence and Civil Institute of

---

From the Central Medical Board Canadian Armed Forces Defence & Civil Institute of Environmental Medicine (DCIEM) Toronto, Ontario, Canada, the Civil Aviation Medicine Medical Services Branch, Department of National Health & Welfare, Ottawa, Ontario, Canada and the Armed Forces ECG Laboratory, Cardiovascular Unit, University Hospital, London, Ontario.

Address for correspondence: George W. Manning, M.D., University Hospital, 339 Windermere Rd., London, Ontario, Canada, N6G 2K3.

Environmental Medicine in Toronto, Ontario provides a consultant service for the Surgeon General of the Canadian Forces (CF) on all CF aircrew. The main functions of the board are twofold: (1) Final medical assessment of all CF aircrew applicants; and (2) special assessment of the flying status of serving aircrewmen. In addition to assessing special cases, the board sees all aircrew members who are temporarily grounded for longer than 3 months.

Handling of cardiovascular problems: Initial processing of all aircrew applicants takes place at the local level. Applicants are then sent to the Aircrew Selection Centre for final selection procedures: psychological testing and further medical screening by the Central Medical Board. Their initial medical examinations are reviewed and control electroencephalograms, audiograms and anthropometric data are established. Also, control electrocardiograms are completed and sent directly by telephone to Dr. Manning's laboratory in London, Ontario, where they are read, recorded and filed. These records are then available for the continuing research. All applicants with abnormal examination results are seen by Dr. Manning as the consultant in cardiology for aircrew selection, and they receive as complete an assessment as is considered necessary to determine their fitness for aircrew duties. The Central Medical Board also has consultants within the city of Toronto to cover other specialties. Initial aircrew medical categories are assigned by the board.

In light of the very high cost of training a young man to become a competent military pilot, we have found routine electrocardiographic studies of applicants for aircrew training a very valuable procedure.[1,2] Table I illustrates the results of some 22,000 applications for aircrew training with the Canadian Armed Forces. On the basis of initial routine electrocardiograms, fewer than 0.5 percent of applicants were considered unfit for aircrew training. The finding that an applicant is unfit for training does not mean that proved heart disease is present, but rather that in peacetime the Armed Forces believes it inadvisable to accept anyone who may have a cardiovascular problem in the ensuing few years. This policy may appear a bit unfair, but we contend that a man entering military aircrew training should be perfectly fit in all respects. We must remember that we are dealing with young men, aged about 17 to 20 years, and that the situation is quite different for older, experienced pilots.

The consultation service exists primarily to ensure a continuing high standard of medical effectiveness among serving aircrew members. Problem cases, which cannot be handled at base level and in which flight safety may be compromised, are referred for work-up, diagnosis, treatment, recommendations and disposition. Once again, various consultants within the area are employed to assist in the work-up. Cardiovascular investigations, up to and including

TABLE I

The Royal Canadian Air Force Electrocardiographic Aircrew Selection Program

Total ECGs reviewed	21,213		
Total repeat studies	1,329		
T wave variations	611		
Pilot declared unfit		28	
By ECG alone			13
By ECG plus questionable signs or symptoms			15
Bundle branch block (78 RBBB, 1 LBBB)	79		
Pilot declared unfit		22	
By ECG alone			11
By ECG plus questionable signs or symptoms			11
Wolff-Parkinson-White (WPW) pattern	47		
Pilot declared unfit		25	
By ECG alone			16
By ECG plus questionable signs or symptoms			9
Prolongation of P-R interval	103		
Pilot declared unfit		6	
By ECG alone			3
By ECG plus questionable signs or symptoms			3
Miscellaneous (right ventricular hypertrophy, arrhythmias, left axis deviation, etc.)	489		
Pilot declared unfit		18	
By ECG alone			5
By ECG plus questionable signs or symptoms			13
Summary			
Routine electrocardiograms	21,213		
Repeat studies	1,329		
Applicants classed as unfit pilot trainees	99		
(with questionable clinical signs or symptoms)	54		

ECG = electrocardiogram; LBBB = left bundle branch block; RBBB = right bundle branch block.

cardiac catheterization, are carried out at the cardiopulmonary unit at the National Defence Centre in Ottawa, or elsewhere if feasible. The Ottawa unit is headed by Dr. Gerald M. FitzGibbon, who is chief of cardiology at the National Defence Medical Centre and a consultant to the Central Medical Board. Upon completion of the work-up, the case is reviewed by a board of physicians, whose chairman is an aeromedical specialist with an aircrew background. The results of that board's deliberations and recommendations for disposition are forwarded to the surgeon general of the Canadian Forces.

Figure 1 shows the incidence of referrals of aircrewmen to the Canadian Medical Board over a 5 year period. The increasing incidence of referrals shown in the graph does not necessarily reflect an increasingly unhealthy population. Changes in orders and procedures over the past 5 years account in part for the trend.

The percent of cases of cardiovascular disease considered by the Canadian Medical Board in comparison with the total number of cases among aircrew has been fairly constant--10 to 15 percent (Figure 2) over the past 5 years. The incidence of cardiovascular disease seen by the board thus seems to have increased from 2 or 3/1,000 aircrewmen to 7 or 8/1,000 aircrewmen. Deaths from cardiovascular disease among aircrewmen have remained constant at about 1 per year; none of the deaths are known to have occurred during flight.

Disposition in cases of cardiovascular disease: The Canadian Medical Board is somewhat flexible in its approach. The two extremes are permanent grounding or return to unrestricted flying duties.

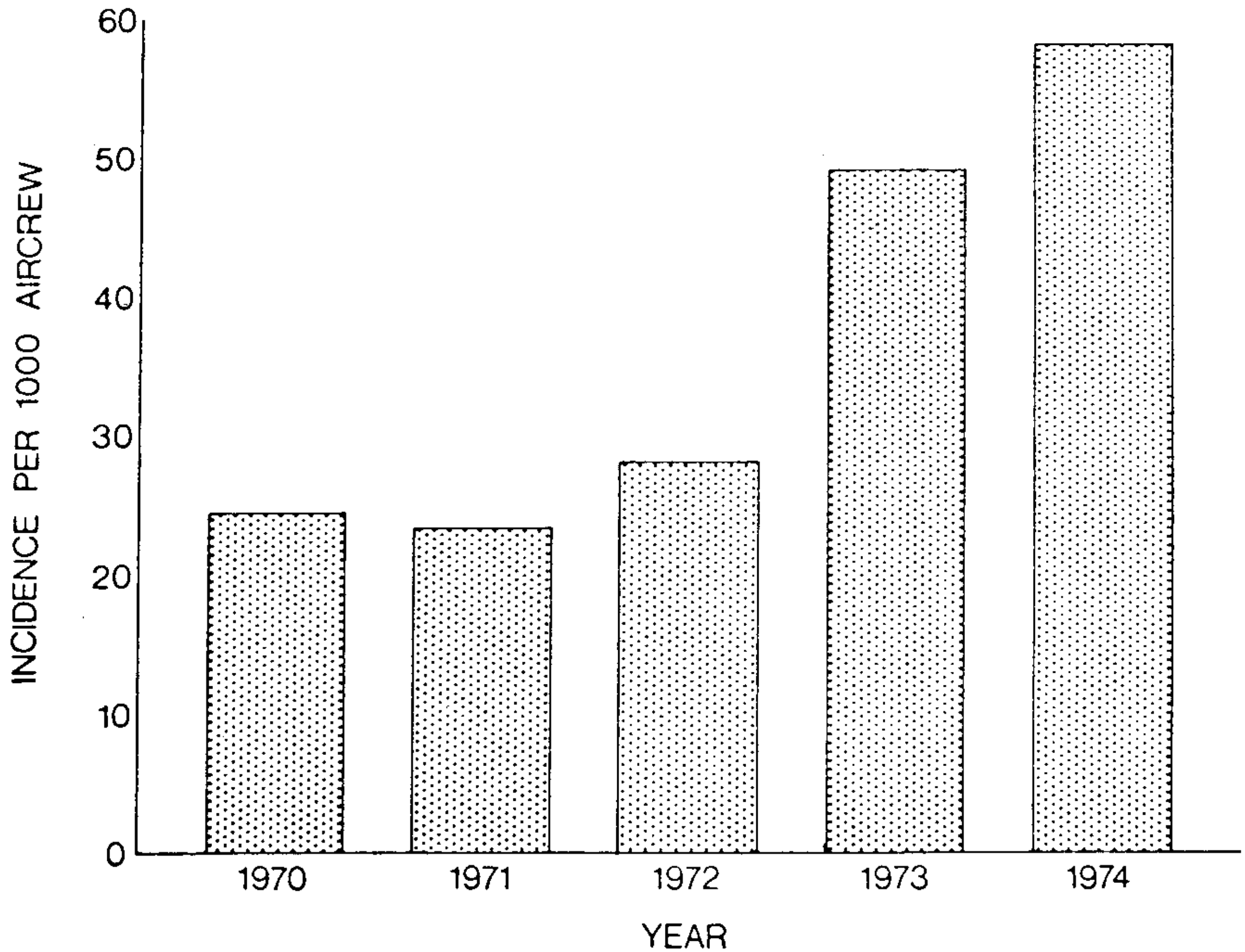


FIGURE 1. Incidence of referral of aircrewmen to the Central Medical Board for assessment, 1970 to 1974.

FIGURE 1. Incidence of referral of aircrewmen to the Central Medical Board for assessment, 1970 to 1974.

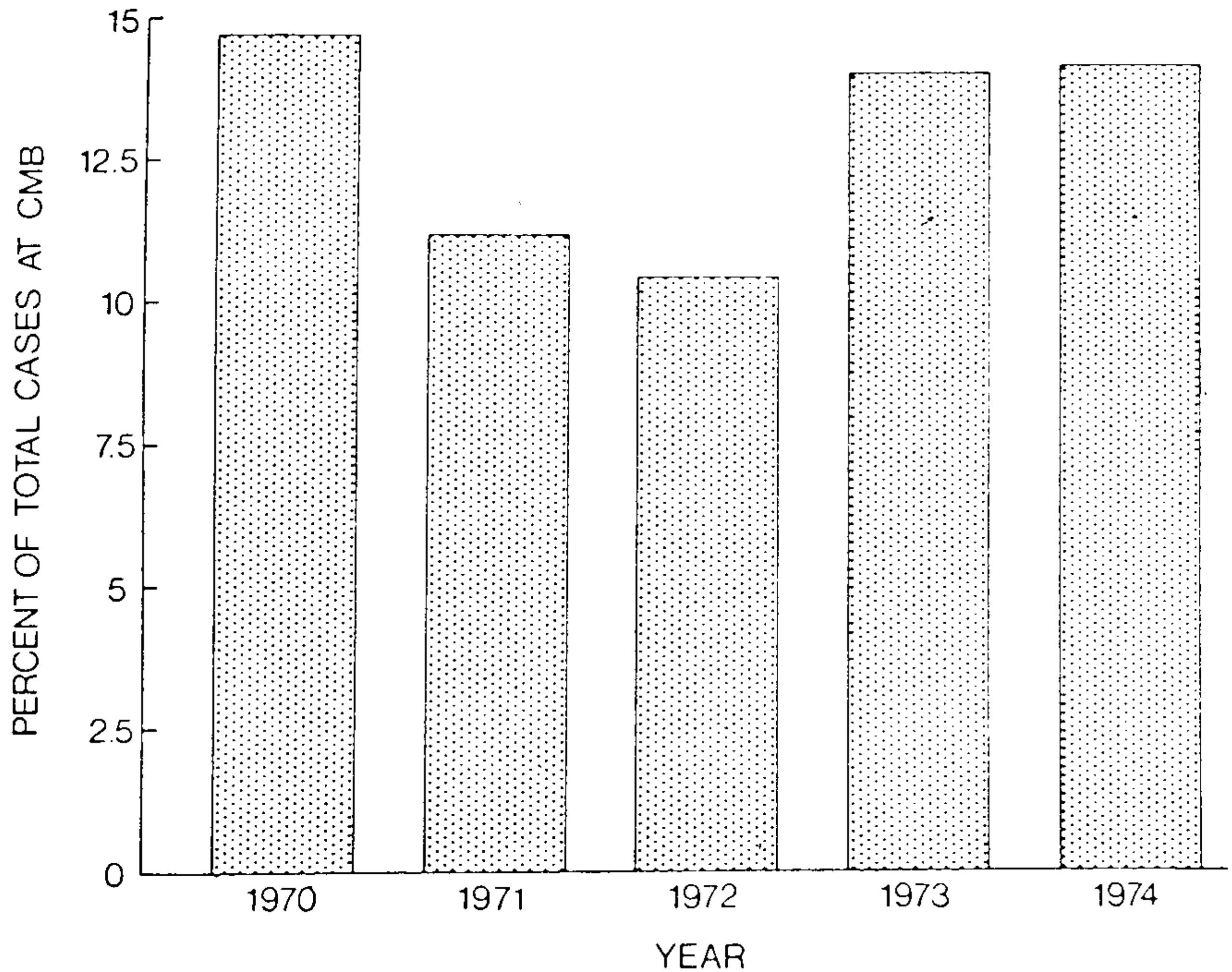


FIGURE 2. Cases with cardiac involvement as a percent of total cases referred to the Central Medical Board, 1970 to 1974.

Between these two extremes, there are restricted flying categories that, depending upon the severity of the restriction, may or may not have career implications. An aircrew member may be restricted from a certain type of aircraft, role or enfironment. Or he may be restricted from flying with or as a copilot. The restricted category causes an increased administrative load, but it is judged worthwhile from an economic point of view and, most importantly, often salvages an airman's career without affecting operational effectiveness. Figure 3 demonstrates our experience for the past 5 years in the disposition of cases on the basis of cardiovascular status. The dispositions shown are based on diagnosis on referral to the Canadian Medical Board. For example, in the category of atherosclerotic heart disease, the Canadian Forces policy is to ground permanently all persons with a firmly established diagnosis of this condition. Aircrewmen who were returned to flying duties had been referred to the Canadian Medical Board with the tentative diagnosis of atherosclerotic heart disease but were proved free of the disease on investigation.

Preventive and identification aspects: The present mode of operation of the Canadian Medical Board and system of annual medical examinations for aircrewmen throughout the Canadian Forces have both preventive and identification aspects. Data from this system seem to indicate that cardiovascular problems may be increasing in our population. The serious career implications of that increase have prompted the Canadian Medical Board to investigate methods of improving the preventive aspects of the system, particularly in relation to cardiovascular problems.

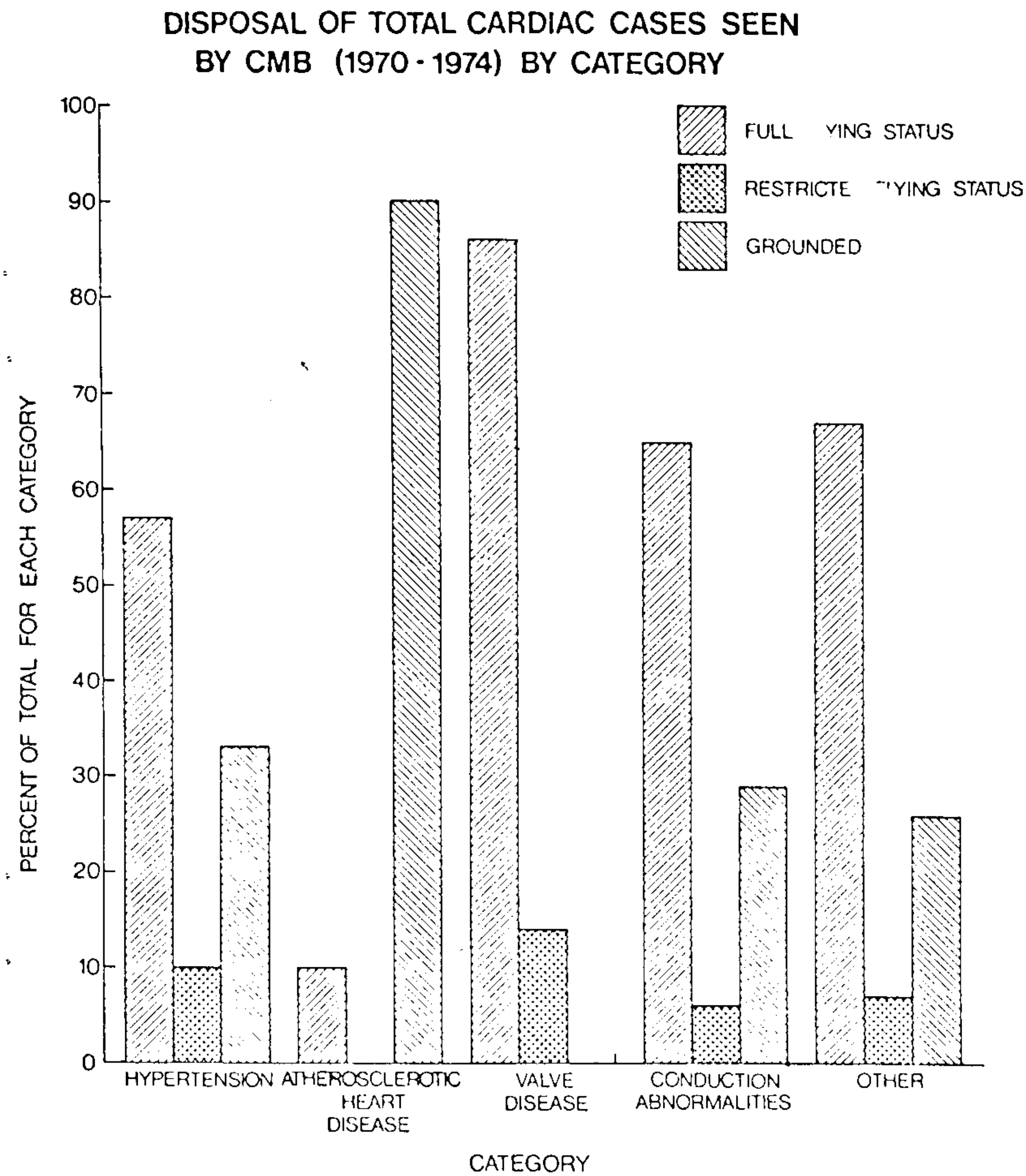


FIGURE 3. Disposition, by category, of all cases with cardiac involvement seen by the Central Medical Board, 1970 to 1974.

The initial approach is two-pronged: the board has begun to prepare risk profiles of aircrew recruits and is planning a survey of 100 aircrewmen presently serving on operational squadrons. The protocol for the survey includes assessment of all the well known cardiovascular risk factors -- historical, medical, biochemical -- and will include exercise stress testing. The initial approach then is to collect data in order to define the problem better and to determine how best to approach it. The board is in a good position to initiate a program of prevention because it sees all aircrew entrants. Once the data have been gathered, the possibility of identifying on entry persons at possible higher risk and then closely following them up during their career in the forces will be investigated. In combination with this, the board would like to initiate a health education program aimed at both the new entrant and the pilot in the field.

The emphasis of the overall program will not be one of policing -- that is, identification for restriction; rather, it will be one of earlier identification for the application of preventive measures. A secondary benefit may be increased ability to identify and screen out high-risk personnel on entry.

Electrocardiographic follow-up program: After World War II, Dr. F.A.L. Mathewson of Winnipeg, Canada undertook to follow up some 5,000 young men who had had routine electrocardiograms early in the war years. This long-term follow-up study comprises some 4,000 men, from whom he has obtained electrocardiograms over the years, together with clinical reports of their status. This follow-up study is still continuing and represents, perhaps, the longest and largest electrocardiographic follow-up study in existence. Although the study is not complete, it has led to some important and interesting findings[3-6]; for example, it has been found that first degree atrioventricular block does not increase morbidity or mortality over that in the normal population. Some data from this work suggest that primary T wave changes may indicate the presence of asymptomatic coronary heart disease, but further follow-up study and investigation will be required to give more conclusive evidence.

The present Canadian Armed Forces (formerly RCAF) electrocardiographic follow-up program is continuing under the direction of the Central Medical Board of the Canadian Armed Forces in Toronto, Ontario, all tracings being forwarded to the electrocardiographic laboratory in London, Ontario. At present, a follow-up review has been undertaken to ascertain the significance of patterns indicating Wolff-Parkinson-White conduction, nonspecific T wave changes, bundle branch block and pathologic left axis deviation. Although the data are plainly incomplete, it does appear that right bundle branch block by itself is probably an innocent finding but that nonspecific T wave changes might well indicate hidden coronary artery disease. In the younger age group, left bundle branch block is an extremely rare finding, not being encountered at all in 22,000 young men between the ages of 17 and 21. When it occurs in a man whose previous electrocardiograms were normal, we regard this as evidence of coronary artery disease. Whenever a significant change occurs in the electrocardiogram of one of our military aircrew population, a careful and thorough review is carried out before he is allowed to continue as a pilot. The situation is difficult since a highly trained pilot with a record of high performance represents a large investment on the part of the Department of National Defence and it is essential that every effort be made to keep him in the air. However, safety must be our prime responsibility, and the decision is one that the Canadian Armed Forces Central Medical Board makes with the greatest care.

CANADIAN CIVIL AVIATION MEDICAL ASSESSMENT

The Civil Aviation Medicine Division is a branch (Medical Services Branch) of the Department of National Health and Welfare, with headquarters in Ottawa, Ontario. Dr. Ian Anderson is the senior consultant; associated with him are four medical consultants who are in charge of accident investigation, research training and development, medical assessments and operational problems. In addition, there is an Aviation Medical Review Board consisting of seven physicians, whose chairman is the senior consultant of the Civil Aviation Medicine Division. The Ministry of Transport, the licensing authority, usually accepts the advice of the Medical Review Board. Nevertheless, as explained later, the pilot can appeal to the Civil Aviation Medical panel of the Ministry of Transport. In view of recent developments, the Armed Forces and Civil Aviation Medicine Division are updating the standards for cardiovascular fitness for aircrew.

General procedures: Most of the licensing is carried out regionally. Applicants are examined by 650 appointed aviation medicine examiners across the country and sent to regional aviation medical officers for assessment.

Resting electrocardiograms are required for the first issue of a license and on reexamination of applicants between the ages of 30 and 40 at least every 2 years (and annually thereafter) for all professional flight licenses and for persons in Air Traffic Control. Private pilots and recreational pilots must have electrocardiograms at age 40 and no less frequently than every 5 years (as of May 1975). Electrocardiograms are not necessarily obtained concurrently with the examination, and problems of standardization, patient preparation and poor mounting occur. Some regional aviation medical officers screen these tracings and others employ a cardiologist, but all tracings are rechecked by a team of cardiologists at headquarters. Frequently a tracing is considered normal in the region and abnormal at headquarters of the Aviation Medical Review Board; this situation usually results in further investigation.[7]

When reasonable doubt exists, a cardiovascular assessment with (if applicable) electrocardiographic stress testing (quadruple Master or treadmill to submaximal state), risk factors and family history will be requested. Cases with significant findings are referred to the Aviation Medicine Review Board for advice or decision. Abnormal electrocardiograms found on screening at headquarters are handled as indicated under "Cardiovascular Fitness and Civil Aviation Licensing in Canada."

The Aviation Medical Review Board meets weekly to consider questionable cases referred by regions or discovered on screening at headquarters. Its chairman is the senior consultant of the Civil Aviation Medicine Division, who is held responsible by the Ministry of Transport for advice given or decisions made.

A pilot found to be unfit under the standards, either by the board or on regional assessment, may appeal to an independent panel (Medical Advisory Panel) convened quarterly by the Ministry of Transport. Ordinarily, such a panel consists of four private consultants (a cardiologist, an ophthalmologist, a psychiatrist and a general practitioner), who have no connection with the Civil Aviation Medicine Division.

During the last 3 years, the Civil Aviation Medicine Division has acquired the capability of clinically assessing problem cases. A small unit of the division has been established at the Department of National Defence Institute of Environmental Medicine in Toronto, and works in conjunction with military personnel involved in aeromedical assessment, accident investigation and aeromedical training. Various types of simulators are available if required. Certain questionable cases selected by the Review Board can be given a complete clinical aeromedical assessment by this organization. Medical expenses involved are paid by the department.

Canadian civil aviation activity is the second largest in the world, covering more than 16,000 registered aircraft. Support by the Civil Aviation Medicine Division involves assessment of approximately 60,000 medical examinations annually, limited assistance in the investigation of more than 600 aircraft accidents a year, and an active aeromedical education program. Some civil aeromedical research and development have been sponsored or carried out by the two agencies concerned (Armed Forces and Civil Aviation).

CARDIOVASCULAR FITNESS AND CIVIL AVIATION LICENSING IN CANADA

Canadian Civil Aviation Medicine policy concerning cardiovascular fitness has received considerable study during the last 5 years. Our present policies are based on findings of the first Bethesda Conference on Aviation Cardiology, but we have had to develop greater specificity because of the increasing need to defend any judgment of unfitness.

Present Guidelines

1. Coronary thrombosis: Survivors of an episode of coronary thrombosis are not licensable under the Canadian medical standards or any flexible interpretation thereof. Some private pilots have been licensed on an appeal basis if the Medical Advisory Panel considers rehabilitation to be satisfactory.

2. Hypertension. Essential hypertension established by specialist investigation: An initial applicant with a diastolic blood pressure reading of less than 100 mm Hg might be granted a private license on an annual review basis, but not a commercial rating. An evaluation of risk factors and a stress test would be required. Cases are considered individually with attention to age, history, weight and other factors. Slowly increasing hypertension revealed on an examination for renewal of license or a hypertensive value appearing for the first time usually results in a request to obtain cardiologic assessment with risk factors and an electrocardiographic stress test. Such applicants are not

ordinarily denied a license unless grounds for clinical concern or high risk factors are apparent. For licensing, the stress electrocardiogram must be normal or show less than 1 mm S-T depression. Use of thiazide derivatives is compatible with licensing, but stability of condition, with normal serum potassium levels, must be demonstrated over a 3 month period. Use of hypotensive agents is disqualifying.

3. Arrhythmias. Abnormal rhythm is assessed individually with respect to probable cause and probability of incapacitation. Specific examples are:

a. Wolff-Parkinson-White electrocardiographic pattern: Licensing is possible if assessment confidently reveals freedom from any symptoms or other signs of heart disease. A past history of Wolff-Parkinson-White syndrome is disqualifying.

b. Premature ventricular beats: This finding is generally considered disqualifying if the arrhythmia occurs in conjunction with questionable cardiovascular assessment, borderline or high risk factors and abnormal stress electrocardiogram. Their isolated occurrence in a fit person is usually reviewed only periodically.

c. Paroxysmal atrial tachycardia: This finding is disqualifying unless investigation reveals a single episode with clear-cut and avoidable etiologic factors. The applicant must demonstrate freedom from further attacks for 1 year before he is considered fit.

4. Conduction disturbances: Left or right bundle branch block occurring in an otherwise healthy person over age 40 with a previously normal electrocardiogram necessitates temporary grounding and cardio-

vascular assessment with risk factor analysis and stress electrocardiogram. If there is no evidence of disease, if the risk factors are average and the stress electrocardiogram is normal, an applicant with right bundle branch block is usually considered fit. Applicants with left bundle branch block have not yet been considered fit on the basis of these criteria, although one candidate who voluntarily demonstrated a normal coronary angiogram as well has a commercial license. (Angiography or cardiac catheterization is never requested for the purpose of determining fitness. If such a procedure is performed for clinical reasons, the report is considered, but a normal record does not necessarily overrule other adverse findings.) Right bundle branch block discovered on the first electrocardiogram calls for the same investigation, and the applicant is considered fit if there is no evidence of disease.

5. <u>Aortic stenosis:</u> This condition is normally disqualifying. When doubt exists and evidence of normal heart function has been obtained, a license has been issued with follow-up requirements. The same applies to selected cases of infundibular (idiopathic) hypertrophic subaortic stenosis.

6. <u>Structural congenital abnormalities:</u> If the abnormality is minimal and poses little or no risk of incapacitation, a license may be issued. Persons with such an abnormality have usually been exhaustively investigated for clinical reasons before application. If corrective surgery has been performed, the individual case is considered in respect to postoperative function, the type of repair and material used, and the overall integrity of the cardiovascular system.

7. Prosthetic devices: No individual with an intracardiac condition corrected with a prosthetic device has been considered for licensing under the standards. A candidate with a Teflon prosthesis for repair of a traumatic aneurysm of the descending aorta was eventually licensed after 5 years of follow-up study. Full cardiovascular assessment revealed no evidence of disease, and risk factors were normal.

8. Pacemakers: A candidate with a rhythm disturbance sufficient to warrant the implantation of a pacemaker is considered unfit for licensing as a pilot under the standards. A commercial navigator who had requested a license some years earlier was eventually licensed but was refused upgrading to pilot status. Examination for upgrading revealed that his device had malfunctioned at least twice; he stated that his only indication of malfunction was excessive fatigue on long overseas flights.

9. Coronary arterial surgery and cardiac revascularization: We have been guided primarily by FitzGibbon's statistics and have not licensed any patient who has undergone the Vineburg procedure because of the unpredictable outcome in these cases. One such applicant was licensed after appeal, and we consider this to be a very bad precedent set by the advisory panel. Our experience with multiple coronary bypass operations has been better, but we believe that it is too soon to consider for licensing applicants who have had such surgery.

10. Aortoiliac surgery: An applicant who had undergone aortoiliac surgery for repair of a single 3 cm area of peripheral atherosclerosis in the iliofemoral area was relicensed after full investigation, including stress electrocardiogram and risk factors. A plane he was flying

subsequently crashed (pilot incapacitation not involved), and autopsy confirmed that there was no general atherosclerosis.

11. Nonspecific electrocardiographic abnormalities: Cardiovascular assessment is requested by headquarters only if both the screening and Review Board cardiologists agree that the tracing is suspect. Assessment usually includes electrocardiographic stress testing and assessment of risk factors. A pilot can only be temporarily grounded pending investigation of an abnormality in a resting electrocardiogram. If cleared by the cardiologist and his stress electrocardiogram is normal, he is found fit. If there is more than 1 mm of S-T segment depression in an adequate stress electrocardiogram and the risk factors are borderline, he would probably be grounded because the probability is greater than 85 percent that he has coronary artery disease. If he subsequently produces evidence suggesting that the stress test is a false positive result, his case will be reconsidered. In the event of disagreement between cardiologists, a third cardiologist is usually asked to act as referee.

Current Policies and Experience in Civil Aviation Medicine

In Canada, 22 million people occupy 4 million square miles in a rather unusual distribution. Sixty-two percent of the population live in 1 percent of the area, around Montreal and the lower lakes plains. In contrast, in the Yukon Territory and Northwest Territories, 0.2 percent of the population is distributed over 41 percent of the total area, with approximately 1 person in every 40 square miles. Over 90 percent of the population lives within 100 miles of the 3,600 mile border between Canada and the United States. Canadians are very dependent upon air transport; the major airports handle around 9 million air movements a year and nearly 20 million passenger movements. Movement in northern Canada is almost entirely dependent upon air transport. More than 10,000 privately operated small aircraft are registered. A considerable amount of commercial flying includes specialized high risk operations such as agricultural spraying, water bombing, geologic and scientific surveying and resupply of isolated communities. Some other variables have a bearing on Canadian medical standards and their interpretation: Most of the country is covered with ice and snow for at least half the year, and almost every flight passes over uninhabited and inaccessible areas. It is very easy for the inexperienced or sick pilot to become lost and, in the event of a successful forced landing, search and rescue are extremely difficult and expensive. Many of the smaller airfields, especially in northern Canada, do not have an all-weather surface, and the use of both floats and skis in smaller aircraft is commonplace. In common with many other countries, Canada places the onus of proving fitness on the pilot. The cost of examination must also be considered. It can, for example, be very costly to obtain a cardiologic consultation if the pilot is operating in northern Canada. Finally, Canadian standards should, when possible, be compatible with those of the United States.

In compiling the new medical standards that became effective on January 1, 1975 we were also obliged to review carefully our accident statistics and the type and extent of medical problems presented during the last 3 years. Both sources indicate that cardiovascular disease is the most frequent threat to flying fitness and the commonest cause of in-flight incapacitation.

Coronary artery disease: In a study of aircrew screening to exclude coronary artery disease, our cardiologist, Dr. E. Patrick, compared statistics on the population used for the Framingham study with observed Canadian mortality and morbidity statistics and concluded that the Framingham criteria could be applied to the Canadian population. On this basis, he calculated that 7 or 8 airline or commercial pilots and 22 or 23 private pilots could be expected to have a coronary event in 1 year. It is often stated that the professional pilot community is a healthier group than the general population, and this is probably correct, but it was disturbing to find the following 10 incidents in 1971: An in-flight infarct in a 37 year old commercial pilot resulted in a crash and his death; in one pilot a period of syncope during aerobatics, probably the result of taking ganglionic blocking agents for hypertension, resulted in a fatal accident; and a 40 year old copilot had anginal pains in the air. In addition to these events, we recorded on-ground heart attacks in five airline pilots and two senior commercial pilots. In five cases the attacks resulted in sudden death; two occurred immediately after landing and one immediately before take-off. The average age of the 10 pilots was 48.6 years (range 37 to 64 years). Although we made a positive effort to identify professional pilots who had a heart attack on the ground, we are certain that the seven identified do not reflect the true picture. There was no doubt in our minds by the end of 1971 that in terms of pilot reliability we were not doing well enough in the detection of early coronary artery disease.

Since cardiovascular disease is the most likely cause of pilot incapacitation, it would appear logical to examine other potential causes of incapacitation in the same light. For example, we have estimated that the average risk of recurrence of a cardiovascular event in a person who has already experienced one because of coronary artery disease is approximately 6 percent in 2 years. Such a person is not licensable at this time under standards in a country belonging to the International Civil Aviation Organization, and there is reason to believe that this is a wise decision in respect to the professional pilot. It is logical, therefore, to identify this risk factor in terms of other incapacitating conditions. Unfortunately, we often lack epidemiologic studies of the precision typified by the Framingham study, but it is a very useful guideline. For example, the risk of a repeated episode of transient cerebral ischemia at any age has been calculated to be approximately 10 percent in 2 years; it is therefore our policy to deny a license to a pilot who has definitely had such an event. Completely asymptomatic gallstones, discovered by chance at an early age, are not necessarily a bar to licensing if the examiner is completely convinced that they are indeed asymptomatic.

The preceding discussion of coronary artery disease considers only the professional pilot flying with or as a copilot. What of the commercial pilot who flies alone, or the private pilot? In the case of the lone professional commercial pilot, a conservative attitude clearly is warranted; it is increasingly necessary to recommend that the restriction "with or as copilot" be placed on individuals who begin to approach the high-risk category after clinical evaluation. As far as private pilots are concerned, each case is considered individually and attention is paid to the number of hours that the individual flies. In doubtful cases a cardiovascular assessment is always requested as well as an adequate exercise electrocardiogram and assessment of the Framingham risk factors. If the prognosis is in doubt or his risk factors judged to be greater than 6 percent a year, the pilot would normally be grounded, although we are prepared to reconsider his case if rehabilitation markedly changes the risk picture. We have very little statistical evidence that rehabilitation alters the probability of a cardiovascular occurrence, but we are prepared to take this chance with pilots who have been temporarily grounded on risk criteria alone, provided we have the unequivocal support of the cardiologic consultant.

Insofar as coronary artery disease is concerned, the adoption of a policy based upon probability of incapacitation and exposure to risk has, despite some obvious drawbacks, resulted in a uniform, defensible and economic procedure concerning fitness to fly. It has enabled us to avoid some of the pitfalls of exercise testing and electrocardiography and angiography, none of which are thought to provide a definitive indication of fitness. For example, we encourage the airlines to use routine stress electrocardiograms for health monitoring purposes, but a positive test alone is not considered cause for grounding: If the cardiologic examination is negative, the family history satisfactory, the triglyceride level normal and the statistical probability of risk by the Framingham criteria acceptable, a positive test is an indication for increased surveillance only, but that should probably include a coronary angiogram. Likewise, hypertension shown to be benign or merely labile is evaluated on the basis of probable risk. The same is true of glucose intolerance short of diabetes.

Other cardiovascular abnormalities: The policy has also had an indirect effect on our assessment of some cardiac conduction abnormalities. Previously, any pilot over the age of 40 with right or left bundle branch block was automatically grounded. In the last few years, we have licensed several applicants with right bundle branch block if the clinical assessment was good and the assessment of risk factors acceptable. We are more cautious concerning acquired left bundle branch block, but we have licensed a few applicants who are otherwise healthy and who have voluntarily undergone coronary angiography. Rarer conditions, such as small atrial defects and minimal asymptomatic aortic incompetence or stenosis, are considered on their own merits. A few applicants have been certified fit: Cardiac catheterization carried out for clinical (as opposed to licensing) reasons is obviously of assistance in such cases. It has also been possible to reconsider certain therapeutic regimens that were previously a bar to licensing: we have a few individually evaluated applicants with benign hypertension but no other evidence of cardiovascular disease who continue to fly while receiving thiazide therapy. They are subject to testing every

3 months, including determination of serum potassium levels (see Appendix).

Any medical policy based upon a derived estimate of acceptable risk is bound to be debatable, but some guideline is surely essential. A physician's clinical judgment of fitness to fly often reflects his general attitude or fears concerning aviation; when in doubt, many physicians adopt a "nil-risk" philosophy and resort to the comfortable decision of "unfit to fly." We have lagged badly behind our aeronautical engineering colleagues, who have evolved techniques to define what risk can be considered acceptable in aircraft design. They have had the courage to admit that there will be rare failures, but they have not relaxed their efforts to ensure that these failures become progressively rarer and less critical with each generation of aircraft. It has been refined to a very precise art under the stimulus of the space program. By comparison, we are obliged to make a crude educated guess as to the reliability of the human component in our aviation activity.[7]

REFERENCES

1. Manning GW: Electrocardiography in the selection of R.C.A.F. aircrew. Circulation 10:401-412, 1954

2. Manning GW, Sears GA: Postural heart block. Am J Cardiol 9: 558-563, 1962

3. Mathewson FAL, Taylor WJR: Prolonged P-R interval in apparently healthy people. Proceedings of sixty-first annual

meeting of Life Insurance Medical Directors of America, 1952.

4. Mathewson FAL, Varnam GS: Abnormal electrocardiograms in apparently healthy people. 1. Long-term follow-up study. Circulation 21:196-203, 1960

5. Mathewson FAL, Varnam GS: Abnormal electrocardiograms in apparently healthy people. II. The electrocardiogram in the diagnosis of subclinical myocardial disease serial records of 32 people. Circulation 21:204-213, 1960

6. Mathewson FAL, Corne RA, Nelson NA, et al: Blood pressure characteristics of a select group of North American males, followed for 20 years. Can Med Assoc J 106:549-557, 1972

7. Anderson IH: Canadian Civil Aviation Assessment. Personal communication, August 1974

APPENDIX

Summary of 117 Cardiovascular Cases Considered by the Review Board, January to June 1974*

	Cases: Total	Cases: no. with Pilot Grounded
I. Conduction defects	31 [27%]	12 (5)
Right bundle branch block	9	2
Ventricular premature beats	9	4
Atrial fibrillation	3	1
Left bundle branch block	2	1
Paroxysmal tachycardia	1	1
1st degree A-V block	1	1
Other	6	2
Remarks: All but one subject (with left bundle branch block) had signs or symptoms of cardiovascular disease in addition to the conduction defect		

	Cases: Total	Cases: no. with Pilot Grounded
II. Hypertension	35 [30%]	22 (7)
Remarks: Of 26 licensed pilots, 15 were grounded; 12 of these had other signs and symptoms of cardiovascular disease. Of the 15 licensed pilots grounded, 5 were airline pilots. Partial or complete risk profiles were available for 10 of the 15 grounded pilots; risk factors were a consideration in the grounding decision in only 3		

	Cases: Total	Cases: no. with Pilot Grounded
III. Arteriosclerosis	13 [11%]	13
Remarks: The presenting signs were: hypertension (4 cases); angina (3 cases); infarction (2 cases); vascular surgery (2 cases); abnormal routine electrocardiogram (2 cases)		
Risk factor profiles were available in 7 subjects		
Stress electrocardiograms available in 6 subjects (1 positive, 2 ? positive, 3 negative)		
Average age of subjects was 49 years (range 37–61 years)		
IV. Congenital heart defects	12 [10%]	2
Remarks: 5 restricted to private pilot status; 5 considered fit		
Conditions include: atrial septal defect (4 cases); conduction defects (2 cases); idiopathic hypertrophic subaortic stenosis (2 cases); ?aortic stenosis (2 cases); pulmonary stenosis (1 case) bicuspid aortic valve (1 case)		
V. Miscellaneous conditions	7	0
Mitral click syndrome	4	0
Viral pericarditis	1	0
Viral carditis	1	0
Mitral valve prolapse	1	0
Remarks: 2 aspiring to higher ratings restricted to private pilot license		
VI. Exercise electrocardiograms	48 [41%]	15
Positive, with satisfactory technique	8 [17%]	3
Negative, with satisfactory technique	24 [50%]	6
Unsatisfactory technique or unequivocal results	16 [33%]	6
Remarks: Exercise electrocardiograms were submitted in 48 of the 117 cases (41 percent), the majority upon request. No subject was grounded on the basis of electrocardiogram alone.		
Distribution of pilots in 117 cases		
Air transport-rated pilots	[10%]	
Commercial transport-rated pilots	[26%]	
Private pilots	[33%]	
Initial applicants	[29%]	
Air traffic control		
Distribution of pilots in Canada (December 1975)		
Air transport-rated pilots	3,999	9
Commercial transport-rated pilots	7,398	17
Private pilots	31,656	70
Glider and gyrocopter	1,827	4
Total	4,880	

* Between January and June 1974 the Review Board considered 304 cases of borderline fitness (for any reason). Of this number, 117 (39 percent) were considered cardiovascular cases, and in 41 (35 percent) the airman or applicant was grounded.

Figures in parentheses indicate number of initial applicants.

OPERATIONAL ASPECTS OF PILOT INCAPACITATION IN A MULTICREW AIRLINER

CAPTAIN HARRY W. ORLADY

Chicago, Illinois

Medical disqualification is the most common cause for the premature involuntary termination of an airline pilot's career. The major reason for that disqualification is the threat of incapacitation--primarily for cardiovascular reasons.[1-3] In a majority of cases, pilots are disqualified because available data indicate that they have become part of a group that has a statistically greater risk of incapacitation from another cardiovascular lesion than that of pilots who have not yet had such a lesion.[1] Several years ago Dr. E. T. Carter made the following statement in a discussion of his evaluation of the medical records of 691 pilots who were grounded and paid benefits under the Air Line Pilots Association Loss of License Program between 1954 and 1964:

> Study of individual cases revealed that ... approximately 35% of all those men grounded were quite capable of flying their aircraft from a physical and mental sense at the time of their grounding. They were grounded on the

---

Address for correspondence: Captain Harry W. Orlady, United Air Lines, P. O. Box 66100, Chicago, Ill. 60666.

> basis of what might happen. And, it was assumed that what might happen represented a significant flying hazard.[1]

Earlier studies of temporary or transient incapacitation, in-flight death, the death of pilots who died while off duty, and of the very sparse material available that might identify the specific operational problems incapacitation incidents could create can be summarized in seven general statements:

1. Pilot incapacitation is a valid and continuing air safety problem.[1-7]

2. Pilot incapacitation can arise from a wide variety of causal factors. The incapacitation can be transient or permanent, partial or complete.[1-3,5,6]

3. Assumptions regarding the hazard potential of in-flight incapacitation are generally overstated.[3,5,8]

4. The incidence of in-flight incapacitation is greatly understated and can be expected to increase.[1-3,5]

5. In-flight incapacitation occurs much more frequently than many of the emergencies we train for routinely.[1-3,5-8]

6. The industry pays a very high price to control the risk to flight safety involved.[1-3,5,9]

7. Medical screening, by itself, cannot be relied upon to reduce the incapacitation hazard to an acceptable minimal level, even with significantly more rigorous standards.[1-5,8]

The risk of pilot incapacitation is, of course, an operational risk. While historically its control had been considered almost exclusively an aeromedical responsibility, many aeromedical and air safety experts developed a growing interest in other methods of control. For example, in the fall of 1968, Dr. Carter told the audience at a Flight Safety Foundation International Air Safety Seminar:

> The whole question of the unconscious and limp pilot needs to be re-evaluated in the light of operational factors and realities. This takes the problem out of the hands of the medical specialist and puts it into the hands of the operational expert. Even if aeromedical experts can provide data predicting the probability of loss of consciousness in a given disease state, there are no hard data now available to predict what sort of a risk this represents in operational terms.[1]

UNITED AIR LINES STUDY OF IN-FLIGHT INCAPACITATION

"Hard data" dealing precisely with this question are now available. They were obtained in a study jointly sponsored by the Flight Operations and Medical Departments of United Air Lines. An interdisciplinary team was given three basic tasks. The first was to identify precisely the operational problems involved in in-flight incapacitation; the second was to develop an effective method for controlling operational risks; and the third was to develop a program for its implementation.[7,9]

Simulated Studies

Reports of air carrier accidents and incidents attributed to or suspected to have involved in-flight incapacitation have provided few details and almost no useful operational data. However, careful analysis of a series of 81 simulated "obvious" and "subtle" incapacitations utilizing 223 airline pilots during their regular recurrent proficiency training periods provided meaningful information. Incapacitation was simulated at the most critical phases of flight and was frequently combined with other emergencies or irregularities. The studies were used to identify the operational problems involved and then to develop and test an effective method of reducing the associated risk to flight safety.[6,7,9]

Dr. Alphonse Chapanis of Johns Hopkins University and other psychologists specializing in human engineering tell us that human activities can be studied only by studying behavior, the specific things people do. This concept provided a basic guide for the United Airlines study. It was important to know specifically what pilots did or did not do when a crew member suddenly became incapacitated during a critical phase of flight. It was also important to know precisely how their actions or inactions affected air safety.

Two things were of immediate interest. The first was the clarity with which the simulator studies identified specific operational problems. The second was the demonstrated relevance of basic behavioral training principles. For example, even under very high levels of stress, pilots performed well if their problem involved judgment or skills in situations for which they had been previously trained. However, considerable variation in performance occurred if the problem covered areas in which they had no previous instruction. This is expected behavior. An emergency situation creating high levels of concentration and requiring correct and reasonably immediate action is not an ideal time for detached objective analysis.

Operational Incapacitations and Problems

All incidents of incapacitation can be divided into two operational classifications: "obvious" and "subtle." Obvious incapacitation is immediately apparent to other crew members. It can occur suddenly. It is usually prolonged and usually results in a complete loss of function. Review of known incidents reveals that in many cases considerable early warning was available. Frequently the significance of the warning was not recognized.[6,7]

Subtle incapacitation occurs more frequently than the obvious type. By definition, it is not obvious to other crew members. It is frequently unreported, partial in nature and usually transient, lasting from a few seconds to several minutes. It is insidious because the affected pilot may look well and continue to operate but have only a partially functioning brain. He may not be aware of his problem or capable of rationally evaluating it. Subtle incapacitation can create severe operational problems.[6,7]

Analysis of these incidents showed that flight crews need help in two areas to reduce the risk associated with in-flight incapacitation. First, they need a method of detecting a subtle incapacitation before it becomes operationally critical. Second, they need an organized method of handling an in-flight incapacitation once it is recognized.[7,9]

Phase I of the study included almost 18 hours of sound and color movie film used to record 45 incidents of obvious incapacitation in DC-8 and B-737 simulators. This phase revealed that in-flight incapacitation creates three basic tasks for the crew whether the incapacitation is obvious or subtle and whether there is a two- or a three-man crew. The three tasks are: (1) maintaining control of the airplane; (2) taking care of the incapacitated crew member; and (3) reorganizing the cockpit and landing the airplane. Simply identifying these tasks provided a three-step organized method for handling all in-flight incapacitation. It is essential that the three steps be taken separately and in order.

<u>Detecting subtle incapacitation</u>: A "two communication rule" was developed to meet the need for a method of detecting subtle incapacitation before it becomes operationally critical. The rule states: "Flight crew members should have a high index of suspicion of a subtle incapacitation any time a crew member does not respond appropriately to two verbal communications, or any time he does not respond appropriately to any verbal communication association with a significant deviation from a standard operating procedure or a standard flight profile." The phrase high index of suspicion is stressed because there are too many variables to encourage impulsive or spontaneous action. The "two communication rule" has proved easy to teach, easy to use and effective. It is easy

to teach and to use because it requires only a very slight extension of normal routine monitoring and cross-checking. It is effective because significant deviations are detected and challenged before they become operationally critical. This is the most important part of this program.

The effectiveness of the two communication rule was demonstrated in Phase II of the study. Twenty-five percent of the incidents of subtle incapacitation in an unindoctrinated group resulted in a crash. There were no crashes in a comparable group that had been taught to use the rule.[6] The relevance of the rule is emphasized by such tragedies as the Trident crash at Staines, England, which killed 118 people.[10] The official report of that accident states that among its underlying causes were these:

1. The abnormal heart condition of Captain Key leading to lack of concentration and impaired judgement sufficient to account for his toleration of the speed errors and to his retraction of, or order to retract, the droops in mistake for the flaps.

2. Lack of training directed at the possibility of "subtle" pilot incapacitation.

Step 1--maintaining control of the airplane: This step seems obvious, but it is stressed because distractions during a critical phase of flight can create serious safety problems if they are permitted to shift attention from operation of the aircraft. This is not a new problem. The crash of an Eastern Airlines L-1011 at Miami, Florida on December 29, 1972 and the crash of an SAS DC-8 in Santa Monica Bay, California on January 13, 1969 are examples, and there are others.[11,12]

Once the incapacitation is recognized, takeover is a minimal problem for a trained crew. Table I shows the time required for effective transfer of control in simulated cases of obvious incapacitation. Effective transfer of control of the aircraft took 4 seconds or less in 86 percent of the 28 cases in which the pilot flying the simulator became incapacitated and 5 seconds or less in 93 percent of them.

The longest period required in the DC-8 series was 6 seconds. In this case, the first officer was making a three-engine approach and slumped over the control pedestal just after passing the outer marker at 1,400 feet above the ground. The captain, who was busy communicating with the tower at the time of the incapacitation, decided to go around. It was approximately 6 seconds before it was clear that effective control had been transferred. At no time did the aircraft descend below 1,200 feet above ground after the incapacitation, and at no time would it have been operationally desirable to have made the transfer more rapidly or more vigorously.

The longest period for effective transfer in the B-737 series was 7 seconds. In this case the captain was making an auto-coupled approach and, after passing the outer marker, collapsed over the center pedestal. He pulled back one throttle as he collapsed. The first officer's take-over was deliberate and quite casual. When approaching 400 feet above ground he informed the control tower that a fatality had occurred in the cockpit. During this transmission he received a stick shaker warning indicating that he was approaching a stall. His air speed had dropped

TABLE I

Effective Control Transfer Time in 28 Incidents of Incapacitation

Time After Incapacitation (sec) *	Incidents no.	Incidents Cumulative %
2	7	25
3	8	54
4	9	86
5	2	93
6	1	96
7	1	100

* Mean time 3.5 seconds.

off because he had not yet noticed the 50 percent power loss, possibly because he had been distracted by the tower conversation. At this point he started to go around and restored power to the throttled engine. The aircraft lost an additional 50 feet, descending to about 300 feet above airport elevation while the go around was being initiated.

When the pilot is incapacitated, the approach and landing are the most critical stages of flight because the airplane is close to the ground and continues to descend toward it. Standard flight profiles require rates of descent of 700 to 800 feet/min during the final approach; a rate of 1,500 feet/min is clearly excessive. Many airlines require specific callouts below 500 feet above ground whenever the rate of descent exceeds 1,000 feet/min. If an aircraft were descending at 1,000 feet/min, the median takeover time in the 28 cases reviewed would have resulted in an altitude loss of 58 feet--with the longest takeover time only 116 feet. At a very disturbing rate of descent of 1,500 feet/min, the median loss would have been 88 feet, the greatest loss 175 feet. At a more normal rate of 800 feet/min, the median loss would have been 47 feet, the longest 93 feet.

It should be noted that this performance was achieved without training of any sort and that taking over control in a simulator is not usually considered by crews undergoing proficiency training. Even the longest takeover times were not operationally disturbing under the existing conditions. Equal or better performance in an actual situation can reasonably be expected from crews who have been trained. A 4 to

5 second takeover is a surprisingly deliberate maneuver. Aircraft displacement at selected rates of descent is shown in Table II.

It is somewhat paradoxical that the increased demands of the jet era have probably reduced the seriousness of pilot incapacitation in terms of air safety. The increased discipline and lower tolerance required in contemporary jet operations have made it possible to detect deviations from standard operating procedures or standard flight profiles before they become operationally critical.[3,5] This was confirmed in our study. We found it is very difficult to get a modern transport airplane into a situation from which it cannot be safely recovered if the initial warning signs are recognized and appropriate actions are taken. There is invariably adequate time to do the right thing if the problem is recognized promptly and analyzed correctly. However, there is not unlimited time to correct an inappropriate reaction, which is precisely the reason airline crews are trained to handle emergencies and irregularities that have been identified.

At present, there is increasing concern over the role of human failure of any cause in air carrier accidents. It is one of several factors that have stimulated reexamination of pilot incapacitation in its broadest context. We now define pilot incapacitation as "any physiological or psychological state or situation which adversely affects performance."[7] There are sound operational reasons for that definition. Operationally we are not at all concerned whether the degraded performance was caused by a transient petit mal episode, preoccupation with a serious personal

TABLE II

Altitude Loss (feet) at Selected Rates of Descent

Seconds	Rate of Descent (feet/min) 700	800	1000	1200	1500
2	23	27	33	40	50
3	35	40	50	60	75
4	47	53	67	80	100
5	58	67	83	100	125
6	70	80	100	120	150
7	81	93	117	140	175

TABLE III

Time to Initial Restraint of Incapacitated Crew Member in 22 Incidents (DC-8 series)

Time After Incapacitation (sec)	Incidents no.	Cumulative %
3	4	18
4	1	23
5	3	36
6–10	11	86
11–20	1	91
21–30	2	100

TABLE IV

Time to Moving Back of Pilot's Seat in 18 Incidents (DC-8 series)

Time After Incapacitation (sec)	Incidents no.	Cumulative %
6–10	2	11
11–20	5	39
21–30	4	61
30+*	5	89
Not moved back	2 (11%)	

* The longest elapsed time in this group was 71 seconds.

problem, a disordered cardiac function or temporary functional hypoglycemia. This is a basic reason why considerable emphasis is placed upon the importance of close adherence to standard operating procedures and standard flight profiles. All crew members should be trained to look for and question significant deviations. Many authorities believe that this is a major justification for this type of training because a high percentage of accidents and incidents are associated with prior, and apparently undetected, operational deviations of one sort or another.

Step 2--taking care of the incapacitated crew member: The lack of previous training began to show up in step 2. The reasons for this step are not entirely humanitarian. If left unattended, the incapacitated pilot may become a definite cockpit hazard and, in any case, is a major distraction to the other crew members. For this reason, responsibility for him should be given to the cabin crew. Preferably he should be removed from the cockpit.

There were fairly wide variations in performance of step 2, although some performance was excellent by any standards. For example, in the DC-8 series of incidents of obvious incapacitation, the incapacitated pilot was restrained by the second officer in 10 seconds or less in 86 percent of the tests and was restrained in 5 seconds or less in 36 percent of tests. This is not really surprising because prompt restraint of a pilot slumped over the center control pedestal is an obvious and almost intuitive reaction. In 17 of these 22 cases transfer of control was required after the incapacitation; in the other 5, the pilot not flying became incapacitated. There was virtually no difference in time for these two groups since the second officer's task was identical in each case (Table III).

In addition to restraining the incapacitated pilot promptly it is also important to move his seat back quickly to minimize the possibility of control or switch contamination and to facilitate his removal from the seat. The lack of previous training or instruction began to show up here. This finding was not entirely unexpected because none of that previous training had considered incapacitation in an operational context. Although 86 percent of the second officers started to restrain the incapacitated pilot within 10 seconds of the incapacitation, few of them were sure of what to do next. Only 39 percent recognized that it was also important to move his seat promptly; 28 percent took 31 to 71 seconds to accomplish this task, and 11 percent did not move the seat back at all (Table IV).

Wide variations were found in several other areas such as the elapsed time before call to cabin crew for help; the elapsed time before removal of the incapacitated pilot from his seat and the use of cabin help to remove him; the use of qualified or nonqualified deadheading crew members, passengers or stewardesses; the type of ground aid requested upon landing; additional precautions made such as preparations for an emergency landing, etc.

<u>Step 3--reorganizing the cockpit and landing the airplane</u>: This step was not and should not be a problem for a trained crew. Details will depend upon many variables including the type of equipment used,

phase of flight and weather en route and on landing. These considerations provide excellent material for classroom discussion.

Effective Method for Controlling Operational Risks

When reviewing these data it is important to remember that none of the crew members who participated in this study were trained to cope with pilot incapacitation. The deficiencies they exhibited are easily correctable with appropriate training such as the programmed presentation prepared by the United Air Lines interdisciplinary team. It consists of a 30 minute sound and color film and an instructor's manual containing additional background material. This material enables personnel without previous familiarity with the problem to conduct meaningful discussions and effective training. That this training is effective is suggested in excerpts from a letter from FAA Inspector James Menard to Captain W. E. Dunkle, Senior Vice President, Flight Operations, United Air Lines:

> On February 4, 1975, I was conducting flight checks on an American Airlines DC-10. The First Officer was flying, we had just made our takeoff rotation and he suffered a fatal heart attack. The check airman in the left seat had just given him the command to "start your left turn to 130 degrees maintain 1000 feet." There was no response either visually or orally. I feel we both recognized a problem, then observed the First Officer was experiencing difficulty breathing. This incident was so similar to the United Air Lines film "Incapacitated Crew," I know my actions were automatic.

The Captain took over the controls, the Flight Engineer and I restrained the First Officer from pitching forward on the control column. We slid the seat aft and removed him from the seat. We started emergency oxygen and heart massage. Unfortunately, we did not save the First Officer.

In retrospect, we were in a critical phase of flight, at night, with a turn out over water, at low altitude. The crew did an excellent job and we landed safely.

IMPLICATIONS OF STUDY

There is little doubt that training provides a new approach to an old problem and can increase safety in the air. With two assumptions, it also has definite implications for the aeromedical and licensing disciplines. The first assumption is that an effective training program has been instituted. The second is that operational handling of incidents of subtle incapacitation has been satisfactorily demonstrated. Then one can say three things:

1. There is nothing in these data to suggest that medical screening should be minimized or, in any sense, that it should not consider the problem of incapacitation. However, the incapacitation risk to flight safety can now be evaluated with considerably more precision than has been possible.

2. The statistical analyses of this risk (such as

those by Lane[8] and Anderson[4]), which have made substantial contributions toward keeping the incapacitation problem in perspective, can be modified. There is little question that the period of critical exposure can be significantly reduced if not virtually eliminated.

3. Conservative modification of medical standards and procedures in relevant areas can be seriously considered while still achieving a meaningful reduction in operational risk. Implicit in this statement is an assumption that such modification can be applied on a selective basis in accordance with demonstrated performance. (This selective application is consistent with current practice in both aircraft certification, where provisions for "equivalent levels of safety" provide acceptable modification from standard requirements, and in medical licensing where, for example, corrective lenses permit equivalent visual performance not otherwise obtainable, and "flexibility clauses" permit modification of established standards if it can be demonstrated that air safety will not be adversely affected.)

Approximately 8 years ago, Dr. Lloyd E. Buley, as the chief medical officer of the International Civil Aviation Organization (ICAO) and secretary of the ICAO Med Study Group, reviewed the progress made in a collaborative study of pilot malfunction by ICAO and the International Air

Transport Association and the International Federation of Air Line Pilots Associations. He concluded his "interim review" by stating:

> ... it is suggested that acknowledgment of pilot on-duty incapacitation ... as a permanent part of the air transport industry scene in the foreseeable future constitutes a constructive rather than a defeatist medical position. Further, it appears essential that the design, management, operational, training and licensing disciplines should recognize that pilot incapacitation must be given due weight .... in the overall judgment of what level of safety is practically attainable. It is suggested that only through such recognition will we achieve satisfactory control over all aspects of this unpalatable but not intractable problem.[5]

These were prophetic words. The problem of pilot incapacitation is indeed tractable and its inherent threat to air safety can be satisfactorily controlled. No longer need the incapacitation of a pilot constitute an emergency condition of greater magnitude than that of the other emergencies the aircraft and its systems are designed to control.

REFERENCES

1. Carter ET: Medical problems facing air carrier pilots today and in the future. Technical Summary of the Flight Safety Foundation 21st Annual International Air Safety Seminar. October 8-11, 1968, p 191-198

2. Kulak LK, Wick R Jr, Billings CE: Epidemiological study of in-flight airline pilot incapacitation. Aerospace Med 42:670-672, 1971

3. Orlady HW: ALPA views on pilot selection, monitoring and the criteria for release from duties involving flying. Summary Flight Safety Foundation 19th International Air Safety Seminar, 1966, p 114-124

4. Anderson IH: Prediction of the high risk airline pilot. Presented at Aerospace Medical Association Annual Scientific Meeting, Las Vegas, 1973

5. Buley LE: Airline pilot incapacitation while on duty. Aerospace Med 40:64-70, 1969

6. Harper CR, Kidera GJ, Cullen JF: Study of airline pilot incapacitation: phase II, subtle or partial loss of function. Aerospace Med 42:946-948, 1971

7. Harper CR, Kidera GJ, Orlady HW: Pilot incapacitation: a new look at an old problem. Presented at Flight Safety Foundation 25th Annual International Air Safety Seminar, Washington, DC, 1972

8. Lane JC: Risk of in-flight incapacitation of airline pilots. Aerospace Med 42:1319-1321, 1971

9. Orlady HW, Kidera GJ, Harper GR: Development of post-training objectives for training pilots in handling in-flight incapacitations. Presented at XXI International Congress on Aviation and Space Medicine, Munich, 1973

10. Report of the Public Inquiry into the Causes and Circumstances of the Accident Near Staines on 18 June 1972. London, Her Majesty's Stationery Office, 1972

11. Aircraft Accident Report, Eastern Air Lines L-1011, N310EA, Miami, Fla., December 29, 1972. Washington, DC, National Transport Safety Board, Report no NTSB-AAR-73-14, 1973

12. Aircraft Accident Report, Scandinavian Airlines System DC-8-62, LN-MOO, in Santa Monica Bay Near Los Angeles, California, Jan 13, 1969. Washington DC, National Transport Safety Board, Report no NTSB-AAR-70-14, 1970

MEDICAL EXCELLENCE AND AIRLINE PILOTS

CAPTAIN RODERIC W. GILSTRAP

First Vice President
Air Line Pilots Association
Incline Village, Nevada

It is a privilege to discuss problems in aviation cardiology and the role of preventive medicine in preserving and maintaining the careers of professional airline pilots. The outcome of this conference will create a better understanding of the interaction of operational in-flight techniques with government medical standards by the users, enforcers and consultants of our national aviation system. Your deliberations will have significant impact on the transportation industry.

Let me state that I am an airline pilot, not a physician. My scientific training is not in the discipline of medicine and in no way do I wish to lecture on the intricacies of the highly scientific disciplines of cardiology. I speak for the Air Line Pilots Association, which seeks the highest excellence in the practice of any specialty where the health and welfare of our membership is concerned. The association has enjoyed the services of an aeromedical advisor since late 1969. His role has been to assist airline pilots and to advise the president of the association and

---

Address for correspondence: Captain Roderic W. Gilstrap, Air Line Pilots Association, 321 Ski Way, Box 3644, Incline Village, Nevada 89450.

its membership regarding medical problems affecting health, welfare and safety. His insistence and ours has always been on selecting consultants to evaluate medical problems of pilots on the basis of their known excellence and their national reputation for expertise in their fields. Indeed, some of the most outstanding names on the roster of the American College of Cardiology have been consultants on cardiovascular problems for airline pilots.

<u>Airline Pilots and Medical Excellence</u>

Let me discuss the problem of excellence and how the airline pilot can suffer if exposed to less than the best in the practice of medicine. First, the prime interest of the Air Line Pilots Association and of the Federal Aviation Administration, which is responsible for administering and enforcing regulations pertaining to medical certification, must be flight safety. There are variations in opinion between pilots and administrators as to how safety is best achieved and the degree of safety achievable in the practical everyday operating environment. Both organizations accept the responsibility for safe delivery of quality transportation to the nation; thus the differences reflect matters of degree rather than basic concepts.

In addition, no airline pilot wishes to endanger his health or the safety of his passengers. It is therefore part of his professional responsibility to recognize that any departure from good health status represents a threat to flight safety. It is regrettable that some physicians appear to believe that the airline pilot and the medical profession are adversaries. It is the position of the Air Line Pilots Association that this is not true, that the physician and pilot can and must work together to ensure that a common interest in medical excellence is fully achieved. We are aware of many instances in which airline pilots have provided information on cardiovascular symptoms that would not otherwise have been uncovered. Some of these pilots are no longer flying. Fortunately, many of them remain on flight status, a situation achieved through the application of professional excellence in judging the medical or cardiovascular condition of a particular pilot.

It is also true that some airline pilots are no longer flying because the evaluations to which they were subjected were performed by physicians who did not demonstrate the highest professional excellence. Inadequate or misleading information submitted to the FAA had to be refuted, updated or supplemented, resulting in unnecessary delays in certification, and all the mental anguish, harassment, loss of flight productivity, excessive and unnecessary use of sick leave and salary loss caused by such delays. We believe the FAA can and must demand the highest quality professional practice from the physicians who certify airmen. We also believe the FAA can and must demand the highest quality of professional excellence from physician specialists in all medical fields evaluating airmen. We understand the FAA when it says that it is in a difficult professional ethical position to demand and enforce the criterion of excellence. We, indeed, understand problems of professionalism and ethics, but we also find intolerable the unwarranted and unnecessary grounding of pilots, and unwarranted and unnecessary the loss of an individual airman's productivity resulting from an incompetent evaluation.

We thus look to the elite of the medical profession, as represented by members of this College, to make recommendations regarding the content and techniques, examinations and special evaluations, together with recommendations on selecting properly trained physicians who continue to demonstrate professional excellence in performing evaluations. These recommendations can then be acted on, with the advice and consent of the users and the FAA, to produce practical, workable and reasonable standards and evaluative techniques for professional airmen.

At this point, I would like to add a personal observation on the value of medical excellence to the airline pilot. It is my belief that only the highly trained, highly competent, strong willed and, I might add, brave physician has the required professional background to make the difficult medical decisions concerning safety that affect the careers of other persons. To put it in very colloquial terms, the easy way out is to say "no," quote the rule book, ground the pilot and escape any possible criticism for the decision. The difficult determination is that of the doctor who says he believes, on the basis of his training and background, that a specific condition is not related to safety and that, given proper medical surveillance and control, the pilot can fly. It is usually one of the leaders of your profession who makes that determination. Physicians at the lower levels of professional excellence often cannot or will not expose themselves to the risk of professional criticism in such instances.

Operational Considerations in Air Safety

It would be well to keep in mind that certain facets of the operating environment, of which the airline pilot is an integral part, have important effects on the excellent safety record of the industry; these factors also play an important role in the result that no fatal accident of a scheduled civilian jet air-carrier in the United States has been attributed to a pilot's medical incapacitation from any cause. I believe you cannot escape careful consideration of this fact in your deliberations, especially where you might be considering the merits of raising or lowering standards or the merits of flexibility as it applies to continued certification in the case of a trained professional pilot. I refer, of course, to matters already discussed in detail by Captain Orlady in his presentation and to the safety improvement produced by having fully trained crews in the cockpit who can take over in any emergency situation and bring the flight to a safe termination.

Awareness of the reality of the cockpit environment of the modern airliner, with its complex instrumentation and numerous safety features and with its redundancy in all systems, including the human beings functioning as part of the operational fail-safe crew, can and should play a role in your deliberations and recommendations for updating standards. Today is 1975, not 1935; we fly DC-10's, not DC-3's, and the requirements are different. The pilots who fly these aircraft are fully trained professional men, capable and ready to function in safety-related emergencies.

Flexibility in Application of Medical Standards

The United States stands ahead of all other nations in its flexible approach to determining continued flying status for skilled airmen with a physical problem that is considered cause for further evaluation or possible disqualification from flight status. The United States is envied by other nations and organizations of airline pilots around the world because of this liberal position on flexibility. That this position has not adversely affected flight safety is a tribute not only to the safety redundancy of trained flight crews, but also to the good common sense applied by the FAA in those many cases in which flexibility is allowed.

In addition, however, the Federal Air Surgeon has seen fit to exercise flexibility on the basis of what he judges to be competent professional opinion exercised, one hopes in all instances, by those who are expert and who uphold the principle of excellence in medical practice. We hope that the outcome of this meeting will enable the FAA to continue its enlightened policy in the use of flexibility and, in addition, to expand it, buttressed by the knowledge that the agency can rely upon professional judgments and upon the best possible recommendation of this group.

We also hope to see increased use of operational experience in decision-making related to standards and flexibility. We would especially like to see advancement in thinking about return to flight status after myocardial infarction, coronary artery bypass surgery, the correction of congenital heart defects and cerebrovascular obstructive lesions, and the control of hypertension by medications, as well as continued flight status for those with heart disorders carrying a magnitude of risk no greater than that of the general population.

Prevention Program for the Airline Pilot

I was not present at the prior deliberations of this group, but I did review the minutes of the Steering Committee meeting, and I hope that this collective group has recognized what we consider to be an omission in the deliberations of this Bethesda Conference. I refer to the absence of any specific task force or directive to consider, with all possible seriousness and effort, a workable program that would establish prevention as the core of an approach to the health problems of airline pilots. Although study (Ohio State University, Kulak study[1]) has shown that airline pilots collectively are healthier than the general population, the greatest toll in loss of license is still disease of the cardiovascular system. Prevention is the primary motivating factor of the medical effort within the Air Line Pilots Association, and we believe that it should be the primary motivating factor of medical effort within the industry and the FAA.

When I refer to prevention, I am referring to preventive medicine in its broad sense, and I trust that every physician in this room is dedicated to the principle of prevention. I believe that a major factor in the idea that pilots and physicians are adversaries is that physicians sometimes tend to view essentially healthy persons primarily in the light of their experience with very sick patients. All too often, the harassed practitioner does not seem to have time to educate his patients on preventive measures that could prolong life and preserve productivity. I believe we can encourage cardiologists to increase their efforts to educate patients to alter their life style and attitudes so as to improve their health.

As I understand the principles of preventive medicine, there are several levels of intervention that will promote positive or optimal health, prevent departure from health and prevent disabling illness after the onset of disease. These levels of prevention are promotion of health, specific protection, early diagnosis and prompt treatment, limitation of disability and rehabilitation.

Speaking from the viewpoint of the most interested party in medical certification, namely, the recipient pilot, I urge you to give serious consideration to this plea and to take action and make recommendations that will improve all aspects of prevention of cardiovascular disease in airmen. With your help, I can promise you that the Air Line Pilots Association will be able, and fully intends, to continue to develop programs that will lead to improved health for all of its members.

REFERENCE

1. Kulak LL, Wick RL Jr, Billings CE: Epidemiologic study of in-flight airline pilot incapacitation. Aerospace Med 42:670-672, 1971

ON EXPERTS AND EXPERTISE: THE EFFECT OF VARIABILITY IN OBSERVER PERFORMANCE

DAVID H. SPODICK, MD, FACC

Boston, Massachusetts

> If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts he shall end in certainties.
>
> Francis Bacon
>
> The Advancement of Learning, 1605

Bacon's message lives--with modifications. To be sure, we have learned to begin with doubts, but physicians must be content to end not in certainties, but rather in statistical probabilities. The modern cardiologist thus has a right to feel certain, within statistical constraints, but never cocksure. Absolute certainty remains for some theologians--and like-minded physicians.

EXPERTISE IN CARDIOLOGY

Training and experience tend to confer a degree of certainty, the product of "expertise." Yet for the cardiologic expert the general lesson

---

Address for correspondence: David H. Spodick, MD, Cardiology Division, Lemuel Shattuck Hospital, 170 Morton St., Boston, Mass. 02130.

has been that any certainty is always relative and conditional. Thus, nitroglycerin still vanquishes angina, but it no longer needs to be a coronary vasodilator to do this, and placebos do the same job often enough that even a prompt response is no longer a "valid" therapeutic test. Serious exercise for cardiac patients, long taboo, can now be selectively prescribed to the limit of tolerance. We no longer say "coronary thrombosis" when we mean "myocardial infarction"; indeed, myocardial infarction might lead to coronary thrombosis. Most systolic clicks used to be extracardiac and innocent; they are now intracardiac and guilty. Splitting of the second heart sound was once a matter of some indifference; we now hear the same thing, but interpret it differently. Phase 4 diastolic depolarization was due to increased sodium permeability; now it is due to decreased potassium permeability. Presence of a fourth heart sound was a reliable sign of heart disease; its blanket reliability is now uncertain. Arguments over the possibility of coronary spasm had the quality of theologic disputations; we have now seen it. Hyperintellectualization of the electrocardiogram--the publication mealticket of arrhythmia speculators--once permitted great inverted pyramids of "inductive reasoning," producing pseudocriteria for items such as "left atrial rhythm," but this is no longer possible because of advances in clinical electrophysiology. In every example, the practice and precept of cardiologic experts have within the recent past undergone marked development or radical change.

CARDIOLOGIC EXPERTISE AT BETHESDA

The decision of acknowledged experts are sought in convocations such as the Bethesda Conferences. What has happened in the decade since the first Bethesda Conference on aviation cardiology? In 1965, advice was provided by three committees and 18 experts; in 1975 we need nine "task forces" and 78 experts. Burch[1] has trenchantly warned us about the nature of committee decisions. We are aware that in some areas their proliferation has a smothering effect. Yet, for better or worse, their present number undoubtedly reflects the stupendous advances in diagnosis, therapy, basic sciences and epidemiology that have occurred in the past decade (Table I). Thus, the sheer quantity of expertise demanded. But what about its quality?

The well written Canadian 1974 Manual of Civil Aviation Medicine incorporates thoughtful medical standards for aircrew, but with frequent variances demanding expert decisions. We learn, for example, that the bases of any exceptions from standards include "selected cases," "accredited medical conclusion," "judgment and discretion" and, of course, "expert advice." Hence, the system can be said to provide for elasticity; but its degree depends on the adjudication of experts--which would be hard enough if all experts performed equally in acquiring and digesting information, not to mention interpreting it.

In considering in-flight safety we are dealing with almost certain catastrophe if there is sudden disability or even slight mental impairment and, unlike the clinical situations familiar to most experts, the consequences do not involve only our patient. If, because of this, we were to insist on "fail-safe" standards, that is, rule out the slightest cardio-

TABLE I

Selected Areas of Progress and Development, 1965–1975

- Conceptual advances
  - Controlled trials
    - Medical and surgical therapy
    - Diagnostic methods
- Coronary arteriography
- Echocardiography
- "Mechanocardiography"
  - Systolic time intervals
  - Diastolic
- Expansion of exercise testing
  - More physiologic (nonstep test) challenges
  - Noninvasive (non-ECG) responses and measurements
- Significance of murmurs
  - "Innocent"
  - Click-murmur syndromes (prevalence)
- Clinical electrophysiology (former research procedures)
  - His bundle electrography
  - Endocardial mapping/stimulating by catheter
  - Epicardial mapping
- Prevalence of cardiomyopathies
  - Asymmetric hypertrophy/hypertrophic obstructive cardiomyopathy
    - Nonobstructive
    - Metabolic (plus preclinical malfunction)
      - Alcoholic
      - Diabetic
      - Uremic (patients on dialysis)
- Effective therapy
  - Surgery for coronary, valvular, congenital lesions
  - Beta adrenergic blockade
  - Pacemaker applications
  - Antihypertensive (definitive proof)

vascular abnormality, we would need valid predictors not only of future illness and sudden death but, more particularly, of subtle disabilities. And even so, we would always have vexing questions of borderline findings. In any case, an inevitable manpower deficit makes a "fail-safe" system impractical. But for an elastic system, expertise is even more in demand, both for overall criteria and in adjudicating exceptions. Indeed, where an Olympian "fail-safe" regiment might yield inadequate pilot manpower, with liberal standards there could be inadequate medical manpower for adjudication of compromises and conscientious follow-up.

One might, with some justification, take a statistical way out, at least for multiple aircrew, that is, have enough aircrew to ensure that one or more crewmen will always be in good condition. Even with two patients with known, but asymptomatic, cardiac disease in the cabin it is highly unlikely that both would be acutely disabled at the same time (and with three, the chances against simultaneous disability would be astronomical). This is, of course, only illustrative hyperbole. We are charged with making ground rules and provisions for exceptions on the basis of expert analysis of updated information. How well are we prepared to do this? What is the quality of our expertise?

THE QUALITY OF EXPERTISE

Figure 1 is an attempt to encompass the elements of expertise, conceptualized within a learning-experience feedback loop. Scientific training and experience never cease to accumulate and interact in a

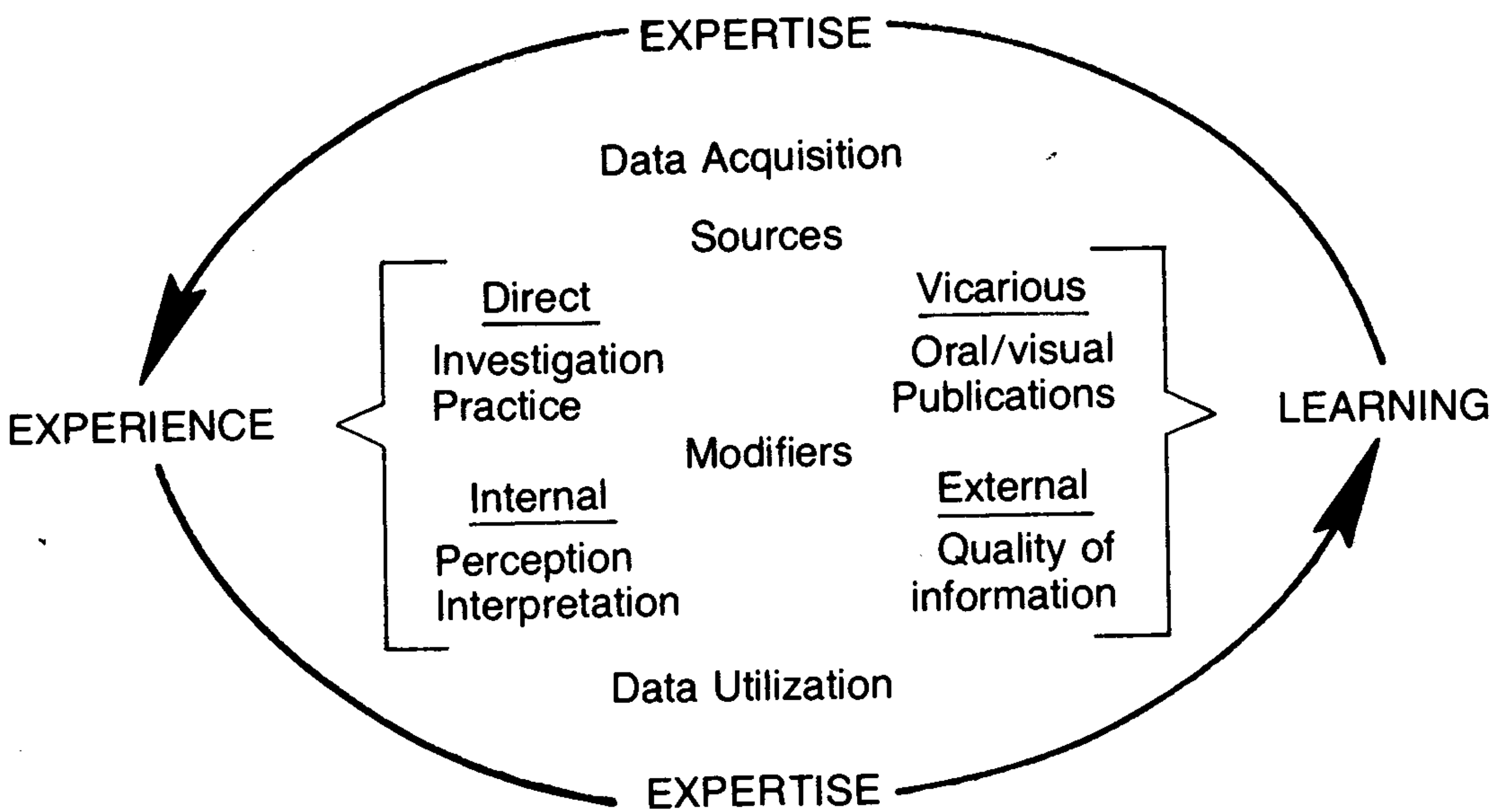


FIGURE 1. Expertise: Learning-experience feedback loop.

FIGURE 1. Expertise: Learning-experience feedback loop.

mutual relation based on continuous acquisition and interpretation of data. Original investigation and practice provide first-hand material, experience of which the expert rightly or wrongly feels most certain. Studies of the Wolff-Parkinson-White syndrome are instructive. Among 128 U.S. Air Force personnel with this syndrome followed up for 5 to 28 years,[2] there were only three deaths (at least two of these, and possibly all, of noncardiac causes), thus suggesting a benign prognosis. However, of 47 hospital patients with this syndrome followed up for 20 years, 19 died,[3] suggesting quite the opposite conclusion. Clearly, it matters greatly whether you start with a physically selected and asymptomatic group. Thus we must view published experience critically (if not biblically), for too often the "Conclusions" giveth, but the "Material and Methods" taketh away.

Changes in thinking on matters such as exercise for cardiac patients, the role of coronary thrombi and the precise antianginal actions of nitroglycerin emphasize the conditional quality of expertise; that is, our opinions are only as good as our information. The expert ought to be up to date on all significant developments. Although he cannot be responsible for tomorrow's discovery, he should be careful to avoid sweeping conclusions in the absence of a definitive investigation because someone might correct this deficit tomorrow. Thus, the distinguished cardiologist who once advised that persons with the Wolff-Parkinson-White syndrome "suffer from an electrocardiogram, not a disease"[4] made this pronouncement without due regard for the quality of the available information.

While experts can be expected to perform only within the constraints of the amount and quality of available information and their interpretations of it, they are subject to the influence of other external factors such as short- and long-term variations within subjects that act to reduce the value of even the most "objective" data. We are well aware of diurnal variation in common tests, such as the electrocardiogram and systolic time interval measurements, which are easily repeatable. Unfortunately, measurements we dare not repeat freely, such as left ventricular enddiastolic pressure, ejection fraction and cardiac index, can vary significantly within 24 hours.[5] In investigations utilizing such measurements, the effect of variability may be lessened by adequate numbers of subjects and careful design of protocol.

If we accept that all or much of the foregoing is fairly well understood and often controllable to some degree, there remains a factor that is difficult to control because of large subjective elements: observer variability. How do well informed and well trained experts perform? If we submit a uniform challenge to a group of acknowledged experts, each of whom may be the ultimate authority in his own field, it is common to find them coming to various and sometimes radically different conclusions. It is especially sobering to find consistently that these differences are based on perception as well as interpretation of data. This phenomenon is not restricted to perceptual differences within a group of recognized experts (interobserver variation). On resubmission of identical material, expert observers quite often change their own previous answers (intraobserver variation). We are obliged, therefore, to raise questions about the nature and consistency of criteria for making crucial decisions.

Formal studies indicate that variability in observer performance is ubiquitous and independent of the field of expertise. For example, when eight expert physicians examined 20 patients for emphysema,[6] their disagreement on well known physical signs ranged from 33 to 85 percent; they agreed on the most simple signs in only 15 percent of cases. The assessments of four experts who obtained medical histories from 993 miners differed widely[7]: Between 13 and 42 percent of the miners were said to produce sputum and between 23 and 40 percent to have had a cough. Changes in serial X-ray films were noted in 8,931 comparisons by three roentgenologists,[8] who disagreed in 29 percent of cases and, on resubmission of the films, disagreed with themselves in 19 percent of cases; the same films produced a 27 percent rate of interobserver disagreement and a 24 percent rate of intraobserver variation among three chest physicians.

Perhaps the commonest call for medical-surgical expertise is the decision for tonsillectomy, that milestone in the life of every American child. In a study of 1,000 schoolchildren,[9] 611 had their tonsils removed. A second group of physicians who examined the remaining 389 decided that 45 percent (174) needed tonsillectomy, leaving only 215 children with apparently normal tonsils. A third group of physicians adjudged 46 percent (99) of those 215 to need tonsillectomy. When the in comparing the vectorcardiogram and electrocardiogram. In every category the electrocardiogram won (Table III). These results stand for "eyeball" interpretation of the two techniques. They do not imply that the quantitative, computerized vectorcardiogram may not be superior (of course, it will have to be compared with the quantitative, computerized 12 lead electrocardiogram). But the results speak eloquently about expert performance with and without biases, particularly when advocates of a competing technique are performing. Despite so many series showing consistent superiority of the vectorcardiogram over the electrocardiogram, vectorcardiographe could not replicate this finding when interpretation was based on objective criteria alone, that is, in a well controlled trial of diagnosis--the analog of the controlled trial of treatment with the identical rationale, minimizing bias.

Perception: So much for readily visible and measurable graphic data, in which the principal cardiologic challenge is more one of interpretation than of perception. Perception, after all, is our primary process in acquisition of data. How do cardiologists perform in controlled trials of perception?

The stethoscope is the traditional symbol of the cardiologist's trade. (In advertising, it has at last supplanted the head mirror as the identifying mark of the physician.) Although it is mysterious to the laity, we know the stethoscope as a more or less hypertrophied hearing aid, which each of us is secretly sure we use better than almost anyone else. How do expert auscultators perform? The work of Caceres and Perry[13] is enlightenin

Eighteen experts were asked to report whether taped heart sounds revealed a systolic or a diastolic murmur in 10 patients, and whether they considered any systolic murmurs to be significant or innocent. The widely divergent results are shown in Table IV. Equally sobering was the result when 12 expert auscultators examined a single patient with an agreed upon systolic murmur (Table V): Five thought the murmur sounded organic, three voted for innocent and four would not comment. Who was "right"?

Performance: It is clear that expert status depends on the amount and quality of information; an expert who hibernated for a few years would no longer be an expert. Expert performance depends on interpretation and perception of data. How can we deal with these factors? It is easier to acquire timely data than to calibrate the two personal factors, perception and interpretation. Today hardly anyone is shy about reporting and disseminating discoveries, so there is little problem in communication. Yet even among highly trained and experienced experts, the amount and quality of information will vary somewhat. (There are often, of course, differences of opinion consistent with all known facts.) Although no one can know tomorrow's discovery, it is enough to be aware that today's "obvious" truth may, in fact, be supported more by biases than by the available data. When, for example, myocardial infarction and coronary thrombosis were clinically synonymous, uncontrolled and poorly controlled studies of anticoagulant therapy repeatedly yielded the anticipated spectacular effects, and it was widely considered malpractice to omit "anticoagulation."[14] Eventually controlled trials settled this issue,

TABLE IV

Assessment by 18 Experts of Taped Heart Sounds in 10 Subjects

			Systolic Murmur			
Subject	Cannot Tell	No Murmur	Innocent	Significant	No Comment	Diastolic Murmur
1	. . .	3	8	3	2	2
2	. . .	12	4	. . .	2	. . .
3	1	2	3	7	4	1
4	. . .	. . .	. . .	16	. . .	2
5	3	4	8	2	1	. . .
6	2	1	1	13	1	. . .
7	3	14	1	. . .	. . .	. . .
8	3	10	5	. . .	. . .	. . .
9	1	12	1	2	1	1
10	1	12	1	3	. . .	1

* Data from Caceres and Perry.[13]

TABLE V

Assessment by 12 Expert Auscultators of Systolic Murmur in Single Patient

	Timing					
Expert	Early	Mid	Late	Probably Innocent	Probably Organic	No Comment
1	+	+	. . .	+	. . .	. . .
2	+	+	. . .	. . .	. . .	+
3	. . .	+	. . .	. . .	. . .	+
4	+	+	. . .	+	. . .	. . .
5	+	+	. . .	. . .	+	. . .
6	+	+	+	. . .	. . .	+
7	+	+	. . .	+	. . .	. . .
8	+	+	. . .	. . .	+	. . .
9	+	. . .	. . .	. . .	. . .	+
10	+	+	. . .	. . .	+	. . .
11	. . .	. . .	. . .	. . .	+	. . .
12	+	. . .	. . .	. . .	+	. . .

* Data from Caceres and Perry.[13]

even before we discovered that the available anticoagulant drugs affect venous but not arterial thrombi. One is reminded of the Red Queen's words to Alice: "That is a well known fact, so well known that it may not be a fact at all."

The impersonal external factors involving expert judgment are susceptible to the kind of well designed efforts to minimize biases used in controlled trials of medical treatment, to which we finally have many more or less willing conversions. Yet considerable doublethink persists when it comes to equal standards for surgical treatment.[15,16] It is precisely this kind of attitudinal block based on deeply cherished biases that affects the internal modifiers of expertise--interpretation and perception.

We have seen highly significant disagreements among experts, who then proceed to disagree with themselves on taking a second look at the same data. Of course, we must accept some irreducible differences within often rather wide limits of tolerance, since we are not machines. However, it is necessary to approach that irreducible level as closely as possible, that is, to minimize biases in data acquisition and interpretation. Part of this can be done by multiobserver-controlled trials of diagnostic methods that can reveal the level of built-in discrepancies. Another part can be done by minimizing biases in practice. In some cardiology departments, for example, electrocardiograms are routinely interpreted twice, first, in ignorance of all but the patient's age and sex, that is, on the basis of criteria alone, without biasing information, so that the tracing speaks for itself. And this interpretation is recorded in writing. The tracings are then reread with the clinical data, and any additional interpretation is added if necessary. But the original reading stands as well. Of course, in many real-life situations we have variable amounts of both helpful and deceptive information. Yet all we can ask of the expert is to be aware of personal fallibility and the possibility of conscious and unconscious biases--not to mention mistakes--in any information bearing on our decisions. Claude Bernard's message is apposite: "The doubter is a true man of science; he doubts only himself and his interpretations, but he believes in science." In any event, decisions are called for, and the possibility of fallibility cannot be permitted to impede our best efforts. Therefore, the final message is from Will Rogers: "It's not so much what we don't know that causes trouble as what we know that ain't so."

REFERENCES

1. Burch GE: Of one mind. Am Heart J 89:127, 1975

2. Berkman NL, Lamb LE: The Wolff-Parkinson-White electrocardiogram. N Engl J Med 278:492-494, 1968

3. Flensted-Jensen E: Wolff-Parkinson-White Syndrome. Acta Med Scand 186:65-74, 1969

4. Bishop LF Jr: Bundle branch block with short P-R interval in individuals without organic heart disease. Am J Med Sci 194:794-800, 1937

n is recorded
ta, and any
inal reading
ve variable
can ask of
bility of
ny in-
s apposite:
nd his
cisions are
ted to im-
ll Rogers:
t we know

iogram.

in
:794-

5. McAnulty JH, Kremkau EL, Rosch J, et al: Spontaneous changes in left ventricular function between sequential studies. Am J Cardiol 34:23-28, 1974

6. Fletcher CM: Clinical diagnosis of pulmonary emphysema. Proc Soc Med 45:577-584, 1952

7. Cochrane AC, Garland LH: Observer error in interpretation of chest films. Lancet 2:505-509, 1952

8. Garland LH: Studies on the accuracy of diagnostic procedures. Am J Roentgenol 82:25-38, 1959

9. Bakwin H: Pseudodoxia pediatrica. N Engl J Med 239:691-697, 1945

10. Ingelfinger F: Peer review in biomedical publications. Am J Med 56:686-692, 1974

11. Davies LG: Observer variation in reports on electrocardiograms. Br Heart J 18:568, 1956

12. Simonson E, Tuna N, Okamoto N, et al: Diagnostic accuracy of the vectorcardiogram and electrocardiogram: a cooperative study. Am J Cardiol 17:829-878, 1966

13. Caceres C, Perry L: The Innocent Murmur. Boston, Little, Brown, 1967

14. Spodick DH: Revascularization of the heart--numerators in search of denominators. Am Heart J 81:149-157, 1971

15. Spodick DH: Numerators without denominators. There is no F.D.A. for the surgeon. JAMA 232:35-36, 1975

16. Spodick, DH: The surgical mystique and the double standard: controlled trials of medical and surgical therapy for cardiac disease: analysis, hypothesis, proposal. Am Heart J 85:579-583, 1973

TASK FORCE I: IDENTIFICATION OF ISCHEMIC HEART DISEASE

Ellestad (Chairman), Fox (Co-Chairman), Bruce, Dodge, Gensini, Humphries, Kannel, Levy, Mankin, McHenry, Sheffield, Tavel

As a result of the phenomenal growth of commercial and corporate air transportation and the increased popularity of private flying, approximately 750,000 pilots held current licenses in 1973. Their average age was 36 years, but 180,000 were over 45, an age at which coronary heart disease is clearly a clinical problem or concern of American men. Although there is little evidence to indicate that the recent increase in aircraft accidents is related to sudden pilot incapacitation, it is appropriate to examine carefully the factors that might lead to cardiovascular problems.

It has been emphasized that for compromised function in the multicrew aircraft, several events must occur simultaneously:

1. The incapacity must affect the pilot at the controls.
2. The incapacity must be sudden or unnoticed.
3. The incapacity not only must be sudden and nearly total, but also must take place during the critical time of takeoff or final approach and landing. During these phases of flight, surprise may delay the reaction of the second pilot so that he is unable to take over the controls in the few seconds available.

It should be well understood that these three conditions seldom occur together in commercial flights and thus accidents caused by physical incapacity of the airline pilot are extremely rare. In single pilot aircraft, the disastrous implications of incapacity are obviously increased.

The following considerations are presented as possible approaches to minimizing hazards and preventing a catastrophe for flying personnel and for those whose lives depend on them.

BACKGROUND MATERIAL

Data indicate that the average American man has 1 chance in 3 of having some major incapacitating cardiovascular problem, and 1 in 5 of having a heart attack before the age of 60 years.[1,2] Premature death from coronary heart disease in the most productive years of life is an acknowledged public health problem. Among persons aged 35 to 64 years (the active age span of flying personnel), nearly 1 death in 3 is attributed to cardiovascular disease.

Of special interest to the air transportation industry are the facts that more than half of all coronary deaths are sudden, and that 65 percent of these are unheralded by prior evidence of overt coronary heart disease and, hence, are unexpected by the victim or his physician or employer.[3,4] In 1 in 5 coronary attacks sudden death is the first presenting symptom. Coronary heart disease, even in its most serious form, can go undetected in persons who are not evaluated periodically. In the Framingham study as many as 1 in 4 myocardial infarctions were not detected at the time of occurrence.[5] Epidemiologic facts about the natural history of coronary disease in particular, and cardiovascular disease in general, emphasize the need for preventive strategy to avert tragedy. There is little reason to believe that these considerations apply any less to flying personnel than to the general population.

<u>Incidence rate of coronary heart disease in pilots:</u> The risk of cardiovascular events in flying personnel initially free of major predisposing impairments such as hypertension, diabetes and abnormalities detected in the electrocardiogram should be somewhat lower than in the general population. True estimates of incidence are not available. The data compiled by the Air Line Pilots Association suggest that aviation personnel are likely to have a lower incidence rate of coronary heart disease than the general population. (These data are most complete in relation to medical loss of license. Instances of sudden death from various causes may have been overlooked since the data are not complete with regard to deaths. The data also tend to underestimate death from coronary heart disease although the authors made a conscious effort to rectify this potential underestimation.) However, it is also clear that the advantage of the pilot group wanes dramatically with advancing age (Table I), presumably because during their career they acquire cardiovascular risk factors that offset their initial advantage. Because of this and the stress of the job, careful, periodic medical evaluation of flying personnel for evidence of vulnerability to a cardiovascular catastrophe is considered advisable to safeguard the lives of airline personnel and the flying public in their charge.

TABLE I

Comparison of Data on Incidence of Coronary Heart Disease in Framingham and Air Line Pilots Association (ALPA) Studies

	Age-Specific Incidence Per/1000 Persons			
Age (yr)	Framingham	ALPA	Difference	Ratio Framingham/ALPA
29–34	2.93	0.151	2.78	19.40
35–39	2.44	0.678	1.76	3.60
40–44	5.16	2.050	3.11	2.52
45–49	7.23	4.460	2.77	1.62
50–54	12.70	8.740	3.96	1.45
55–59	19.80	15.900	3.90	1.25

Reliable and complete data on the incidence of cardiovascular disease in pilots are not available. Adequate statistics on the rate of cardiovascular incapacitation due to cardiovascular problems in flying personnel on active duty are almost totally unavailable. Reporting of such events should be made mandatory. Since about 10 percent of a pilot's time is spent in flight, this is presumably the time of principal public concern. On this basis, the rates of coronary attack during duty would be assumed to be no less than 10 percent of the number of such attacks. The Air Line Pilots Association study does indicate that in the age group 35 to 59 years, cardiovascular disease is the most frequent single cause of termination of flying careers, myocardial infarction and hypertension being the chief categories.[6]

Estimates of the risk of in-flight commercial pilot incapacitation without warning are unduly speculative. The Air Line Pilots Association suggests that 25 to 30 such occurrences can be expected in 10 years. The National Transportation Safety Board has released figures from 1961 to 1970 indicating 31 incidents of in-flight aircrew incapacitation in U. S. air carriers. Although the diagnosis was not available in all cases, 11 incidents were of cardiac origin and 8 resulted in the death of the captain. Apparently none of these caused a fatal accident. Kulak et al.[6] reported 16 cases of on-duty pilot deaths due to coronary disease between 1952 and 1966. Only one is said to have resulted in a fatal crash.[6] However, an ICAO-IFALPA (International Civil Aviation Organization/International Federation of Air Line Pilots) study reported five incidents in which sudden pilot incapacitation in 17 countries resulted in accidents that led to 148 deaths among passengers and crew between 1961 and 1969.

Profile for identifying risk in presymptomatic persons: Epidemiologic investigators at Framingham and elsewhere over the past 2 decades have devised a profile of the potential candidate for cardiovascular disease that allows estimation of risk in presymptomatic persons.[2,7] As indicated, this is important because coronary artery disease is extremely common, frequently attacks without warning, is often silent even in its most dangerous form and may present with sudden death as its first and only symptom. In such a disease, the identification of vulnerable persons for application of effective prophylactic management offers the promise of safeguarding potential victims.

By using ordinary office procedures and simple laboratory tests, it is now possible for an occupational health unit to identify among its employees both those who are prime candidates for a cardiovascular attack and those already afflicted with asymptomatic cardiovascular disease. Information such as the blood lipid content, the blood pressure, carbohydrate tolerance and electrocardiographic findings focuses attention on the person prone to coronary disease. Each of these observations and certain habits, such as cigarette smoking, have been shown in prospective epidemiologic studies to be related significantly to the rate of development of clinical cardiovascular disease and to the extent of coronary atherosclerosis (Fig. 1).[1,7-10] In population studies it has been shown that the greater the number of risk-related traits present and the larger nd crew

pidemiologic
es have de-
isease that
cated, this
, fre-
t dangerous
ptom. In
lication
uarding

ests, it
its
r attack
ase.
carbo-
tion on
and
spective
level-
onary
shown
larger

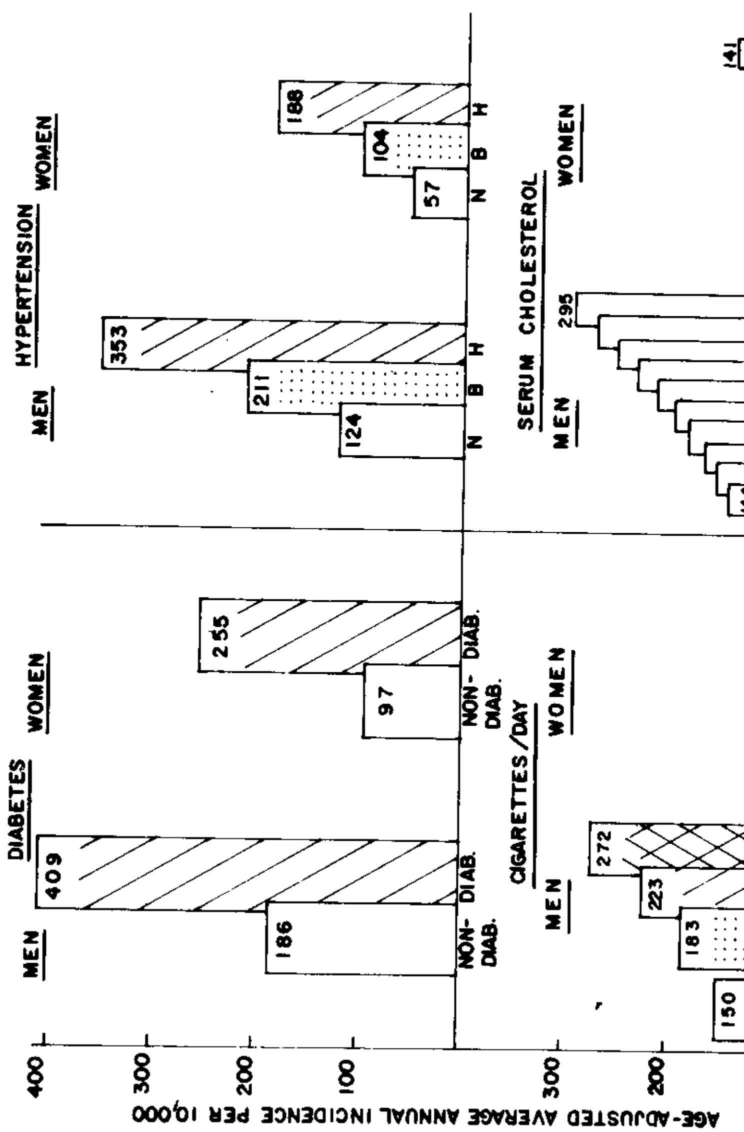


FIGURE 1. Risk of cardiovascular disease according to specified risk factors in men and women aged 45 to 74 years. Framingham study: 18 year follow-up. B = borderline; DIAB. = diabetic; H = hypertensive; N = normotensive.

the aberrations, the greater the risk of a cardiovascular event (Fig. 2).

The identified abnormalities that promote atherosclerotic cardiovascular disease can be handled quantitatively as ingredients of a cardiovascular risk profile so that the joint effect of the multiple contributors can be estimated.[2,7] An efficient and practicable set of risk variables for this purpose has been selected[2]: blood tests for cholesterol and sugar, a blood pressure determination, electrocardiogram and a history of cigarette smoking. Such an evaluation can conveniently be obtained periodically without hazard or undue expense, atraumatically, by a nurse or a technician under medical supervision.

With this set of variables, 10 percent of the asymptomatic general population can be identified, from which 25 percent of the cases of coronary heart disease, 40 percent of the cases of occlusive peripheral arterial disease and 50 percent of the cases of stroke and congestive heart failure will emerge (Fig. 3). The chances of a cardiovascular event within 8 years in such high-risk persons is 34 percent, and a coronary attack can be expected in 13 percent in this period.

More specific diagnostic indicators of presymptomatic cardiovascular disease are being developed or may already be available in medical centers, but no great innovations are required to usefully identify candidates for a cardiovascular event and to estimate the risk. Handbooks prepared by the National Heart and Lung Institute[2] allow estimation of coronary or cardiovascular risk from simple office procedures (Table II). Once a certain level of remediable risk is established (perhaps at twice the

(Fig. 2).

ardio-
a
iple
set of
for
rdiogram
eniently
atically,

general
of
ipheral
stive
ular
d a

ovascular
al centers,
dates for
ared by
ary or
nce a
e the

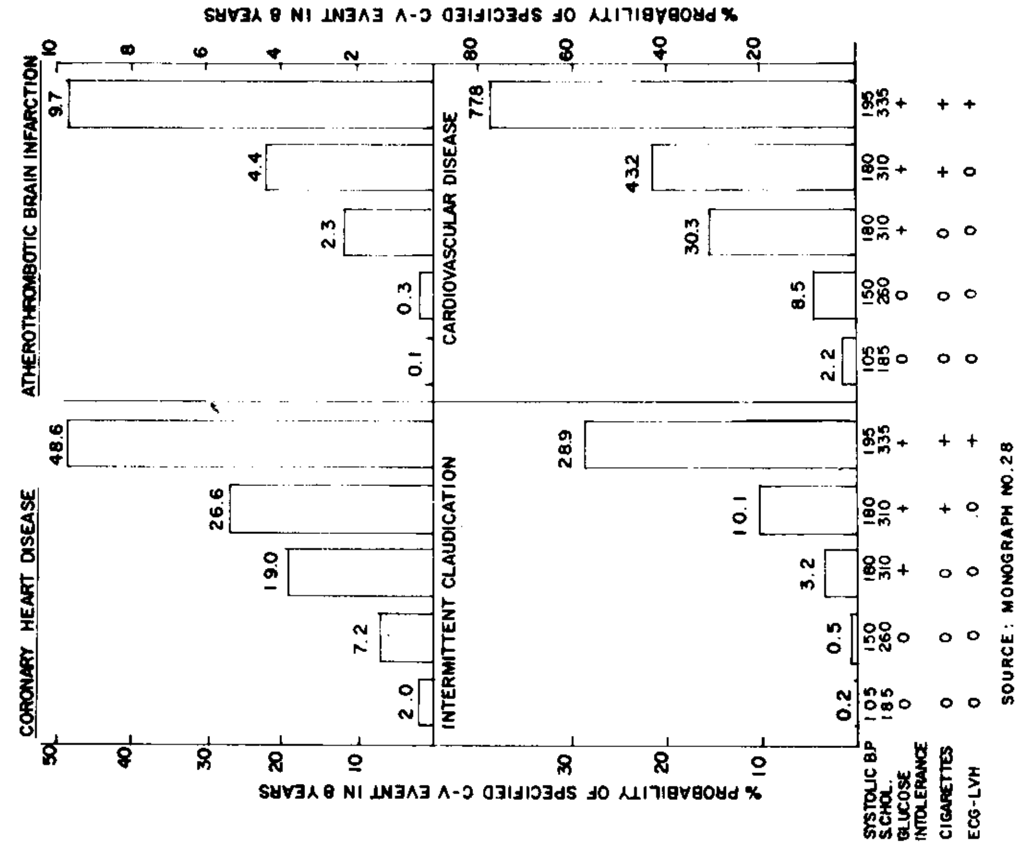


FIGURE 2. Risk of cardiovascular disease according to intensity of major risk factors in men aged 45 years. Framingham study: 18 year follow-up. BP = blood pressure (mm Hg); C-V = cardiovascular; ECG-LVH = left ventricular hypertrophy by electrocardiogram; S. CHOL. = serum cholesterol.

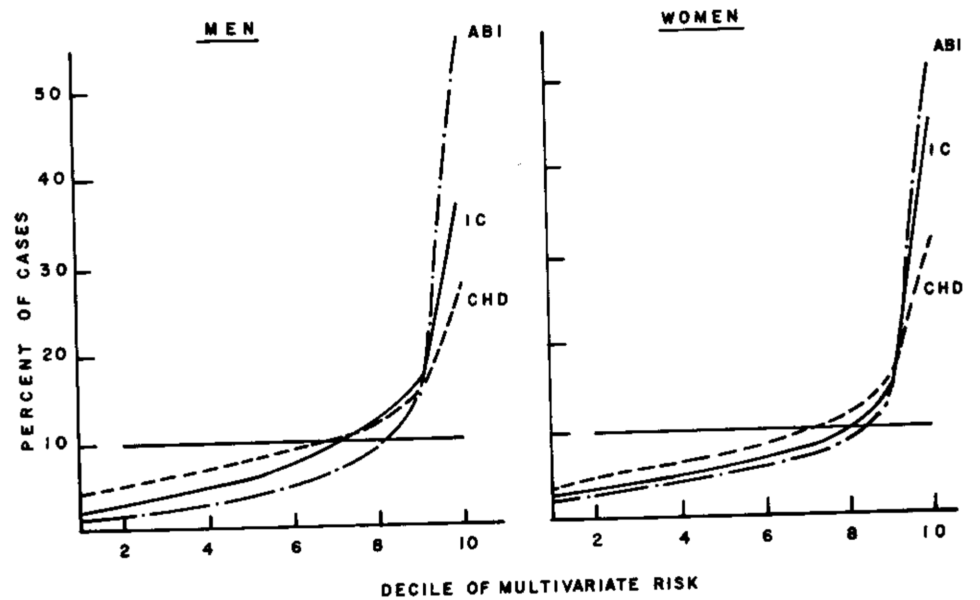


FIGURE 3. Percent of cases of coronary heart disease (CHD), atherothrombotic brain infarction (ABI) and intermittent claudication (IC) in each decile of multivariate risk. Framingham study: 16 year follow-up.

TABLE II

Probability (per 1,000) of Having Cardiovascular Disease in 8 Years According to Specified Characteristics in Men Aged 45 Years. Framingham Study: 18 Year Follow-Up*

	Does Not Smoke Cigarettes								Smokes Cigarettes							
	Serum Choles-terol (mg/100 ml)	Systolic Blood Pressure (mm Hg)							Serum Choles-terol (mg/100 ml)	Systolic Blood Pressure (mm Hg)						
		105	120	135	150	165	180	195		105	120	135	150	165	180	195
A. No Left Ventricular Hypertrophy by Electrocardiogram																
No glucose intolerance	185	22	27	35	43	54	68	84	185	38	47	59	73	91	112	138
	210	28	35	43	54	68	84	104	210	47	59	73	91	113	138	169
	235	35	44	54	68	84	104	129	235	59	74	91	113	139	169	205
	260	44	55	68	85	105	129	158	260	74	92	113	139	170	206	247
	285	55	68	85	105	129	158	192	285	92	113	139	170	206	247	293
	310	68	85	105	130	158	192	232	310	114	140	170	206	248	294	345
	335	85	105	130	159	193	232	277	335	140	171	207	248	295	346	401
Glucose intolerance	185	39	49	61	76	95	117	143	185	67	83	102	126	154	188	226
	210	49	61	76	95	117	144	175	210	83	103	126	155	188	227	271
	235	62	77	95	117	144	176	212	235	103	127	155	189	227	271	320
	260	77	95	118	144	176	213	255	260	127	156	189	228	272	321	374
	285	96	118	145	176	213	255	303	285	156	189	228	272	321	375	431
	310	118	145	177	214	256	303	335	310	190	229	273	322	375	432	490
	335	145	177	214	256	304	356	411	335	229	273	323	376	433	491	550
B. Left Ventricular Hypertrophy by Electrocardiogram																
No glucose intolerance	185	60	75	93	115	141	172	208	185	101	124	152	185	223	266	315
	210	75	93	115	141	172	209	250	210	124	152	185	223	267	315	368
	235	93	115	142	173	209	251	297	235	153	186	224	267	316	369	425
	260	116	142	173	209	251	298	349	260	186	224	268	316	369	426	484
	285	142	173	210	252	298	350	405	285	225	268	317	370	426	485	543
	310	174	210	252	299	351	406	464	310	269	318	371	427	485	544	602
	335	211	253	300	351	406	464	523	335	318	371	428	486	545	602	657
Glucose intolerance	185	105	129	158	191	231	275	324	185	170	205	246	293	344	399	456
	210	129	158	192	231	275	325	378	210	206	247	293	344	399	457	516
	235	158	192	232	276	325	379	436	235	247	294	345	400	457	516	574
	260	193	232	277	326	380	436	495	260	294	346	400	458	517	575	631
	285	232	277	327	380	437	496	554	285	346	401	459	518	576	632	685
	310	278	327	381	438	496	555	612	310	402	459	518	576	633	685	734
	335	328	382	438	497	556	613	667	335	460	519	577	633	686	734	778

* Framingham men aged 45 years have an average systolic blood pressure of 131 mm Hg and an average serum cholesterol value of 234 mg/100 ml. Sixty-eight percent smoke cigarettes, 0.7 percent have definite left ventricular hypertrophy by electrocardiogram and 3.9 percent have glucose intolerance. At these average values the probability that cardiovascular disease will develop in 8 years is 75/1,000.

average risk), flying personnel could periodically be reassessed for improvement in risk factor scores. Emphasis should be placed on correcting the adverse risk status with the hope of extending an individual's flying career.

PRECLINICAL ISCHEMIC MYOCARDIOPATHY (ELECTROCARDIOGRAM)

In persons with an unfavorable cardiovascular risk profile (and a presumed propensity to accelerated atherogenesis), the development, without other explanation, of certain electrocardiographic abnormalities or cardiac enlargement on X-ray study may herald the onset of ischemic myocardiopathy (Fig. 4). Such persons have a statistically increased risk of experiencing coronary attack, stroke and congestive heart failure.[3]

The development of electrocardiographic changes consistent with myocardial infarction provides evidence of a damaged myocardium, usually from a compromised coronary circulation. One in four infarctions is silent or unrecognized, and the appearance of the electrocardiographic changes in periodic examinations is the usual means of detection. The apparent mildness of the attack should provide no reassurance, for the prognosis for recurrence and survival is no better than in those surviving a symptomatic attack.[5]

While other electrocardiographic abnormalities at rest (including left ventricular hypertrophy, intraventricular conduction disturbances and nondiagnostic S-T and T wave abnormalities) do not warrant more than a presumptive diagnosis of coronary heart disease when other explanations are not available, an excessive amount of overt coronary heart disease does develop in persons with these findings (Fig. 4).

Evidence of left ventricular hypertrophy in the electrocardiogram is a particularly important finding. Within 5 years of its appearance, 38 percent of patients with this finding will be dead; the rate of sudden death and the risk of congestive heart failure and stroke are many times those of the general population (Table III). Left ventricular hypertrophy is associated with an increased risk of every clinical manifestation of coronary heart disease, and carries a prognosis no better than that of an actual myocardial infarction.[3,11] Personnel with this finding should be subject to the same review as those with electrocardiographic evidence of a myocardial infarction.

In persons with patterns of left ventricular hypertrophy, infarction and block, the appearance of ventricular premature beats at rest is associated with at least a threefold increased risk of sudden death.[12,13]

ELECTROCARDIOGRAPHIC STRESS TESTING

In persons with a normal electrocardiogram at rest, a compromised coronary circulation may often be detected by an exercise test. Development of certain changes (S-T segment displacement) during or after exercise may provide the earliest evidence of myocardial nutritional impairment, and very often may indicate a functionally important degree of impairment of coronary blood flow. In groups of persons with such abnormal exertional responses, even when asymptomatic, overt coronary heart disease has generally been found to develop at a markedly increased rate, often at seven or more times the rate of those with normal exercise

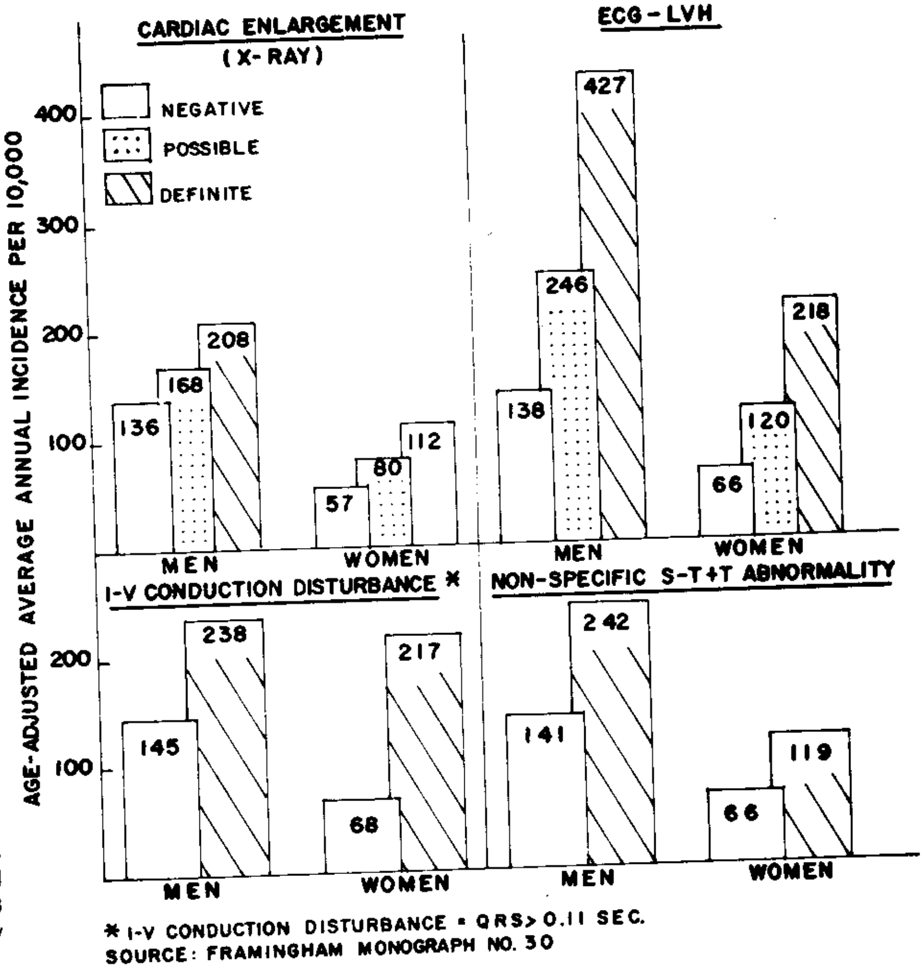


FIGURE 4. Preclinical ischemic cardiomyopathy. Risk of coronary heart disease according to abnormalities in electrocardiographic and X-ray studies in men and women aged 45 to 74 years. Framingham study: 18 year follow-up. ECG-LVH = left ventricular hypertrophy by electrocardiogram; IV = intraventricular.

SOURCE: FRAMINGHAM MONOGRAPH NO. 30

by electrocardiogram; IV = intraventricular.

TABLE III

Incidence of Cardiovascular Morbidity and Mortality Related to Left Ventricular Hypertrophy by Electrocardiogram in Men and Women Aged 45 to 74 Years. Framingham Study: 18 Year Follow-Up (5 year age-adjusted incidence per 100)

	Left Ventricular Hypertrophy by Electrocardiogram					
	None		Possible		Definite	
	M	F	M	F	M	F
A. Mortality						
Cardiovascular mortality	3.6	1.6	11.1	5.2	31.8	16.4
Coronary mortality	1.4	0.5	3.7	1.0	9.5	1.8
Sudden death	0.8	0.2	2.1	0.4	5.5	0.7
Overall mortality	6.7	3.6	16.4	8.6	37.6	19.6
B. Morbidity						
Cardiovascular disease	9.1	4.7	18.5	11.7	35.9	27.9
Coronary disease other than angina pectoris	4.6	1.5	9.0	2.2	17.3	3.3
Brain infarction	0.8	0.6	1.7	2.1	3.5	6.9
Congestive heart failure	1.4	1.0	4.2	3.2	12.5	10.2

and postexercise responses.[14-18] In one prospective study, 85 percent of subjects had overt coronary heart disease within 5 years.[19] In presumably healthy air force flying personnel, 20 percent with an abnormal test had coronary heart disease within 6 years, a 14-fold increased risk.[20]

No practical method will detect all persons with silent coronary atherosclerosis even when severe. However, electrocardiographic surveillance with attention to the aforementioned precursors of coronary attacks in persons with atherogenic traits can reduce the large reservoir of undetected silent coronary artery disease. The periodic use of the electrocardiogram at rest and with exercise is the only practical noninvasive method available for routine use in detecting asymptomatic coronary disease.

ANGINA PECTORIS AND MYOCARDIAL INFARCTION

As in the general population, myocardial infarction and angina pectoris may go unrecognized in aviation personnel. After an infarction, as many as 25 percent of persons will recover to have a relatively normal electrocardiographic pattern. Most persons with angina pectoris have symptoms for at least a year before they consult a physician.[21,22] In such persons with either angina or myocardial infarction, whether recognized or not, the risk of subsequent cardiovascular events is substantial.

About 30 percent of those with a myocardial infarction will soon have angina pectoris. Mortality in persons with either undetected or overt angina or myocardial infarction will occur at a rate of 4 percent a year, and sudden deaths will occur at four times the rate observed in the general population (1.5 percent a year) (Fig. 5). About 2 percent a year of those with angina will have congestive heart failure. Strokes will occur at five times the rate observed in the general population, and occlusive-peripheral arterial disease with intermittent claudication at three times the rate found in the general population.[23,24]

CURRENT METHODS OF DETECTING ISCHEMIC HEART DISEASE IN PILOTS

The following background data are now required:

1. Resting 12 lead electrocardiogram: This is required by the Federal Aviation Administration (FAA) on first examination after attainment of age 35 years, at age 40 and annually thereafter until mandatory retirement at age 60 years (class I airline pilot and class II if flying large commercial aircraft). There is no maximal age limitation for class III PILOTS. The requirement for a resting electrocardiogram does not apply to the class II or class III pilots unless the history or physical examination suggests cardiac disease. Class I pilots are not required to have an electrocardiogram when hired (minimal age 23).

2. Exercise electrocardiograms: These are not routinely required by the FAA for pilots of any class. They may be required if history, physical examination or resting electrocardiogram arouses suspicion of cardiac disease. The age- and weight-adjusted double Master two step test is the recommended exercise test.

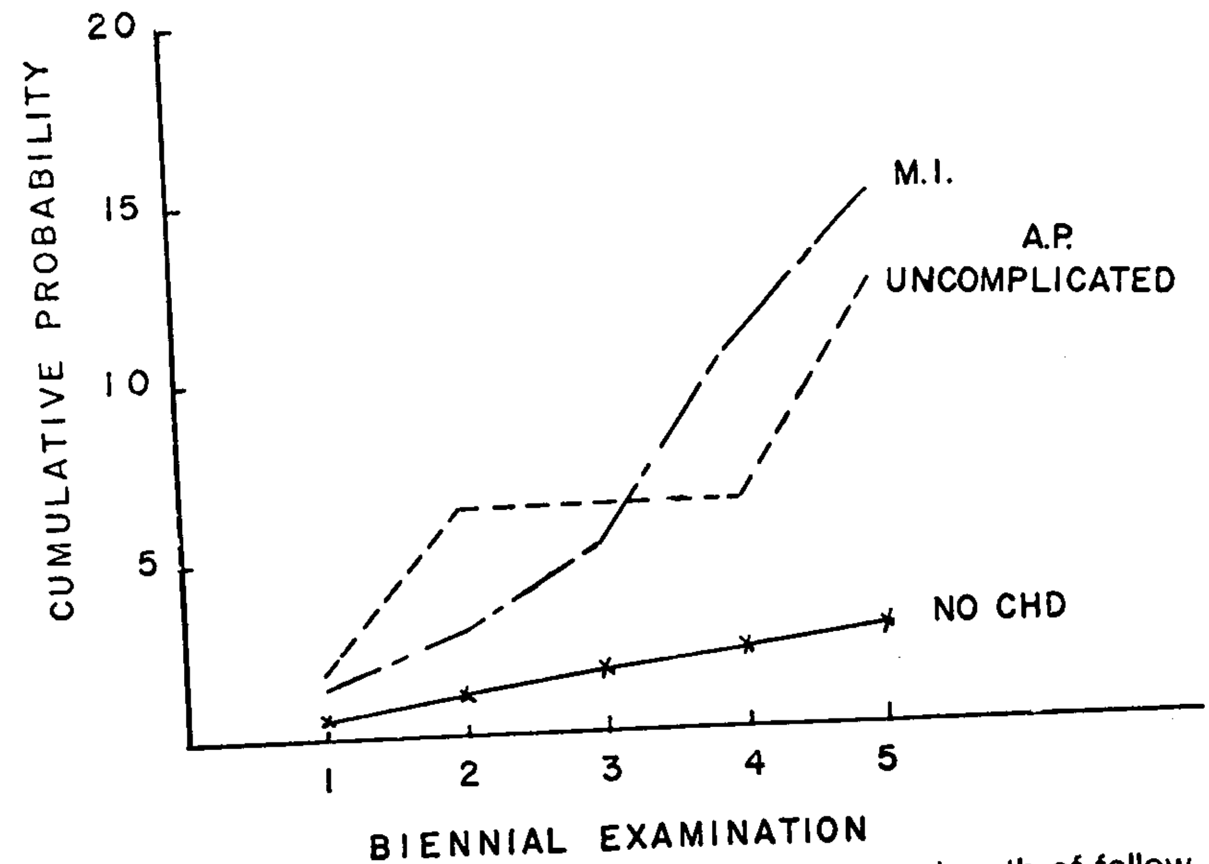


FIGURE 5. Probability of sudden death according to length of follow-up and prior status of coronary heart disease (CHD) in men aged 55 to 64 years. Framingham study. A.P. = angina pectoris; M.I. = myocardial infarction.

3. <u>Acquisition and disposition of electrocardiographic data acquired for FAA review</u>: There are about 5,000 Aviation Medical Examiners, of whom about 2,000 are specially licensed to examine class I pilot personnel. Many of these examiners are physicians with minimal current involvement in general medicine, cardiology or electrocardiography. The routine resting electrocardiograms obtained as indicated are submitted to the FAA for official review; at present a minimum of 3 months usually elapses before this review. The physician originally recording the electrocardiogram can ground the pilot if a major abnormality is present and recognized. The FAA on its eventual review can ground the pilot at that time if a major abnormality is detected.

The FAA keeps a file of previous electrocardiograms, allowing for valuable comparisons. Despite this opportunity, there are many examples of class I pilots who have had single or multiple myocardial infarcts and have not been promptly grounded; instead, a cardiovascular consultation has been requested within the next 30 days. The consultation and the transmittal of the report to the FAA may easily involve 30 or 60 days more. Potentially, it can be up to 6 months after infarction that the pilot can be still exercising the entitlement of a previously valid medical certification. At no time until the ultimate grounding by the FAA can the medical department of the pilot's airline, if there is such a department, be notified of the infarction without the pilot's written authorization. No mechanism or authority exists whereby FAA personnel may directly communicate their medical concerns to the airline until ultimate grounding. Until that moment, the FAA'communicates solely with the pilot in question and the examining physician or physicians.

4. Physical examinations and data acquisition by Aviation Medical Examiners: Class I personnel are examined every 6 months, with the known limitations that exist with this type of review for the detection of latent or even manifest ischemic heart disease. Class II personnel are examined every year and class III personnel every 2 years. The electrocardiographic requirements are as described previously.

5. Class I personnel--airline medical departments: Orford and Carter[25] reported that approximately 35 percent of U. S. airline pilot personnel are employed by companies without a medical director or medical department. These airlines rely on the Aviation Medical Examiner system of the FAA to provide medical surveillance of their aircrewmen. Aircrewmen in these companies may embark on a career in the airline industry without comprehensive examination, submitting an unsupervised medical history with no resting or exercise electrocardiogram. No established program for recognizing and correcting risk factors for coronary heart disease exists for these persons.

Some 65 percent of the U. S. airline aircrew personnel are under the surveillance of an airline medical department in addition to undergoing examinations conducted by the FAA's Aviation Medical Examiners. Only two medical departments of major U. S. airlines have a budget for conducting an annual examination, and these airlines employ fewer than 25 percent of the industry's pilots. The chief employers of aircrewmen can examine their personnel in their own facility only every 2 or 3 years.

Most medical departments can examine their personnel only once in 3 to 5 years. These limitations in medical surveillance are self-imposed by the industry as a consequence of its budgetary constraints and ordering of priorities.

Dr. P. Siegel, immediate past Federal Air Surgeon, clearly recognized the need for early detection of ischemic heart disease in airline aircrew personnel. To this end, he recommended the minimum of a standard double Master two step exercise electrocardiographic test annually for personnel over the age of 40 years. This recommendation was never implemented because of pressures within the agency and the industry. He also proposed that medical examination of pilots be performed through the medical department of the pilot's airline. Such a plan appears superior to the current program because aviation medical specialists would conduct the examinations, any findings of note could be handled promptly, and better preventive medical programs could be implemented to enhance career longevity. This proposal was opposed and defeated, but deserves further consideration.

RECOMMENDATIONS

In the interest of the pilot, the public and the aviation industry, appropriate medical requirements to safeguard all concerned should be established. The following recommendations are intended (1) to establish reasonable criteria for qualifying persons beginning or continuing a career in flying, and (2), by providing for periodic evaluation and appropriate care, to help maintain cardiovascular health through preventive management of adverse risk factors, thus enhancing career longevity and performance.

Airline Medical Departments

All airlines engaged in passenger transportation should have a designated medical director or contract for the required medical and allied health science personnel to examine their own pilot and cockpit personnel at least once a year and provide the stipulated electrocardiographic tests described. Occupational health units should be set up in the aviation industry, not only to detect persons susceptible to cardiovascular events but also to implement effective prophylactic programs designed to correct impairments or precursors of cardiovascular disease as soon as they are discovered before the employee must be disqualified from flying. Such efforts should help to ensure a longer uninterrupted career for flying personnel. Existing data indicate that when an airline has a competent medical department, fewer persons are disqualified from flying on medical grounds.[25]

All Airline Medical Examiners responsible for passenger-carrying class II pilots should be able to take and interpret resting and exercise electrocardiograms and should be well versed in internal and aviation medicine. Examiners responsible for class III pilots should have the same capabilities, or have close collaboration with those competent to identify signs and symptoms of cardiovascular disease, or be able to identify and refer their pilot patients to a qualified facility for the electrocardiographic and exercise test-oriented portions of the examination, with "same day" reporting to the Airline Medical Examiner, and to the FAA within the same week.

History and Physical Findings Considered to Warrant Temporary Disqualification or Special Testing

A. Chest Pain

1. Typical angina pectoris is disqualifying.
2. Atypical chest pain in the absence of obvious noncardiac explanation is disqualifying.

B. Symptoms of Decreased Cardiac Performance

1. Typical symptoms of congestive heart failure (such as dyspnea on exertion, orthopnea, nocturnal dyspnea, cardiac enlargement on X-ray study, low vital capacity, gallop rhythm, pulmonary vascular congestion, edema, venous engorgement, hepatomegaly, pulsus alternans, in some combinations) are disqualifying if the remaining clinical findings are consistent with this diagnosis.
2. Partial or incomplete picture of cardiac dysfunction, that is, significant change in exercise capacity, dyspnea on exertion or fatigue, requires careful additional evaluation before certification.

C. Palpitations:

1. These require careful additional study, especially if sustained or associated with change in consciousness. An attempt should be made to obtain electrocardiographic rhythm strip recordings representative of the period of dysrhythmia or palpitations.

D. Physical Examination

1. Cardiomegaly greater than 30 percent: This finding is disqualifying if it is supported by an additional laboratory study such as roentgenography or echocardiography.

2. Abnormal cardiac pulsations:

   a. Sustained systolic lift or eccentric location of outward systolic movement requires further study before certification.

   b. Abnormal diastolic impulses, that is, a palpable A wave or accentuated rapid filling wave, especially if confirmed by phonocardiogram or apex cardiogram, require further study.

3. Auscultation:

   a. Gallop sounds alone are not considered disqualifying.

(1) A loud and persistent third heart sound in a person over age 35 requires further evaluation, but it can be the hallmark of excellent cardiac capabilities in a well trained person with the bradycardia of training adaptation.

(2) A fourth heart sound is disqualifying only if associated with a palpable (apical) A wave. If a fourth heart sound is thought to be present, but such a wave is not palpable, a high quality phonocardiographic and apexcardiographic evaluation should be obtained before the finding is labeled abnormal.

b. A murmur of organic lesions, such as a pansystolic or late systolic mitral murmur consistent with papillary muscle dysfunction, should be considered disqualifying until evaluated extensively.

4. Examination of the chest: Pulmonary rales in conjunction with other signs of congestive heart failure are disqualifying.

It is suggested that phonocardiography and systolic time intervals not be used for routine screening. They may have application in documentation of certain physical findings such as a third or fourth heart sound. They may also be helpful in determining more rationally which persons with abnormal responses have abnormal hemodynamic status and should therefore be disqualified.

Resting Electrocardiograms

Because of the rapid increase in the manifestations of coronary heart disease after age 45, the following recommendations are offered: A properly standardized 12 lead control electrocardiogram should be obtained in all pilots of all classes before medical certification by the FAA or after a certification lapse of 5 years. All pilots should have an electrocardiogram when upgrading their class status, for example, from class III to class II. An additional standard 12 lead electrocardiogram should be obtained from all pilots during the first examination after and within 12 months of attaining age 35 and again after age 40. Thereafter, a resting 12 lead electrocardiogram should be obtained from class I and class II pilots annually, and every 2 years for class III pilots.

A resting electrocardiogram is to be taken only under the supervision of physicians who can be held responsible for achieving a high degree of quality control of the data acquired and who are versed in the interpretation of potentially life-threatening electrocardiographic abnormalities. If such an abnormally exists, the responsible physician should immediately contact the medical director of the air carrier or the director of pilot personnel, or both, and require a temporary "off-flying duty" status for the pilot until a cardiovascular consultation can be obtained. Less specific abnormalities evident in the resting electrocardiogram may be handled by prompt transmittal to the FAA of the complete data. The FAA reviewing office must process and review all tracings received during the standard work week and some definitive, even if preliminary, disposition made of each pilot's medical application during the same work week.

Exercise Electrocardiogram (Appendix I).

An exercise electrocardiogram should be required of all pilot classes before certification, as well as at ages 40 and 45 and every 2 years thereafter if no abnormalities are found. Exercise electrocardiograms may be carried out only in authorized facilities that have demonstrated a high level of quality control of data acquisition and the ability to provide qualified interpretation of the data acquired. Demonstration of exercise-induced dysrhythmias or ischemia, or both, will at this juncture require an "off-flying duty" status for the pilot (Appendix I); his medical director or director of pilot personnel, or both, will be notified within 24 hours. Prompt cardiovascular consultation is required, the findings to be reviewed by the FAA, with the latter providing the same expeditious handling and disposition of cases outlined for resting electrocardiograms.

The exercise stress test must meet the following requirements: multistage, progressive exercise tolerance test with electrocardiographic monitoring and recording of tracings to include at least a V_5 position lead (such as CM_5) at the end of each specified stage (speed, grade, duration), and preferably every minute, with recording of blood pressure, clinical signs and symptoms during each stage of the test and every minute for at least 5 minutes or disappearance of abnormalities after exertion (Appendix I).

Exertion should be pushed progressively (if not productive of signs, symptoms or electrocardiographic abnormalities as specified in greater detail in the main document), until the age-related heart rates shown in Table IV are reached or exceeded.

If exertion eliciting heart rates at or below these age-related criterion rates is accompanied by 0.10 mv of excess horizontal or divergent S-T segment displacement of at least 0.06 second's duration when compared with the preliminary resting tracing in the same position (upright or supine), the subject must have a repeat exercise evaluation within 2 weeks. If this evaluation, again at heart rates at or below the stated criteria, again demonstrates S-T segment displacement at or greater than 0.10 mv, but less than 0.20 mv, the subject will be permitted to fly but must have a repeat exercise test evaluation within 6 months ad seriatum until the S-T segment displacement at or after the criterion heart rate or above becomes less than 0.10 mv or more than 0.20 mv.

Bruce and Dodge[26] expressed some concern about the adequacy of evidence that postexertional S-T depression is indicative of coronary heart disease in carefully screened healthy men. However, a majority of the task force concluded that if the S-T segment depression exceeds 0.20 mv

TABLE IV

Age-Related Heart Rates for Exercise Stress Testing

Age (yr)	Criterion Heart Rate (beats/min)
20–29	170
30–39	165
40–49	160
50–59	155
60–69	145

in each of two appropriately performed exercise tests at or below the criterion heart rates, the subject will be considered to be at such risk of having severe obstructive coronary heart disease or ischemic heart disease that it is not in the public interest or appropriate to his personal safety to certify him for any class of aircrew flight responsibilities until organic coronary heart disease is proved to be a most unlikely cause of the abnormal response.

The exercise tolerance test with electrocardiographic monitoring and recording should be required at ages 40 and 45 years, and every 2 years thereafter when no abnormalities are found, as well as at times of initial, reinstatement or upgraded certification as defined under Resting Electrocardiograms.

Coronary Arteriography

Although coronary angiography and ventriculography may be a near necessity to define the status of the coronary circulation, such studies are considered inappropriate for mandatory imposition on subjects. However, the choice relative to angiography should be made by the individual pilot concerned after he has received such medical advice and consultation from all sources as he may wish in order to requalify for flying status (Appendix II).

A. Coronary arterial lesions that as such are disqualifying (Appendix II):

1. Fifty percent or greater reduction of lumen diameter of the main left coronary artery.

2. Seventy-five percent or greater reduction of lumen diameter, when occurring in the distribution of at least two coronary arteries (left anterior descending; left circumflex or right coronary artery). Reported data indicate that the risk of significant clinical events in these groups is considerably greater than that of the general population.
3. Seventy-five percent or greater reduction of lumen diameter of the proximal portion of the left anterior descending artery has been described as being associated with a greater incidence of clinical cardiac events and accordingly should be considered disqualifying.
4. Persons with asymptomatic single vessel coronary disease involving either the right (especially when nondominant) or the circumflex artery* who have normal exercise capacity and ventricular performance may be considered for certification since their

---

*The other vessels are either normal or show less than 25 percent reduction in diameter.

risk of sudden death or incapacitation is not appreciably greater than that of the untested population.

B. Coronary arterial lesions that should be considered potentially disqualifying:

1. Twenty-five to 49 percent reduction of lumen diameter of the main left coronary artery.

2. Any amount of disease that is less than previously described but 50 to 75 percent or greater in one or more vessels.

Any coronary arterial lesion or lesions described under (A) or (B) will be disqualifying when combined with any of the following: angina pectoris; ejection fraction less than 55 percent; left ventricular end-diastolic pressure greater than 15 mm Hg in the absence of stress.

C. Left ventricular abnormalities that as such are disqualifying:

1. Ejection fraction less than 50 percent.

2. Left ventricular end-diastolic pressure greater than 15 mm Hg in the absence of stress.

3. Any left ventricular contraction abnormality resulting in akinesis, dyskinesis or frank aneurysm and even simple hypokinesis when it involves more than one ventricular segment or more than 25 percent of the ventricular contour.

4. Filling defect or defects presumed to be clots.

D. Qualifying criteria

The implication of the criteria listed in this section leads to the conclusion that a coronary arteriographic and myocardial function study demonstrating all of the following will serve to overrule any limitation imposed by the findings that were the indication for the test and will lead to the granting of the type of certificate requested by the applicant:

1. Either normal coronary arteries or less than 50 percent narrowing of a vessel other than the main left stem.
2. Left ventricular end-diastolic pressure less than 15 mm Hg at rest.
3. Ejection fraction of 56 percent or greater.
4. Absence of any left ventricular contraction abnormality or filling defect.
5. No evidence of significant malfunction of mitral and aortic valves.

It should also be noted that no obvious evidence of concentric or asymmetric hypertrophy should be accepted as proof of adequate function.

Need for Further Studies

The Task Force subscribes to the urgent need for continued, expanded and long-term research studies to obtain the necessary data base for further recommendations.

REFERENCES

1. Intersociety Commission for Heart Disease Resources. Primary of the Atherosclerotic Disease. Circulation 42:A55-A77, 1970

2. McGee D: The Probability of Developing Certain Cardiovascular Diseases in 8 Years at Specified Values of Some Characteristics. Washington DC, US Government Printing Office, DHEW Publ no (NIH) 74-618, 1973

3. Shurtleff D: Some Characteristics Related to the Incidence of Cardiovascular Disease and Death: Framingham Study; 18-Year Follow-Up. Washington DC, US Government Printing Office, DHEW Publ no (NIH) 74-599, 1974

4. Gordon T, Kannel WB: Premature mortality from coronary heart disease: Framingham study. JAMA 215: 1617-1625, 1971

5. Margolis JR, Kannel WB, Feinleib M, et al: Clinical features of unrecognized myocardial infarction--silent and symptomatic: 18-year follow-up. Framingham study. Am J Cardiol 32:1-7, 1973

6. Kulak LL, Wick RL Jr, Billings CE: Epidemiological study of in-flight airline pilot incapacitation. Aerospace Med 42:670-672, 1971

7. Kannel WB, Dawber TR: Contributors to coronary risk: implications for prevention and public health: Framingham study. Heart and Lung 1:797-809, 1972

8. Deming QB, Mosback EH, Bevans M, et al: Blood pressure, cholesterol content of serum and tissues and atherogenesis in the rat. J Exp Med 107:581-598, 1958

9. Wissler RW: Recent progress in studies of experimental primate atherosclerosis. In, Progress in Biochemical Pharmacology (Miras LJ, Howard AN, Paoletti R, ed), Vol 4. New York, S. Karger, 1968

10. Astrup P, Kjeldsen K: Carbon monoxide, smoking and atherosclerosis. Med Clin North Am 58:323-350, 1974

11. Kannel WB, Gordon T, Castelli WP, et al: Electrocardiographic left ventricular hypertrophy and risk of coronary heart disease: Framingham study. Ann Intern Med 72:813-822, 1970

12. Hinkle LE, Carver ST, Stevens M: The frequency of asymptomatic disturbances of cardiac rhythm and conduction in middle-aged men. Am J Cardiol 24:629-650, 1969

13. Chiang BN, Perlamn LV, Ostrander LD, et al: Relationship of premature systoles to coronary heart disease and sudden death in the Tecumseh epidemiologic study. Ann Intern Med 70:1159-1166, 1969

14. Bellet S, Roman L, Nicholas G, et al: Detection of coronary prone subjects in a normal population by electrocardiographic exercise test: follow-up studies. Am J Cardiol 19:783-787, 1967

15. Mattingly TW: The post-exercise electrocardiogram: its value in

the diagnosis and prognosis of coronary arterial disease. Am J Cardiol 9:395-409, 1962

16. Brody AJ: Master two-step exercise test in clinically unselected patients. JAMA 171:1195-1199, 1959

17. Rumball A, Acheson ED: Latent coronary heart disease detected by electrocardiogram before and after exercise. Br Med J 1:423-428, 1960

18. Ellestad MH, Wan MKE: Predictive implications of stress testing. Circulation 51:363-369, 1975

19. Doyle JT, Kinch SH: The prognosis of an abnormal electrocardiographic stress test. Circulation 41:545-553, 1970

20. Froelicher VF, Thomas MM, Pillar C, et al: Epidemiologic study of asymptomatic men screened by maximal treadmill testing for latent coronary artery disease. Am J Cardiol 34:770-776, 1974

21. Kannel WB, Feinleib M: Natural history of angina pectoris in the Framingham Study. Am J Cardiol 29:154-163, 1972

22. Kannel WB: The Natural History of Myocardial Infarction: Framingham Study. Leiden University Press, 1973

23. Wolf PA, Kannel WB, McNamara P, et al: The role of impaired cardiac function in atherothrombotic brain infarction: Framingham study. Am J Public Health 63:52-58, 1973

24. Kannel WB, Shurtleff D: The natural history of arteriosclerosis obliterans: peripheral vascular disease. Cardiovasc Clin 3:38-52, 1972

25. Orford RR, Carter ET: Survival as an Airline Pilot Thesis for the degree of MS, Mayo Graduate School of Medicine, University of Minnesota, 1975

26. Bruce RA, Dodge HT: personal communication, April 1975

27. Bruce RA, Kusumi F, Hosmer D: Maximal oxygen intake and nomographic assessment of functional aerobic impairment in cardiovascular disease. Am Heart J 85:546-562, 1973

28. Bruce RA, Gey GO, Cooper MN, et al: The Seattle Heart Watch: Initial clinical, circulatory and electrocardiographic responses to maximal exercise. Am J Cardiol 33:459-469, 1974

29. Bruce RA, Fisher LD, Cooper MN, et al: Separation of effects of cardiovascular disease and age on ventricular function with maximal exercise. Am J Cardiol 34:757-763, 1974

30. Bruce RA: Values and limitations of exercise electrocardiography. Circulation 50:1-3, 1974

31. Sheffield LT: Exercise testing and training of apparently healthy individuals. Circulation 32:622-629, 1965

32. McHenry PL: Correlation of computer-quantitated treadmill exercise electrocardiogram with arteriographic location of coronary artery disease. Am J Cardiol 30:747-752, 1972

33. Ellestad MH, Wan MKE: Predictive implications of stress testing: followup of 2700 subjects after maximum treadmill stress testing. Circulation 51:363-369, 1975

xercise

artery

sting:

sting.

APPENDIX I

STRESS TESTING PROTOCOL

Methods

Dynamic, rather than static, muscular exercise is to be applied with the patient upright, using the multistage principle, beginning at a low work load of no more than 4 to 5 METS (multiples of resting metabolic requirements) and increasing progressively in intensity by 1 to 3 METS, continuously without intermediate rest periods, until the following predetermined end points are reached:

A. At least 90 percent of average normal predicted maximal heart rate, age-adjusted, in absence of untoward symptoms and signs or electrocardiographic responses.

B. Limiting symptoms of chest pain, dyspnea, lightheadedness, weakness or marked fatigue before the 90 percent heart rate response is attained. Protocols well suited for this test include (but are not limited to) those of Bruce,[28,29] Sheffield,[31] McHenry[32] and Ellestad and Wan.[33]

C. Mandatory indications to stop exertion: Onset of three or more ventricular premature complexes, hypotension or blood pressure below resting level, or ataxic staggering gait.

Equipment

A calibrated, motor-driven treadmill is preferable to a bicycle ergometer because of greater precision of exercise with involuntary regulation of work loads when the body weight is fully supported by the legs. A bicycle ergometer may be substituted if the pedal rate is closely regulated by a metronome and energy requirements have been defined. A single or multichannel direct-writing electrocardiograph, properly damped, with a frequency response of 0.05 to 100 hertz and an accurate millivolt reference standard, is required. A monitoring oscilloscope is strongly recommended. An accurate sphygmomanometer, a stethoscope of excellent quality and a clock with a second hand are required. Standardized forms for consent, data collection and interpretation are useful. A direct-current defibrillator, oxygen supply and emergency drugs should be immediately available.

Procedure

1. An appropriately standardized 12 lead electrocardiogram must be obtained at the time of each legally required clinical examination. Evidence of recent myocardial infarction or unstable angina or other acute illness constitutes a contraindication to testing.

2. An informed consent form must be signed and witnessed, indicating the purpose, procedure, risks, benefits and expressed concern for the patient's rights and welfare.

3. The preparation of skin, application of electrode gel interface between skin and electrode, and adhesive ring fixation must be performed

with great care; lightweight, shielded cables are recommended.

4. Supervision and monitoring of the subject's blood pressure and electrocardiographic responses are necessary for at least 1 minute before and throughout exercise, and for at least 5 minutes after exercise by either (a) qualified allied health science personnel under physician supervision if clinical evaluation reveals no heart disease, or (b) a qualified physician if clinical evaluation reveals heart disease.

5. A minimum of a single bipolar precordial electrocardiographic lead from V_5 to the manubrium sterni, right subclavicular fossa or the inferior tip of the right scapula. The preferred lead combination is V_3, V_4, V_5, V_6, II and a VF.

6. The original electrocardiographic recordings representative of the past portion of the last minute of each work load (specified as to speed, duration, incline, etc.) and each minute after exercise for at least 5 minutes and the local interpretation should be forwarded promptly to the FAA.

7. Serial blood pressure readings obtained before exercise, at each stage and during recovery should be part of the permanent record.

8. Auscultation of the heart should be performed before and after testing and notation made of change in findings.

CRITERIA FOR AN ABNORMAL STRESS TEST

S-T depression: An abnormal "ischemic response" to exercise testing refers to a horizontal or downsloping S-T segment of at least 0.06 second's duration after the J point when it is "deviated" at least 0.2 mv (2 mm) more than that of the control tracings above or below the reference P-R interval or Q-Q base line in one or more leads. Horizontal or downsloping S-T segment depression of 0.10 mv (1 mm) is considered a "risk factor" and should be an indication for retesting within 6 months. Inability to exercise to a level eliciting a heart rate of 90 percent of maximal predicted for age is also considered a risk factor and an indication for retesting within 6 months. Patterns of right and left bundle branch block initiated as a result of stress testing will be treated in the same manner as those patterns elicited at rest. (See report of Task Force IX on arrhythmias.)

Dysrhythmias: Certain types of exercise-induced ventricular dysrhythmias are considered highly suggestive of underlying coronary heart disease. These include multifocal ventricular premature contractions (defined as premature beats of three or more distinct configurations, not including fusion characteristics) and ventricular tachycardia (defined as three or more consecutive ventricular premature complexes). The correlation of multifocal ventricular premature contractions and ventricular tachycardia with underlying coronary heart disease is especially significant when these dysrhythmias are seen at heart rates of less than 70 percent of the predicted maximal. Likewise, the appearance of frequent

(10 or more per minute) unifocal ventricular premature contractions during any given minute of exercise before achievement of a heart rate equivalent to 70 percent of maximal is highly correlated with underlying coronary heart disease. Exercise-induced ventricular dysrhythmias meeting these criteria are considered to indicate a subject at high risk for a future manifestation of coronary heart disease (angina, myocardial infarction or sudden death). Persons with exercise-induced ventricular dysrhythmias that fall into one of these high-risk categories should be required to have more frequent serial follow-up studies. Ventricular tachycardia mandates disqualification until extensive evaluation, probably including coronary angiography, has been completed. If a progressive or deteriorating pattern is established, further cardiovascular evaluation is considered mandatory.

The appearance of supraventricular dysrhythmias or tachycardia during exercise has not been well correlated with underlying ischemic heart disease. However, those subjects having a tendency toward sustained, rapid supraventricular dysrhythmias or tachycardia during stress may represent a hazard when they are at the controls of an aircraft.

Exercise-induced atrial fibrillation is considered an indication for further complete evaluation.

<u>Blood pressure</u>: If the systolic blood pressure fails to increase more than 10 mm over the control value or drops below this level, this constitutes an abnormal response requiring evaluation.

<u>Criteria for repeat test</u>: If the test response is abnormal, it should be repeated with the following stipulations:

The exercise test should be carried out within 2 weeks in all patients manifesting horizontal or divergent S-T displacement of 0.2 mv (2 mm) or more during a routine exercise test. The conditions under which this repeat test should be carried out are as follows:

1. The person being tested should discontinue use of all drugs for at least 1 week before evaluation (2 weeks for digitalis preparations). If he has been taking diuretic agents, he should take steps to correct potential potassium depletion.

2. The patient should be tested in the fasting state (unsweetened orange juice excepted).

3. If hyperventilation is performed before exercise, it should be completed at least 15 minutes before the start of the test.

It must be emphasized that S-T segment depression is a manifestation of an electrophysiologic process reflecting changes in the myocardium, and is not necessarily related to anatomic coronary disease.

APPENDIX II

PROTOCOL FOR CORONARY ARTERIOGRAPHY AND MYOCARDIAL FUNCTION STUDIES

I. Purposes of coronary arteriography and myocardial function studies as applied to the medical certification of current or prospective aerospace personnel

   A. To confirm, detect or quantify the presence and extent of heart disease that may be associated with an increased risk of sudden death or incapacitation in aircraft personnel while at the controls.

   B. To rectify a false positive diagnosis of suspected heart disease of this type.

II. Standard of performance of coronary arteriography and myocardial function studies (minimal criteria)

   A. Both right anterior oblique and left anterior oblique views for each of the right and left coronary arteries are the minimal views acceptable.

   B. The quality of the arteriograms must be good enough to show arteries with a diameter as small as 10 percent of the diameter of the coronary arteriographic catheter (about 150 to 200_{u}).

   C. Contrast left ventriculography should be performed before coronary arteriography to provide a clearly outlined left ventricular contour in systole and diastole in at least the right anterior oblique view during at least one normally conducted beat.

D. Measurements of left ventricular and aortic pressure free of obvious artifacts, during initial control conditions and preferably both before and after any form of stress testing, including left ventriculography.

E. Whenever these studies are performed, the results should be incorporated in a central registry, which should be available for further decision-making, refinement of certification criteria or future study by the FAA.

TASK FORCE II: RECOMMENDATIONS FOR SUBJECTS WITH ISCHEMIC HEART DISEASE

LIKOFF (Chairman), KNOEBEL (Co-Chairman), AMSTERDAM, FRYKHOLM, McMEEKIN, MORRIS, ROBERTS

PERSPECTIVE

Medical licensing requirements in International Civil Aviation[1] relative to ischemic heart disease state: (1) A history of proven myocardial infarction shall be disqualifying. (2) There shall be no established medical history or clinical diagnosis of angina pectoris or other evidence of ischemic heart disease. (3) There shall be no significant functional or structural abnormality of the circulatory tree (varicosities not included). Provision is made, however, for the exercise of a degree of flexibility in the application of these medical standards. Specific guidelines for flexibility are not cited.

In view of increased knowledge regarding the diagnosis, natural history and treatment of ischemic heart disease accumulated during the past decade, the Task Force determined that reevaluation of the problem was indicated.

CONSIDERATIONS AND RECOMMENDATIONS

Ischemic heart disease is the result of obstructive coronary atherosclerosis, which is responsible for an unfavorable balance between coronary blood flow and the metabolic requirements of the myocardium. The principal clinical manifestations of this active, incapacitating default are angina pectoris, acute myocardial infarction and sudden death. Other less precise manifestations include certain dysrhythmias and signs of heart failure. The most reliable graphic method of recognizing the ischemic state is the electrocardiogram at rest or after exercise.

The diagnosis of ischemic heart disease can usually be reached by clinical manifestations and electrocardiographic abnormalities alone or in combination. Since active myocardial ischemia carries the continuing threat of sudden unpredictable overt or subtle incapacitation, the condition disqualifies the candidate for recertification. However, because the cited indications of active myocardial ischemia are not necessarily specific for coronary heart disease, selective coronary arteriography and left ventricular angiography should be offered for definitive diagnosis and determination of the extent of disease. The studies should be performed in accordance with criteria established. It is recommended that coronary angiography be interpreted in the following manner:

1. If the coronary arteries are normal, medical recertification should be granted. The roles of coronary spasm and "small vessel disease", in this or any other group of patients are uncertain at present.

2. Obstructive narrowing (greater than 75 percent) in two or more major coronary arteries is disqualifying.

3. In the various combinations of coronary luminal narrowing other than those in the first two groups, information regarding pathophysiologic consequences and prognosis is insufficient to warrant categorical statements

However, in the interest of air safety, recertification should be withheld in this group when there are other indications of active myocardial ischemia.

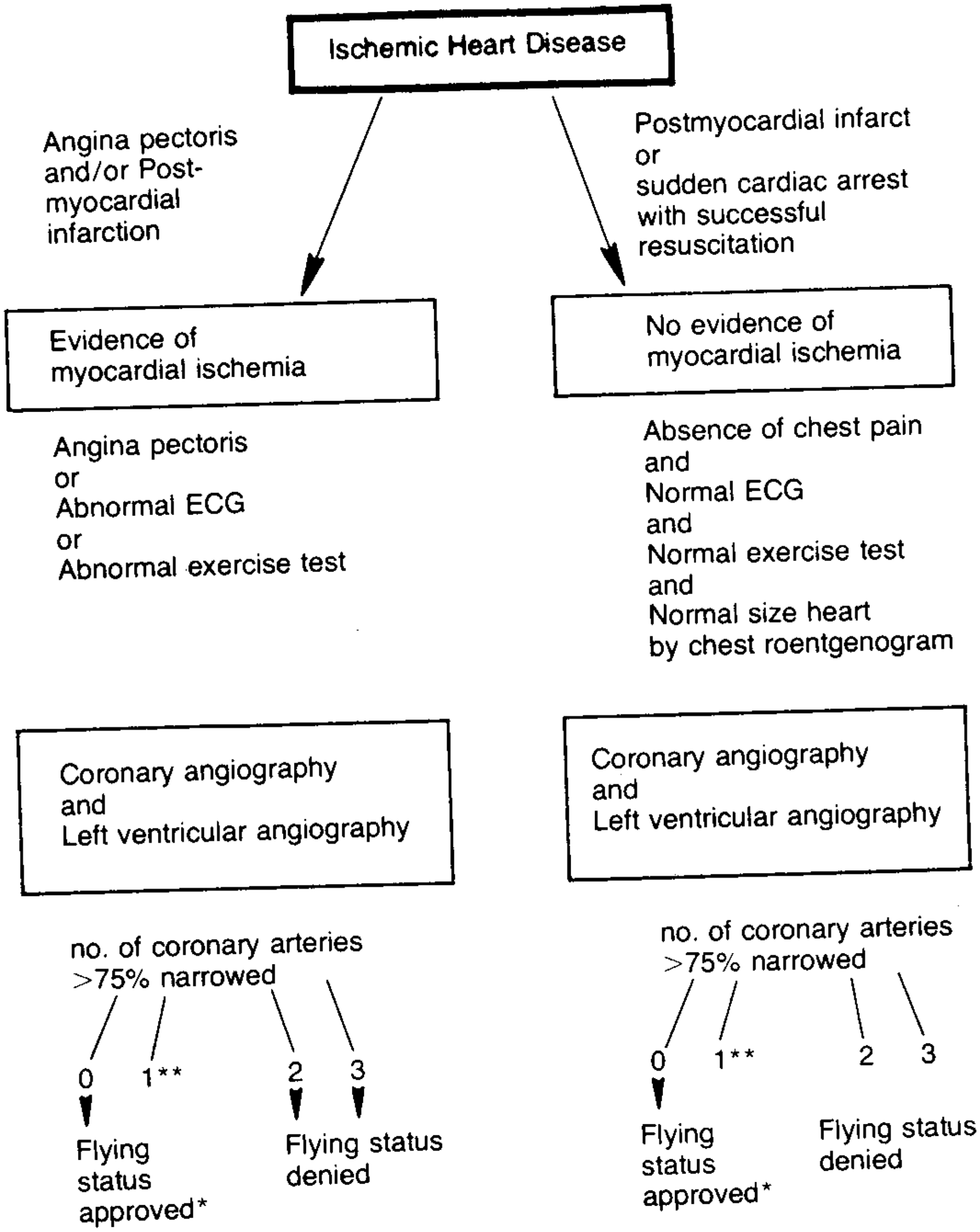
Persons without current evidence of myocardial ischemia who have clinical evidence of past myocardial infarction should not be considered for recertification until 1 year after the infarction. Evaluation for recertification in this instance must include selective coronary and left ventricular angiography, again in accordance with the technical and decisional criteria outlined by Task Force I. Figure 1 provides a graphic presentation of the recommendations.

In addition, in all instances of recertification of a pilot with a history of coronary heart disease, it is strongly recommended that the subject discontinue cigarette smoking, maintain ideal body weight and engage in a physical activity program according to medical recommendation. Follow-up evaluation of pilots who have been recertified should be performed every 6 months. In all instances in which the diagnosis of ischemic heart disease is being evaluated, examination should be performed by a qualified internist or cardiologist.

Recertification of airmen who are being evaluated for active myocardial ischemia should be held in abeyance pending the results of such evaluation.

REFERENCE

1. International Civil Aviation Organization (ICAO). Annex 1, 6th edition 1973



*No aneurysm or area of dyskinesia by left ventricular angiography

**Whether or not certification for flying should be granted to these persons is uncertain. If recertification is granted, clinical reevaluation should be done every six months.

FIGURE 1. Summary of recommendations for recertification in subjects with ischemic heart disease.

TASK FORCE III: RECOMMENDATIONS FOR POSTOPERATIVE PATIENTS WITH ISCHEMIC HEART DISEASE

RACKLEY (Chairman), COLLINS (Co-Chairman), GORDON, MASON, REIS, URSCHEL, WILLIAMS

BACKGROUND INFORMATION

Prognostic information on survival of patients with coronary artery disease has been obtained from long-term observations on the natural history of the disease based on coronary arteriography and ventriculography.[1-4] These studies are fairly consistent in predicting the yearly mortality in patients with significant coronary arterial stenosis or obstruction in one, two or three vessels and in patients with disease of the left main coronary artery. Recent evidence suggests that in persons with established coronary disease the risk of death may be substantially reduced by multivessel revascularization surgery.[5-9] Many patients with coronary artery disease by arteriography will manifest progression of disease within 2 years but vessels unaffected by the atherosclerotic process are unlikely to develop angiographic evidence of the disease during a 2 year period of observation.[10] Reports on distal bypassed coronary arteries do not reveal increased progression of the disease.[11] Vein grafts patent 1 year after coronary arterial surgery are likely to remain patent for 2 additional years.[12]

RECOMMENDATIONS

On the basis of current data, the following recommendations are made for the evaluation of a commercial pilot 1 year after coronary arterial surgery:

1. Complete examination by a cardiologist with routine laboratory studies of blood and urine, chest roentgenogram and electrocardiogram. If the patient is without angina pectoris, symptoms of heart failure or arrhythmia, additional studies should be performed.

2. Determination of exercise capacity with electrocardiographic monitoring.

3. A 24 hour period of observation for significant rhythm disturbances.

4. Cardiac catheterization, with visualization of vein grafts and coronary arteries; assessment of left ventricular function by angiocardiography.

If, 1 year after coronary arterial surgery, a commercial pilot does not manifest angina, symptoms of heart failure, arrhythmias or evidence of ischemia on exercise testing, and cardiac catheterization reveals patent vein grafts without progression of distal coronary artery disease and with satisfactory ventricular function, then certification for flying should be considered.

Pilots recertified to fly 1 year after coronary arterial surgery should be evaluated every 6 months by the previously mentioned noninvasive techniques and every 2 years by invasive cardiac catheterization. The Task Force believes that this position is based on data now available and that further prospective data should be accumulated on these patients, with critical review in 5 years. Concern was expressed as to pilots who have had coronary surgery flying private planes without an additional qualified pilot. The preceding recommendations apply to cockpit crews in which the member who has had coronary surgery is not the sole qualified pilot. More stringent criteria may be required in situations where there is no redundancy in cockpit crew.

REFERENCES

1. Freisinger GC, Page EE, Ross RS: Prognostic significance of coronary arteriography. Trans Assoc Am Physicians 93:78-92, 1970

2. Oberman A, Jones WB, Riley CP, et al: Natural history of coronary artery disease. Bull NY Acad Med 48:1109-1125, 1972

3. Bruschke AVG, Proudfit WL, Sones FM Jr: Progress study of 590 consecutive non-surgical cases of coronary disease followed 5-9 years. Circulation 47:1147-1153, 1973

4. Humphries JO, Kuller L, Ross RS, et al: Natural history of ischemic heart disease in relation to arteriographic findings. A twelve-year study of 224 patients. Circulation 49:489-497, 1974

5. Cohn LH, Boyden CM, Collins JJ Jr: Improved long-term survival after aortocoronary bypass for advanced coronary artery disease. Am J Surg 129:380-385, 1975

6. Hall RJ, Garcia E, Al-Bassam MS, et al: Aortocoronary bypass surgery, 1969-1973: review of 2566 patients. Bull Texas Heart Inst 1:74-80, 1974

7. Sheldon WC, Rincon G, Effler DB, et al: Vein graft surgery for coronary artery disease: survival and angiographic results in 1000 patients. Circulation 47: Suppl III:III-184-III-189, 1973

8. Spencer FC, Isom OW, Glassman EG, et al: The long-term influence of coronary bypass grafts on myocardial infarction and survival. Ann Surg, in press

9. Anderson RP, Rahimtoola SH, Bonchek LI, et al: The prognosis of patients with coronary artery disease after bypass operations. Time-related progress of 532 patients with disabling angina pectoris. Circulation 50:274-282, 1974

10. Gensini GG, Kelly AE: Incidence and progression of coronary artery disease. Arch Intern Med 129:814-827, 1972

11. Mathur VS, Guinn GA, Anastassiades LC, et al: Surgical treatment for stable angina pectoris: prospective randomized study. N Engl J Med 292:709-713, 1975

12. Grondin CM, Lesperance J, Bourassa MG, et al: Serial angiographic evaluation in 60 consecutive patients with aortocoronary artery vein grafts two weeks, one year and three years after operation. J Thorac Cardiovasc Surg 67:1-6, 1974

TASK FORCE IV: CEREBRAL VASCULAR DISEASE, VENOUS AND ARTERIAL THROMBOSIS

DALEN (Chairman), COUCH, MC INTYRE, WHISNANT

The peripheral vascular disorders discussed in this section have, in all cases, the potential to cause sudden disability. When the safe function of an aircraft is absolutely dependent on the normal function of one pilot (that is, when no "fail-safe" system exists), the recommendation for disqualification should hold without major modification.

On the other hand, when "fail-safe" systems exist and are operated by fully trained, experienced backup personnel, criteria for disqualification may be modified as indicated. These medical conditions nevertheless carry a risk of sudden disability or death and, for these reasons alone, definitive treatment should be urged. (We do not wish to imply that threats of disqualification should be used to compel such treatment.)

DISEASES OF THE VENOUS SYSTEM

Deep Venous Thrombosis

Deep venous thrombosis (including similar disorders such as thrombophlebitis, phlebitis, phlebothrombosis, endophlebitis, periphlebitis), when it occurs in any portion of the deep venous system of a lower limb, is always ctinically important because of the risk of subsequent pulmonary embolism. Deep venous thrombosis should be distinguished from simple varicose veins or superficial thrombophlebitis, two conditions that rarely affect flying status. The diagnosis of acute deep venous thrombosis, which may be clinically suspected, can be made reliably only by special techniques, most particularly phlebography (also called venography). When deep venous thrombosis has been suspected or proved, evaluation to determine flying status must be made in collaboration with a qualified peripheral vascular specialist. This evaluation should take place at least 3 months after the episode of pulmonary embolism and at least 1 month ofter anticoagulant therapy has been discontinued.

Circumstances under which the pilot may resume flying status:

A. The episode was found to be a condition other than deep venous thrombosis (for example, superficially thrombophlebitis not involving areas above the knee).

B. The last episode of deep venous thrombosis ended more than 3 months before the time of evaluation and (1) anticoagulant therapy was terminated at least 1 month before evaluation; (2) there are no current symptoms or signs suggestive of persistent or recurrent deep venous thrombosis as verified by phlebography; and (3) a lung scan and chest X-ray films show no evidence of pulmonary embolism.

Circumstances under which the subject should be disqualified without exception:

A. Further anticoagulation is indicated.

B. Evidence of acute deep venous thrombosis persists.

C. Lung scan and chest X-ray films show evidence of pulmonary embolism.

Circumstances under which the subject should be provisionally disqualified, pending evaluation by a qualified peripheral vascular specialist:

A. Recurrence of deep venous thrombosis at any time after the first episode.

B. Occurrence of deep venous thrombosis in the absence of recognizable, reversible predisposition.

Pulmonary Embolism

Pulmonary embolism is caused by a clot or thrombus formed outside the pulmonary circulation that is carried by the blood to the pulmonary arterial system. The clinical syndrome of pulmonary embolism is a symptom complex, usually of acute onset, that may include dyspnea, tachypnea, tachycardia, hemoptysis, chest pain, hypertension, shock or cardiac arrest. Deep venous thrombosis may not be diagnosed on clinical grounds but is nearly always demonstrable by techniques such as phlebography.

When pulmonary embolism has been suspected or diagnosed, evaluation to determine flying status should be made in collaboration with a qualified cardiologist. This evaluation should take place at least 3 months after the episode of pulmonary embolism and at least 1 month after anticoagulant therapy has been discontinued.

Circumstances under which the pilot may return to flying status:

A. An identifiable predisposition to venous thrombosis was present at the time of the episode of pulmonary embolism and is no longer present.

B. There have been no cardiac or pulmonary symptoms in the 3 months since the episode of pulmonary embolism.

C. There is no evidence of pulmonary photoscan (ventilation and perfusion) of significant pulmonary vascular obstruction.

D. There is no evidence of acute deep venous thrombosis by phlebography and there have been no symptoms or physical findings of deep venous thrombosis since the episode of pulmonary embolism.

Disqualification is recommended at the time of evaluation by a qualified cardiologist 3 or more months after the episode of pulmonary embolism under the following circumstances:

A. Further anticoagulant therapy is indicated.

B. There is evidence of cor pulmonale.

C. There is evidence of acute deep venous thrombosis verified by phlebography.

D. The pulmonary photoscan shows evidence of recurrent pulmonary embolism or important residual pulmonary vascular obstruction.

Circumstances under which provisional disqualification is indicated pending review by a qualified cardiologist:

A. Documented or suspected recurrence of pulmonary embolism at any time after the first episode.

B. Occurrence of pulmonary embolism in the absence of recognizable, reversible predisposition.

Sodium Warfarin Therapy

The disorders discussed in the preceding section are routinely treated with sodium warfarin. This treatment is associated with the risk of sudden incapacity. Accordingly, we recommend that individuals who continue to require this therapy be suspended from flying status.

Serious and even fatal complications may result from unsatisfactory control of prothrombin levels. A system by which such control could be standardized would substantially reduce the risks of sodium warfarin therapy.

COR PULMONALE

Cor pulmonale is defined as heart disease that is secondary to disease of the lungs or the blood vessels of the lungs. The clinical syndrome consists of pulmonary and right ventricular hypertension with or without signs and symptoms of right ventricular failure. The diagnosis is established by history, physical examination, electrocardiogram and chest roentgenograms.

We recommend that the diagnosis of cor pulmonale by a cardiologist disqualify for flying status.

HEMATOLOGIC DISORDERS

The following hematologic disorders require evaluation by a hematologist to determine their relevance to flying status:

A. Anemia (hematocrit under 35 percent).

B. Thrombocytopenia (platelet count under 100,000/mm^3).

C. Granulocytopenia (total granulocyte count under 2,000/mm^3).

D. Polycythemia if hematocrit is over 60 percent or platelet count over 1,000,000.

E. Overt bleeding dyscrasias.

CEREBROVASCULAR DISEASE

Conditions Requiring Exclusion From Flying Status

It is recommended that flying status be suspended for the following conditions:

A. Cerebal, cerebellar or brainstem infarction due to any cause.

Possible exceptions*:

---

*As stated in our opening paragraph, exceptions may also be possible for pilots flying with "fail-safe" operational systems.

1. If the infarction was related to trauma and associated with total recovery of motor, sensory, language and intellectual functions as determined by a neurologist.
2. If the infarction was related to an embolus and the source for the embolus has been corrected so that it is no longer a source and there has been total recovery of motor, sensory, language and intellectual functions as determined by a neurologist.

B. Transient ischemic attack, defined as less than 24 hours of symptoms related to focal cerebral ischemia.

Possible exceptions:

1. A person in whom the transient ischemic attack was related to a known embolus and the source for the embolus has been corrected so that it is no longer a source and there has been total recovery of motor, sensory, language and intellectual functions as determined by a neurologist.
2. A person in whom the transient ischemic attack was related to carotid stenotic disease, which has been corrected so that it is no longer a source and there has been

total recovery of motor, sensory, language and intellectual functions as determined by a neurologist.

C. Amaurosis fugax.

D. Internal auditory or labyrinthine artery occlusion, with associated vertigo, with or without unilateral hearing loss.

E. Internal carotid stenosis greater than 50 percent of lumen or with demonstrated ulceration with or without symptoms.

Possible exception: There has been surgical removal of plaque and there is no associated impairment of sensory, motor, language or intellectual function since at least 3 months after operation, as determined by a neurologist.

F. Hypertensive encephalopathy.

G. Meniere's syndrome or other recurring episodes of vertigo.

H. Intracerebral or subarachnoid hemorrhage from any cause.

Possible exception:

1. The lesion was related to trauma and associated with total recovery of motor, sensory, language and intellectual function, as determined by a neurologist.

2. The lesion was related to anticoagulant therapy but the indications for anticoagulant therapy have been corrected and there is no longer need for such anticoagulant therapy.

I. Intracranial aneurysm

J. Arteriovenous malformation

Possible exception: When the malformation has been surgically corrected without impairment of sensory, motor, language or intellectual function, as determined by a neurologist at least 3 months after operation.

Conditions That Should Not Exclude From Flying Status

A. Incidental detection of occlusion of a carotid, vertebral or intracranial artery that has not been associated with impaired sensory, motor, language or intellectual function as determined by a neurologist.

B. Migraine, unless associated with impaired motor or intellectual function or impaired consciousness.

TABLE I

Existing Regulations Regarding Upper Limits of Blood Pressure with Which Pilots Are Permitted to Fly Related to the Probability of Development of Atherosclerotic Heart Disease

Age Group (yr)	Maximal Readings Permitted (mm Hg)				Probability That Coronary Disease Will Develop Within 6 Years (per 100) (Framingham Study[2,3])				
	Not Adjusted		Adjusted*				S BP Maximal Permitted for Age		
	S	D	S	D	Average Risk (male)	S BP 120. Nonsmoker. Serum Cholesterol 185 mg/100 ml	Nonsmoker Serum Cholesterol 185 mg/100 ml	Smoker. Serum Cholesterol >300 mg/100 ml	Smoker. Serum Cholesterol >300 mg/100 ml, Glucose Intolerance
20–29	140	88	—	—	No data	No data	No data	No data	No data
30–39	145	92	155	98	1.0	0.4	0.6	5.1	6.8
40–49	155	96	165	100	4.4	1.8	3.1	14.5	18.1
⩾50	160	98	170	100	9.5	4.5	8.0	21.7	26.6

* For an applicant at least 30 years of age whose reclining blood pressure is more than the maximal reading for his age and whose cardiac and kidney status, after complete cardiovascular examination, is found to be normal.

BP = blood pressure (mm Hg); D = diastolic; S = systolic.

TASK FORCE V: HYPERTENSION

GIFFORD (Chairman), MARTZ (Co-Chairman), CARTER (Co-Chairman), BERRY, CARIS, FREIS, HICKLER

HYPERTENSION AS A RISK FACTOR

Level of Blood Pressure

In the absence of any clinical or laboratory evidence of cardiovascular disease, blood pressure is the best predictor of subsequent cardiovascular events that might cause unexpected disability or death in a pilot or crew member during performance of duty. The cardiovascular consequences of hypertension are proportional to the level of the blood pressure.[1]

For example, present regulations permit a 45 year old pilot to fly if his blood pressure is not higher than 165/100mm Hg provided he has no evidence of cardiac or renal disease (Table I). Data from the Framingham study[2,3] indicate that in comparison with a 45 year old man with a systolic blood pressure of 120mm Hg a 45 year old man with a systolic blood pressure of 165mm Hg has 1.8 times the risk of having some manifestations of coronary heart disease (whether or not angina pectoris is included), 1.5 times the risk of sudden death and 2.9 times the risk of having a cerebrovascular accident although the absolute incidence of strokes is low (0.39 compared with 0.13 percent per year).

<u>Recommendations</u>: The Task Force concurs that the increased risk

permitted by present regulations regarding blood pressure is acceptable and it recommends no change.

Additional Risk Factors

The Task Force calls attention to the existence of other controllable risk factors for cardiovascular disease that are at least additive to blood pressure and that could increase the risk to unacceptable levels. These include hyperlipidemia and cigarette smoking. A 45 year old male pilot who smokes one pack of cigarettes a day has 2.8 times the risk of sudden death as a nonsmoker irrespective of any other risk factors.[2] The risk that overt manifestations of coronary heart disease will develop is eight times greater for a 45 year old male pilot who has a systolic blood pressure of 165 mm Hg and a serum cholesterol level of 310 mg/100 ml and who smokes cigarettes than for a 45 year old male nonsmoker who has a systolic blood pressure of 120 mm Hg and a serum cholesterol concentration of 185 mg/100 ml (Table I).[3] Moreover, the risk of stroke is increased 15-fold (from 1 in 1,000 to 15 in 1,000).[4] The 55 year old cigarette-smoking male pilot with a systolic blood pressure of 170 mm Hg and a serum cholesterol level of 310 mg/100 ml has a more than 1 in 5 chance that some manifestation of coronary disease will develop within 6 years (Table I).[3] Glucose intolerance further increases the risk.

Recommendation: In the opinion of the Task Force, risks of this general order are excessive and the recommendation is made that serum cholesterol and glucose concentrations and cigarette smoking must be included in the equation with blood pressure in determining health criteria for flying status. To aid in quantitating the effect of multiple risk factors, tables are available from the American Heart Association[3,4] and other sources such as the Cardiodial Service of Ciba.

ANTIHYPERTENSIVE DRUGS

It has been demonstrated that effective medical treatment of hypertension will prevent or postpone cardiovascular complications and will prolong life.[5,6] The present policy of the Federal Aviation Agency (FAA) forbids the use of antihypertensive drugs other than diuretic agents; this leads pilots who have increased blood pressures within the range permissible for flight to avoid optimal therapy even though it is detrimental to their health for them to do so. Furthermore, it excludes hypertensive pilots whose hypertension could be controlled with additional medication.

Recommendations

Thiazides and related diuretic drugs: Although never written into regulation (Part 67 of the Federal Air Regulations) by the FAA, thiazide compounds and related diuretic agents have been used by so many pilots for so long that their acceptability is generally acknowledged, and the Task Force recommends that their use be given official sanction without further testing.

Acceptable antihypertensive drugs: The Task Force further recommends that the effects of other antihypertensive drugs on gravitational tolerance, hypoxia tolerance and flying skills in simulated tests be evaluated under controlled conditions with hypertensive pilots as subjects. It is possible that propranolol and hydralazine will be found to have little, if any, adverse effects in such studies. These studies should be repeated each time it is necessary to increase the dose of propranolol. At first, only pilots who show no significant change in physiologic or mental capacities under test conditions as the result of taking antihypertensive medications (other than diuretic agents) should be permitted to fly. As experience accumulates, it is probable that these drugs will be judged acceptable without the need for testing each pilot individually.

Unacceptable antihypertensive drugs: The following medications were prejudged by the Task Force as probably undesirable: guanethidine, bethanidine and ganglionic blocking agents because of their potentiality for producing orthostatic hypotension; Rauwolfia derivatives because of their propensity to cause depression; and methyldopa and clonidine because of their tendency to cause drowsiness. However, it is deemed worthwhile to study their effects on pilot performance under the test conditions described.

The Task Force recommends that hypertensive pilots whose blood pressure can be controlled with acceptable medications and who have no evidence of target organ disease (see next section) be granted a waiver to fly so long as their blood pressure is maintained within the limits given in Table I.

TARGET ORGAN DISEASE

Because certain evidence of target organ disease increases the risk of untoward complications so greatly, the Task Force recommends that the following criteria should be disqualifying regardless of the level of blood pressure or the ability to control hypertension:

1. Left ventricular hypertrophy as manifested in the electrocardiogram by voltage changes and ST-T abnormalities. (Voltage changes alone should not be disqualifying.)

2. Roentgenographic evidence of cardiomegaly (greater than 20 percent by the Ungerleider criteria or a cardiothoracic ratio of greater than 50 percent).

3. Azotemia (serum creatinine greater than 2.0 mg/100 ml).

4. Hypertensive retinopathy of Group 3 or 4 (Keith-Wagener-Barker classification). (Overt manifestations of atherosclerotic heart disease and cerebral vascular disease will be considered by other Task Forces.)

SURGICALLY CORRECTED HYPERTENSION

<u>Adrenal or renal surgery</u>: The Task Force recommends that a pilot who has normal blood pressure 3 or more months after a successful operation for pheochromocytoma, primary aldosteronism (unless bilateral adrenalectomy has been performed), renovascular disease or unilateral renal parenchymal disease and who shows no evidence of target organ disease be permitted to return to crew status. If residual hypertension is present and can be controlled with acceptable drugs (as described earlier), and there is no target organ disease, permission to fly as crew should be

granted on the same basis as for persons with essential hypertension.

Because of the likelihood of late recurrence of hypertension after adrenal or renal surgery, blood pressure should be measured at least every 6 months for normotensive aircrewmen, and more often for those who are receiving antihypertensive therapy regardless of class of Airman's Medical Certificate (see below).

Cushing's syndrome and lumbodorsal sympathectomy: The Task Force recommends that a person who has had either surgical treatment for Cushing's syndrome or lumbodorsal sympathectomy for hypertension should not be permitted to fly as crew even if he is normotensive as a result of the operation.

Cushing's syndrome presents metabolic problems in addition to hypertension that must be considered in determining the advisability of permitting persons with this disorder to fly. Surgical cure of hypertension in Cushing's syndrome usually involves total or subtotal adrenalectomy requiring replacement therapy, which might present a problem for members of a flight crew.

Inherent in lumbodorsal sympathectomy is the danger of orthostatic hypotension, which should preclude flight crew status for pilots even though the operation has restored blood pressure to normal.

LABILE HYPERTENSION

Intermittent blood pressure measurements above the ranges listed in

Table I are not disqualifying provided a resting or average reading is within the limits stated. The person with intermittent or labile hypertension presents a problem in terms of career choice and acceptability to commercial airlines because the risk that sustained hypertension that might ultimately prove disqualifying will develop is estimated to be two to four times as high as for normotensive persons.[1-12]

A more liberal attitude toward the use of antihypertensive drugs (as described earlier) may eventually make a career in commercial aviation more realistic for the person with labile hypertension and make him more attractive to the industry.

FREQUENCY AND METHOD OF MONITORING THE PILOT WITH HYPERTENSION

If pilots are to be granted waivers to fly contingent upon their taking antihypertensive medications that have proved acceptable (as described), there must be some method to ensure that medication is taken regularly and that the blood pressure remains under satisfactory control.

The Task Force recommends that:

1. A pilot treated with acceptable antihypertensive agents be permitted to return to duty when the blood pressure is within specified limits (Table I) and he has been free of undesirable side effects for 3 consecutive weeks, the blood pressure having been recorded at weekly intervals.

2. A pilot who is taking antihypertensive medication have his blood pressure measured at least once every 3 months in the supine or the

seated position and in the standing position after 3 minutes, and that the examining physician file a signed report of the readings in the pilot's medical file in the regional FAA medical office after each visit.

3. More than 75 percent of blood pressure readings be equal to or less than the upper limit given in Table I and none be more than 10 percent above this level if the pilot is to be permitted to continue to fly with a waiver.

4. A pilot whose blood pressure exceeds 140 mm Hg systolic or 90 diastolic, or both, be required to have his blood pressure measured every 6 months and the results entered in his medical file, even though he may choose not to take medication because his blood pressure is within the acceptable limits outlined in Table I.

Automated devices for measuring blood pressure: The Task Force recognizes that there may be a conscious or subconscious tendency on the part of sympathetic physicians to "shade" blood pressure readings when a career and a livelihood hang in the balance. Such a practice is to be condemned because it is not in the best interest of the pilot, the public or the industry. For this reason, the Task Force investigated various ways to ensure objectivity in measuring blood pressure. None of the available automated devices for measuring blood pressure compared favorably with the standard mercury manometer,[13] which remains the instrument of choice. Even if an automated device were developed to reflect accurate the intraarterial blood pressure, its usefulness might be limited because virtually all of the clinical experience and knowledge is based on indirect readings with the sphygmomanometer. The random-zero (Hawksley) instrument does away with digit preference. Of course, there is no way to prevent deliberate falsification of the true blood pressure reading.

SUMMARY

The Task Force recommends that:

1. There be no changes in the present regulations regarding limits of blood pressure that are acceptable for flying status.

2. The serum cholesterol and glucose concentrations and cigarette-smoking habits be included in the equation with blood pressure in determining health criteria for flying status.

3. Thiazide compounds and related diuretic agents be officially approved for use by pilots and crew members without further testing.

4. The FAA initiate plans to support research to determine the effect of other antihypertensive drugs on pilot performance under controlled conditions with hypertensive pilots as subjects and using treadmill exercise, the human centrifuge, simulators, the altitude chamber and specific physiologic and psychologic testing methods already perfected.

5. A hypertensive pilot whose blood pressure can be controlled with medications acceptable from the standpoint of flying safety and who has no evidence of target organ disease be granted a waiver to fly so long as his blood pressure is maintained within the limits prescribed by present regulations.

6. The following evidence of target organ disease should be disqualifying regardless of the level of blood pressure or the ability to control hypertension with medication: (a) left ventricular hypertrophy as manifested in the electrocardiogram by voltage changes and ST-T abnormalities (voltage changes alone should not be disqualifying); (b) roentgenographic evidence of cardiomegaly (greater than 20 percent); (c) azotemia (serum creatinine greater than 2.0 mg/100 ml); (d) hypertensive retinopathy of Group 3 or 4 (Keith-Wagener-Barker classification).

7. A pilot or crew member who has normal blood pressure 3 or more months after successful operation for pheochromocytoma, primary aldosteronism, renovascular disease or unilateral renal parenchymal disease, and who shows no evidence of target organ disease or adrenal insufficiency, be permitted to fly. If residual hypertension is present and can be controlled with acceptable drugs, and there is no target organ disease, permission to fly should be granted on the same basis as for persons with essential hypertension.

8. A pilot who has had surgical treatment for Cushing's syndrome or lumbodorsal sympathectomy for hypertension not be permitted to fly, even if he is normotensive as a result of the operation.

9. A pilot treated with acceptable antihypertensive agents be permitted to return to duty when the blood pressure is within specified limits (Table I) and he has been free of undesirable side effects for 3 consecutive weeks, the blood pressure having been recorded at weekly intervals.

10. A pilot who is taking antihypertensive medication have his blood pressure measured at least once every 3 months in the supine or the seated position and in the standing position after 3 minutes, and the examining physician file a signed report of the reading in the pilot's medical file in the regional FAA medical office after each visit. More than 75 percent of the readings must be equal to or less than the upper limit prescribed in present regulations and none more than 10 percent above this level if the pilot is to be permitted to continue to fly with a waiver.

11. A pilot whose blood pressure exceeds 140 mm Hg systolic or 90 diastolic, or both, be required to have his blood pressure measured every 6 months and the results entered in his medical file, even though he may choose not to take medication because his blood pressure is within acceptable limits according to current FAA regulations.

General Recommendations

1. In view of the rapid growth of general aviation and its impact on total air safety, all certificate classes should be governed by the same cardiovascular standards.

2. Aviation's particular environmental and operational characteristics lead to complex decisions concerning the crewman's medical fitness. In light of these characteristics, these decisions should be made by physicians chosen for their special qualifications in clinical preventive, environmental and predictive medicine, and for the capability to follow up and ensure the safety of aircrewmen flying with or without waivers. This Task Force recommends that the FAA require that examinations be accomplished

by such qualified physicians to ensure the excellence in evaluation the pilots desire and deserve and, further, to ensure greater public safety.

REFERENCES

1. Kannel WB: Role of blood pressure in cardiovascular morbidity and mortality. Prog Cardiovasc Dis 17:5-24, 1974

2. The Framingham Study. Some Characteristics Related to the Incidence of Cariovascular Disease and Death: 18 year Follow-Up (Kannel WB, Gordon T. ed). DHEW Publication no (NIH) 74-599. Washington, DC, U.S. Government Printing Office, Stock no. 1740-00379, 1974

3. Kannel WB: Handbook of Coronary Risk Probability. Dallas, Texas, American Heart Association Publication, 1972

4. Kannel WB, Dawber TR: Stroke Risk Handbook. Dallas, Texas, American Heart Association Publication, 1974

5. Veterans Administration Cooperative Study Group on Antihypertensive Agents. Effects of treatment on morbitity in hypertension--results in patients with diastolic blood pressures averaging 115-129 mm Hg. JAMA 202:1028-1034, 1967

6. Veterans Administration Cooperative Study Group on Antihypertensive Agents. Effects of treatment on morbidity in hypertension. II. Results in patients with diastolic

blood pressure averaging 90-114 mm Hg. JAMA 213:1143-1152, 1970

7. Levy RL, Hillman CE, Stroud WD, et al: Transient hypertension: its significance in terms of later development of sustained hypertension and cardiovascular renal diseases. JAMA 126:829-833, 1944

8. Julius S, Schork MA: Borderline hypertension--a critical review. J Chronic Dis 23:723-754, 1971

9. Harlan WR, Osborne RK, Graybiel A: A longitudinal study of blood pressure, Circulation 26:530-543, 1962

10. Madsen PER, Buch J: Long-term prognosis of transient hypertension in young male adults. Aerospace Med 42:752-755, 1971

11. Labarth DR, Hawkins CM, Remington RD: Evaluation of performance of selected devices for measuring blood pressure. Am J Cardiol 32:546-553, 1973

12. Kannel WB, Gordon T, Castelli WP, et al: Electrocardiographic left ventricular hypertrophy and risk of coronary heart disease. Ann Intern Med 72:813-822, 1970

TASK FORCE VI: VALVULAR HEART DISEASE

HALL (Chairman), BRISTOW, CHEITLIN, HULTGREN, KOUCHOUKOUS, McALLISTER

CARDIAC EVALUATION

Detection of organic heart disease is dependent upon the competence of the physician conducting the flight physical examination. Persons with suspected cardiac abnormalities should be further and more completely evaluated by a consultant in cardiology. This may be an internist with broad experience in cardiology or a board-certified cardiologist.

The clinical evaluation should include a careful history for past rheumatic fever and other conditions (Table I) known to cause valvular disease of the heart; past knowledge of cardiac murmurs; history of palpitations, cardiac irregularities, rhythm disturbances, syncope and transient cerebral ischemic episodes; and symptoms of angina, dyspnea, paroxysmal nocturnal dyspnea and hemoptysis. The physical examination should include measurement of the blood pressure, careful evaluation of the jugular vein and peripheral arterial pulsations, and careful inspection, palpation and auscultation of the heart. These observations should be made with the patient in the supine, sitting and left semidecubitus positions. The examining clinician must be attuned to recognize subtle murmurs of aortic regurgitation and mitral stenosis, which may require multiple positioning of the patient as well as examination after exercise.

Screening noninvasive studies will include a posteroanterior and lef

TABLE I

Classification of Causes of Valvular Heart Disease

- Congenital
- Rheumatic
- Infectious
  - Syphylitic
  - Infectious endocarditis
- Traumatic
- Heritable disorders, such as Marfan's syndrome
- Tumors (myxoma)
- Rheumatoid arthritis and ankylosing spondylitis
- Carcinoid heart disease, right and left valvular lesion
- Degenerative
  - Calcific aortic stenosis
  - Degenerative and inflammatory lesions of the aortic root with secondary aortic regurgitation
- Unknown cause (myxomatous transformation; "floppy valve" syndrome)
  - Ruptured chordae tendineae (multiple causes)
  - Idiopathic hypertrophic subaortic stenosis

lateral chest roentgenogram and 12 lead electrocardiogram. Evaluation of cardiac chamber enlargement in the presence of heart murmurs usually requires four views of the heart with barium swallow. When palpitations, irregularities or arrhythmias are elicited on history or examination, 24 hour Holter electrocardiographic monitoring may further elucidate the type, frequency and genesis of these abnormalities. Standard graded treadmill exercise testing, in addition to demonstrating changes associated with coronary insufficiency, will assist in evaluating functional capacity, and will yield information regarding symptoms and arrhythmias related to physical stress. Image-amplifier cardiac fluoroscopy will facilitate detection of intracardiac calcification in valves or supporting structures. Echocardiography has become an important noninvasive procedure and is especially valuable in diagnosing mitral stenosis, prolapse of the mitral leaflets, idiopathic hypertrophic subaortic stenosis, some types of mitral insufficiency, tumors of the heart and aortic valve lesions, and for estimating chamber size, wall thickness and ventricular contractility. Phonocardiography will usually have no advantage other than documenting the characteristics of audible murmurs and facilitating proper timing of cardiac sounds.

Invasive examinations, cardiac catheterization and angiography may at times be required to document the presence and severity of valvular lesions. The risk associated with invasive procedures, even though minimal, must be considered when pursuing such studies.

COMPLICATIONS OF VALVULAR HEART DISEASE RESULTING IN INCAPACITATION

The risk of these disorders constitutes the basis for disqualification.

Arrhythmias: Although arrhythmias may occur with any cardiac valvular deformity, atrial arrhythmias are especially common with mitral valve disease, particularly mitral stenosis. Ventricular arrhythmias are seen in association with myocardial ischemia secondary to severe aortic stenosis. These arrhythmias may be precipitated by physical and emotional stress, and may result in serious sudden impairment of cardiac output and perfusion of vital organs, especially the brain. Although any type of rhythm disturbance may occur in association with the mitral click-murmur syndrome, ventricular ectopy is the most troublesome and, in the more advanced forms of this syndrome, may result in syncope or sudden death, although this is probably rare.[1]

Myocardial decompensation and acute pulmonary edema may occur suddenly in situations of increased stress, usually physical but also emotional, especially with more severe valvular deformities.

Systemic embolization occurs most frequently with mitral stenosis; it may complicate even milder degrees of obstruction and occur in the absence of recognized or sustained atrial fibrillation.

Impaired cardiac output with syncope can occur under circumstances demanding increased forward flow as a complication of the more critical obstructive lesions, especially aortic stenosis. This most often occurs during physical exertion.

Infectious endocarditis can complicate any organic valvular lesion and result in emboli, cardiac decompensation or sudden rupture of a valve or chorda tendina.

Valve or chordal rupture can also occur in patients with myxomatous valvular degeneration, Marfan's syndrome and the mitral click-murmur syndrome. This can lead to sudden acute cardiac decompensation.

Catastrophic vascular accidents have a high incidence rate in patients with Marfan's syndrome and other heritable connective tissue disorders; careful attention must be paid to the identification of these lesions even in the absence of detectable cardiovascular abnormalities.

RECOMMENDATIONS

General Considerations

In defining causes for disqualification, maximal consideration has been given to minimizing the risk of sudden pilot incapacitation resulting from any valvular lesion. Any departure from these criteria for qualification, by waivers related to personnel redundancy or duty position, mus[t] not result in increased risk of accident from sudden incapacitation. In-flight incapacitation of a pilot in any flight classification is a seriou[s] problem.

1. It is the consensus of the Task Force that all acquired valvular heart disease be considered disqualifying on initial examination for flight qualification.

2. Newly discovered and previously undocumented valvular abnormalities in already certified flight personnel should be disqualifying until sufficient time has elapsed to permit serial observation to establish clinical severity and stability.

3. The risk of incapacity, even in the presence of mild valvular lesions resulting from infectious endocarditis, necessitates that the pilot be temporarily disqualified because of unexplained fever or other unexplained constitutional symptoms of more than 3 days' duration until a complete and thorough evaluation has been carried out.

4. Murmurs occurring in the absence of cardiac disease (innocent or functional murmurs) must be distinguished from those due to organic disease. Final classification as an innocent murmur depends upon the absolute exclusion of any cardiac abnormality, and this may not always be possible. Absence of radiographic, electrocardiographic and echocardiographic abnormalities, while not absolute proof of the functional nature of a murmur, are important corroborative findings.

The innocent pulmonary ejection murmur is usually short and is due to increased flow or enhanced audibility of turbulent flow in the pulmonary outflow tract found in the young and in states such as pectus excavatum and the straight back syndrome. Since the murmur is similar to that of mild pulmonary valve stenosis and atrial septal defect, normality of the splitting of the second heart sound is an important concomitant of the innocent murmur.

The functional left heart ejection murmur is also characterized by its early timing in systole, absence of ejection click, and normal electrocardiogram and roentgenogram. This murmur may be heard at the cardiac apex. Echocardiography serves to exclude aortic leaflet eccentricity and thickening. Cardiac catheterization and angiography may be required to exclude an anatomic cause of a presumed atypical functional murmur. Diastolic murmurs never occur in the absence of anatomic deformities of the heart or increased intracardiac flow with intracardiac shunts or hyperkinetic circulatory states.

Aortic Stenosis

Severe and moderately severe aortis stenosis: There is abundant evidence supporting a poor prognosis for symptomatic patients with severe aortic stenosis.[2-7] The time from appearance of symptoms to death is usually short, and these patients are candidates for valve replacement. Sudden death is highest in the group that has symptoms.[4,6,8] The asymptomatic person with severe aortic stenosis also has a poor prognosis and is also subject to sudden death. There is little question that these persons should be disqualified.

Mild aortic stenosis: Flight personnel discovered to have mild aortic stenosis can be considered for continued certification if they are asymptomatic, have a systolic murmur of grade 3/6 or less, have no palpable fourth heart sound, and have no left ventricular hypertrophy by physical examination, electrocardiography, radiography or echocardiography.

A graded submaximal treadmill test should be normal. Occasionally patients with a high gradient (small valve area) can present with a normal electrocardiogram and physical findings suggesting mild aortic stenosis.[10-13] Cardiac catheterization is necessary in these patients and should reveal an aortic systolic mean pressure gradient of less than 20 mm Hg at rest and with exercise to three times resting oxygen consumption, with a normal left ventricular end-diastolic pressure (12 mm Hg). Because of the adverse influence of concomitant coronary artery disease, coronary arteriography should reveal no more than minimal luminal irregularities. Yearly reevaluation by a qualified cardiac consultant is mandatory since the rate of progression of this lesion is not well documented.[4-7]

Aortic Regurgitation

Patients with symptomatic aortic regurgitation have a prognosis poor enough to disqualify them.[14-16] There is good evidence that patients with mild aortic regurgitation can live a long life without manifesting symptoms.[14-15]

Mild aortic regurgitation: Flight personnel with mild aortic regurgitation may be considered qualified when they are asymptomatic, with a normal blood pressure (that is, pulse pressure equal to or less than 55 mm Hg and a diastolic pressure equal to or greater than 65 mm Hg). The chest roentgenogram and the electrocardiogram should be normal, with no evidence of cardiac enlargement. A graded submaximal treadmill test to 85 percent of the predicted heart rate should be normal based on criteria for a "fit individual."

Hemodynamic studies may be required to confirm the mild nature of the aortic regurgitation. They should demonstrate normal intracardiac pressures (mean pulmonary arterial pressure of 20 mm Hg and mean pulmonary arterial wedge pressure of 15 mm Hg or less and absence of left ventricular-aortic gradient) both at rest and on supine exercise (as described). An aortogram should reveal 2+ or less regurgitation or a regurgitant fraction of less than 25 percent of left ventricular stroke volume.

Aortic Stenosis with Aortic Regurgitation

Persons with both aortic stenosis and aortic regurgitation should be disqualified unless they qualify under the preceding separate criteria.

Mitral Stenosis

Mitral stenosis is the valvular lesion best studied in terms of natural history.[17-19] Both symptomatic and asymptomatic patients with mitral stenosis may have episodes of sudden increase in pulmonary capillary pressure and acute pulmonary syndrome especially at times of sudden hemodynamic overload and at the onset of atrial fibrillation.[17,18,20] Episodes of systemic embolism occur even with clinically mild mitral stenosis and after apparently successful mitral commissurotomy and can cause sudden incapacitation.

For these reasons, anyone with the findings of mitral stenosis, even if asymptomatic with or without operation, should be precluded from operating an airplane.[21-23]

Mitral Regurgitation

Mild versus severe regurgitation: In contrast to mitral stenosis, mitral regurgitation, usually of rheumatic origin, if mild by physical examination, electrocardiogram or chest roentgenogram is rarely associated with sudden incapacity and has an excellent prognosis.[23] With mitral regurgitation sufficient to cause moderate to severe cardiac enlargement, the incidence of symptoms and disability increases.[24] Whereas moderate or severe mitral regurgitation is disqualifying, a person with mild mitral regurgitation can be qualified for flying. Such a person should be asymptomatic, with no more than a grade 3/6 apical systolic murmur. There should be no evidence of mitral stenosis clinically or by echocardiography. There should be no evidence of cardiac enlargement on physical examination or radiography, and no greater than 1+ enlargement of the left atrium on barium swallow. The electrocardiogram should reveal no more than minor atrial abnormalities. There should be no evidence of paroxysmal arrhythmia on history or maximal graded treadmill test. Occasionally, hemodynamic studies may be required to establish the minimal nature of the mitral regurgitation and should reveal normal pressure (as cited earlier), and the left ventriculogram should reveal no more than 2+ mitral regurgitation (or a regurgitant fraction less than 25 percent of left ventricular stroke volume).

Nonrheumatic causes of mitral regurgitation include ruptured chordae tendineae, chest trauma and healed infectious endocarditis. Criteria for certification would be as stated earlier, after a sufficient period to establish stability.

Mitral regurgitation secondary to papillary muscle dysfunction, cardiomyopathy and idiopathic hypertropic subaortic stenosis must be considered separately under their primary causes.

Mitral Click-Systolic Murmur Syndrome

Mitral insufficiency with this syndrome is usually mild, but there is a significant incidence of atrial and ventricular arrhythmias, chest pain and ST-T wave changes on electrocardiography.[25,26] There is also a small but well documented incidence of sudden death (true frequency unknown) and infectious endocarditis in this syndrome. Long-term follow-up studies[27] show that most patients with this syndrome do well. Patients who have either died or become progressively disabled have come from the group with symptoms or with ST-T wave changes and arrhythmias.[26] For these reasons symptomatic persons or those with arrhythmias should be disqualified from operating an aircraft. Persons with the click-systolic murmur syndrome who are asymptomatic and free of ectopy but who have ST-T wave changes constitute a group whose long-term risk has not been established. They may be permitted to fly, but periodic reevaluation is required. The criteria established for minimal mitral regurgitation must also be fulfilled

Other Acquired Valvular Disease

Tricuspid stenosis and tricuspid regurgitation of rheumatic origin are almost always associated with mitral or aortic valve disease, or both, and are disqualifying. Occasionally tricuspid regurgitation of nonrheumatic origin secondary to trauma or infectious endocarditis is

ı,
e con-

there is
st pain
a small
wn) and
dies27
have
oup with
easons
ed from
drome
nges
They
ne
fulfilled.

rigin
or
of
is

mild and the subject has a normal-sized heart and normal systemic venous pressure. Persons with this condition have an excellent prognosis and are qualified for flight certification.

Pulmonary insufficiency and tricuspid insufficiency secondary to pulmonary hypertension are disqualifying.

Surgical Valve Replacement

Valve replacement has proved successful in improving patients' well-being and exercise tolerance and, very likely, in prolonging life. However, the complications and problems of valve replacement are a primary concern.[28,29] Some of these complications are not predictable as new valves, or variations, are introduced. Persisting problems include thromboembolism, thrombotic changes leading to obstruction or insufficiency, or both, valve dehiscence, hemolytic problems, prosthetic endocarditis and poppet abnormalities. Even tissue valves have suffered from progressive incompetency, disruption and even thromboembolism, but to a lesser degree.[30]

For these reasons, individuals with artificial heart valves of any type, either prosthetic or tissue, are not qualified to pilot aircraft.

REFERENCES

1. Gulotta SJ, Gulco L, Padmanahan V, et al: The syndrome of systolic click, murmur, and mitral valve prolapse. A cardiomyopathy? Circulation 49:717-728, 1974

2. Mitchel AM, Sacket CH, Hunzicker WJ, et at: The clinical features of aortic stenosis. Am Heart J 48:684-720, 1954

3. Takeda J, Warren R, Holzman D: Prognosis of aortic stenosis. Arch Surg 87:931-936, 1963

4. Ross J Jr, Braunwald E: Aortic stenosis. Circulation 37 & 38: Suppl V:V-61, 1968

5. Morrow AG, Roberts WC: Obstruction to left ventricular outflow. Ann Intern Med 69:1255-1286, 1968

6. Bergeron J, Abelmann WH, Vazques-Milan H, et al: Aortic stenosis - clinical manifestations and course of the disease. Arch Intern Med 94:911-924, 1954

7. Rotman M, Morris JJ Jr, Behar VS, et al: Aortic valvular disease: comparison of types and their medical and surgical management. Am J Med 51:241-257, 1971

8. Tuuteri L, Landtman: Natural history of congenital aortic stenosis. Acta Paediatr Scand [Suppl] 206:51-52, 1970

9. Frank S, Johnson A, Ross J Jr: Natural history of valvular aortic stenosis. Br Heart J 35:41-46, 1973

10. Sanders CA, Friedlich AL: Misleading electrocardiographic findings in severe aortic stenosis. Medicine 43:393-399, 1964

11. Glancy DL, Epstein SE: Differential diagnosis of type and severity of obstruction to left ventricular outflow. Prog Cardiovasc Dis 14:153-191, 1971

12. Jones RC, Walker WJ, Jahnke EJ, et al: Congenital aortic stenosis in correlation of clinical severity with hemodynamic and surgical findings in forty-three cases. Ann Intern Med 58:486-493, 1963

13. Hohn AR, Van Praagh S, Moore AAD, et al: Aortic stenosis. Circulation 32:Suppl III:4-12, 1965

14. Goldschlager N, Pfeifer J, Cohn K, et al: The natural history of aortic regurgitation. Am J Med 54:577-588, 1973

15. Segal J, Harvey WP, Hufnagel C: A clinical study of 100 cases of severe aortic insufficiency. Am J Med 21:200-210, 1956

16. Spagnuolo M, Kloth H, Taranta A, et al: Natural history of rheumatic aortic regurgitation. Circulation 44:368-380, 1971

17. Rowe JC, Blanal EF, Sprague HB, et al: The course of mitral stenosis without surgery: ten- and twenty-year perspectives. Ann Intern Med 52:741-749, 1960

18. Olesen KH: The natural history of 271 patients with mitral stenosis under medical treatment. Br Heart J 24:349-357, 1962

19. Selzer A, Cohn KE: Natural history of mitral stenosis: a review. Circulation 45:878-890, 1972

20. Dubin AA, March HW, Cohn K, et al: Longitudinal hemodynamic and clinical study of mitral stenosis. Circulation 44:381-389, 1971

21. McHenry MM: Systemic arterial embolization in patients with mitral stenosis and minimal dyspnea. Am J Cardiol 18:169-174, 1966

22. Deverall PB, Olley PM, Smith DR, et al: Incidence of systemic emboli before and after mitral valvotomy. Thorax 23:530-536, 1968

23. Wilson MG, Lim WN: The natural history of rheumatic heart disease in the third, fourth and fifth decades of life. Circulation 16:700-712, 1957

24. Reichek N, Shelburne JC, Perloff JK: Clinical aspects of rheumatic valvular disease. In, Valvular Heart Disease (Sonnenblick EH, Lesch M, ed). New York, Grune & Stratton, 1974, p 145

25. Pocock WA, Barlow JB: Etiology and electrocardiogaphic features of the billowing posterior mitral leaflet syndrome. Am J Med 51:731-739, 1971

26. Jeresaty RM: Mitral valve prolapse-click syndrome. Prog Cardiovasc Dis 15:623-652, 1973

27. Epstein EJ, Coulshed N: Phonocardiogram and apex cardiogram in systolic click-late systolic murmur syndrome. Br Heart J 35:260-275, 1973

28. Behrendt DM, Austen WG: Current status of prosthetic valves for heart valve replacement. In Ref 24, p 275-307

29. Hylen JC: Mechanical malfunction and thrombosis of prosthetic heart valves. Am J Cardiol 30:396-404, 1972

30. Angel WW, DeLonerolle P, Shumway NE: Valve replacement: present status of hemograft valves. In Ref 24, p 309-342

TASK FORCE VII: CONGENITAL HEART DISEASE

BROCKMAN (Chairman), ENGLE, SCHWARTZ

The following recommendations for applicants for licensure as pilots are based on what is known about the natural history of congenital heart disease and about the long-term follow-up to date of postoperative patients. The increasing success in the operative treatment of congenital heart disease with resulting longevity will undoubtedly result in an increase in the frequency with which subjects with congenital heart disease apply for flight training. It is hoped that applicants suspected of having congenital cardiovascular disease will be screened and appropriately identified and evaluated prior to entry into pilot training. Therefore, the question of recertification of flight crew with congenital heart disease will depend upon serial evaluation of existing residua. For this reason, it is particularly important that initial screening be completed by a physician who is knowledgeable in the field of cardiovascular disease.

DIAGNOSTIC EVALUATION

In contrast to the recommendations of the first Bethesda Conference,[1] the presence of congenital heart disease as such should not automatically disqualify applicants as medically unfit for pilot certification or recertification. This decision should be based on the specific anatomic diagnosis and its severity and whether the condition has or has not been surgically treated. The decision for certification should consider not only the applicant's present status but also the possibility of late onset of functional derangements or disability. These judgments may be modified as more data become available on postoperative patients. When initial screening by the physician suggests the presence of a congenital cardiac anomaly, the applicant should be referred for further cardiac evaluation. The definitive diagnosis of the condition and its severity should be established by a cardiologist expert in the field of congenital heart disease. This evaluation should utilize appropriate noninvasive as well as invasive techniques.

The following noninvasive studies should be carried out in every applicant suspected of having congenital heart disease: complete history and physical examination, a 12 lead electrocardiogram and a routine chest roentgenogram. In those considered at risk for the development of arrhythmia, continuous electrocardiographic monitoring at rest and during exercise should be carried out. Intracardiac electrophysiologic studies may be necessary to evaluate certain conditions properly. Under certain circumstances, echocardiography may aid in the assessment of cardiac structure and function. In selected cases, hemodynamic studies with contrast visualization should be performed.

RECOMMENDATIONS

Applicants for licensing are likely to be those with mild forms of congenital heart disease for which surgery is not considered indicated or in which the condition has spontaneously resolved. In addition, those who have previously undergone surgical repair of a malformation may apply for pilot training. Persons with severe congenital heart disease are not likely to apply for commercial pilot licensing but might, nevertheless, apply for private licensing. Criteria for evaluating applicants for all levels of flying status with the following common congenital cardiovascular anomalies should serve as guidelines for assessing all forms of congenital heart disease. For postoperative applicants, a minimal period of 1 year is recommended to permit clinical and hemodynamic evaluation of results.

I. Aortic Stenosis

A. Valvular

1. Unoperated on, whether mild, moderate, or severe: disqualifies

2. Operated on, with or without valve replacement: disqualifies

B. Subvalvular, discrete, membranous, without associated valvular abnormalities or secondary hypertrophic cardiomyopathy

1. Unoperated on: disqualifies

2. Operated on: qualifies, provided there is no residual hemodynamic, electrophysiologic or roentgenographic abnormality and no electrocardiographic abnormality at rest or during exercise stress testing

C. Supravalvular, discrete

1. Unoperated on: disqualifies

2. Operated on: qualifies provided the gradient is abolished and there are no residual abnormalities, as for IB

II. Atrial Septal Defect

A. Secundum or sinus venosus

1. Unoperated on: disqualifies

2. Operated on: qualifies after surgical closure if during the long-term follow-up there has been return to normal of physical findings and of roentgenographic and electrocardiographic abnormality. Specifically, there should be no history of arrhythmia and no demonstration, on stress testing or continuous electrocardiographic monitoring, of atrial dysrhythmia. Periodic reevaluation for arrhythmia should be carried out in this manner.

B. Ostium primum defect

1. Unoperated on: disqualifies

2. Operated on: disqualifies

III. Coarctation of the Aorta

A. Unoperated on: disqualifies

B. Operated on: qualifies if the success of surgery is attested to by the following criteria:

1. Absence of associated aortic valve disease

2. Absence of hypertension

3. Absence of the gradient between the upper and lower aortic segments by the presence of normal heart size on chest roentgenogram and normal electrocardiogram at rest and during exercise

4. Response of blood pressure during exercise should be evaluated and should be within the established norm for age

5. Periodic reevaluation should be undertaken to assess blood pressure during rest and exercise

IV. Patent Ductus Arteriosus

A. Unoperated on: disqualifies

B. Operated on: qualifies, provided results of physical examination, electrocardiogram and chest roentgenogram are normal

V. Pulmonary Stenosis

A. Valvular

1. Unoperated on: disqualifies unless proved at cardiac catheterization to have mild obstruction--that is, peak systolic pressure of 50 mm Hg or less in the right ventricle. In equivocal cases, cardiomegaly or electrocardiographic abnormality out of proportion to right ventricular pressure, or both, is disqualifying

2. Operated on: qualifies if postoperative study indicates that the gradient has been abolished or the peak right ventricular pressure is less than 50 mm Hg. In addition, the chest roentgenogram and electrocardiogram should be normal. Mild residual right ventricular hypertrophy by electrocardiogram does not disqualify if the heart size is normal. The presence of mild residual pulmonary valve incompetence does not, in itself, disqualify unless postoperative hemodynamic and angiographic studies indicate that right ventricular function is compromised

B. Subvalvular, discrete (with or without small ventricular septal defect)

1. Unoperated on: disqualifies

2. Operated on: qualifies if there is postoperative proof of elimination of pressure gradient and the chest roentgenogram and electrocardiogram are normal

C. Subvalvular, hypertrophic (infundibular)

1. Unoperated on: disqualifies

2. Operated on: qualifies, provided the criteria in VB are fulfilled. Periodic reevaluation should include a repeat hemodynamic study if a new abnormality in physical examination, electrocardiogram or chest roentgenogram appears

D. Supravalvular

1. Unoperated on: disqualifies unless the resting systolic pressure in the right ventricle is less than 50 mm Hg and there is neither right ventricular hypertrophy by electrcardiogram nor cardiomegaly

2. Operated on: qualifies, provided the pressure gradient is abolished and the electrocardiogram and chest roentgenogram are normal

VI. Tetralogy of Fallot

A. Unoperated on: disqualifies

B. Operated on: Subjects who have undergone successful correction of tetralogy of Fallot qualify if the following criteria are met:

1. Normal chest roentgenogram, including cardiac size and intrapulmonary vascularity

2. Absence of electrocardiographic evidence of bifascicular block, atrioventricular conduction delay, or dysrhythmia at rest or on exercise

3. In addition, it is recommended that cardiac catheterization be undertaken to confirm closure of the ventricular

septal defect. Peak right ventricular pressure should not exceed 50 mm Hg

4. Electrophysiologic studies are recommended for the evaluation of atrioventricular conduction as well as continuous tape monitoring to exclude ventricular arrhythmia

5. Periodic reevaluation of these applicants is recommended, with particular attention to right ventricular function and conduction abnormalities. This is particularly relevant to the late onset of ventricular arrhythmia at rest or during graded exercise testing. The appearance of transient complete heart block in the postoperative period is disqualifying

VII. Transposition of the Great Arteries

A. Unoperated on: disqualifies

B. Operated on: Since the long-term effects of the right ventricle's functioning as a systemic ventricle are not known, it is recommended that right ventricular performance be assessed periodically by appropriate techniques. Qualification may be considered if there is evidence, by cardiac catheterization with contrast visualization and electrophysiologic studies, including continuous tape monitoring, that hemodynamics, cardiac rhythm and conduction are normal

VIII. Ventricular Septal Defect

A. Unoperated on:

1. Qualifies if there is no evidence by comprehensive non-invasive evaluation, supplemented by cardiac catheterization with contrast visualization, that there is no associated cardiopulmonary or electrophysiologic abnormality other than the small left to right shunt of less than 1.5:1 and normal right-sided pressures

2. Spontaneously closed: qualifies if confirmation of closure and normal cardiovascular function is obtained by hemodynamic studies with contrast visualization

B. Operated on:

1. Qualifies if there is proof of successful closure on physical examination; and proof of normal heart size and pulmonary vascularity on chest roentgenogram, and a normal electrocardiogram at rest and on continuous tape monitoring. Postoperative cardiac catheterization with contrast visualization is required to confirm abolition of the shunt and the presence of normal right-sided pressures

2. If the only residual abnormality is right ventricular conduction delay, the subject may qualify if His bundle studies show no prolongation of the H-V interval and if

no dysrhythmia occurs during stress testing and continuous Holter electrocardiographic monitoring. Delayed appearance of ventricular arrhythmia either at rest or on stress testing is reason for removal from active flight status pending further evaluation

3. If the only abnormality detected is a trivial left to right shunt, the candidate may qualify if he fulfills the other criteria outlined for the postoperative patient. Transient complete heart block in the postoperative period is disqualifying

COMMENTS

Subjects with other less common forms of congenital cardiovascular abnormalities may apply for licensure. It is recommended that their evaluation be in keeping with the preceding recommendations.

REFERENCE

1. Standards of physical fitness of aircrew. First Bethesda Conference of the American College of Cardiology, November 6 and 7, 1965, Bethesda, Maryland. Am J Cardiol 18:630-636, 1966

TASK FORCE VIII: MYOCARDIAL-PERICARDIAL DISEASE

BURCH (Chairman), SHABETAI, SPODICK

PERICARDITIS

Any symptom or abnormality determined by any diagnostic procedure that proves to be due to pericarditis[1,2] or a congenital pericardial defect is sufficient to ground the pilot. Complete absence of pertinent symptoms, physical findings and laboratory abnormalities is necessary for a return to flying status. The clinical study should identify pericarditis due to systemic and myocardial disease and exclude life-threatening illness that might masquerade as primary pericarditis.

CARDIOMYOPATHY

An aviation pilot with either primary or secondary cardiomyopathy should be disqualified.[3,4] When the myocardial disease has completely disappeared, without recurrence despite normal daily activity, he may be relicensed to fly. Cardiomyopathy recognized early is more likely to return to normal with proper therapy; when it is recognized late, clinical cure is less likely. Abnormal heart size as determined by X-ray examination, arrhyt mias of any sort and an abnormal electrocardiogram are important disqualify objective manifestations of an abnormal myocardial state in a patient with cardiomyopathy even if he is symptom-free. The electrocardiogram is the most sensitive means for detecting early and subtle myocardial disease.

Electrocardiographic abnormalities are often the last signs of myocardial disease to return to normal. Because of the complexities of the problem and variability of the clinical and physiologic manifestations, once a pilot has had cardiomyopathy medical clearance for flying status should be determined by a certified cardiologist.

HYPERTROPHIC OBSTRUCTIVE CARDIOMYOPATHY

Hypertrophic obstructive cardiomyopathy[4,5] is a fairly uncommon type of cardiomyopathy. Since it tends to occur in families, a pilot with a family history of sudden death or idiopathic hypertrophic subaortic stenosis should be examined carefully for this condition. When properly used, echocardiography can be of considerable assistance in diagnosis and is particularly valuable because the procedure is not hazardous or injurious. The clinical and diagnostic manifestations are often subtle, so that the disease often goes undiagnosed when a pilot is not examined by a competent cardiologist. Evidence of idiopathic hypertrophic subaortic stenosis is sufficient to ground the pilot permanently.

REFERENCES

1. Spodick DH: Acute Pericarditis. New York, Grune & Stratton, 1959

2. Wood FC: Observations on pericardial disease. Med Clin North Am 37:1639-1646, 1953

3. Burch GE, DePasquale NP: Heart Muscle Disease. Disease-a-Month Monograph. Chicago, Year Book Medical Publishers, May 1968

4. Goodwin JF: Cardiac function in primary myocardial disorders. Part I. Br Med J 1:1527-1533, 1964

5. Braunwald E, Lambrew CT, Rockoff SD, et al: Idiopathic hypertrophic subaortic stenosis: I. A description of the disease based upon the analysis of 64 patients (abstr). Circulation 29, 30:Suppl IV:IV-3, 1964

TASK FORCE IX: ARRHYTHMIAS

SURAWICZ (Chairman), DONOSO, ESCHER, LANCASTER, NELSON, SELZER

Cardiac arrhythmias represent disturbances of electrical impulse formation or transmission, or both, and must be regarded as "symptoms" rather than "disease." Data obtained in recent years indicate that the range of normal may be rather broad and that some of the disturbances are merely alterations or extensions of normal physiology rather than indications of serious pathology. It is acknowledged that the standard electrocardiogram is a rather crude record of highly complex electrical phenomena and, as usually recorded, represents a brief and random sample. Most of our standards and norms, however, are based on such recordings, and will undoubtedly be subject to future clarification and revision. It is therefore difficult to establish decisive boundaries between normal and abnormal. All judgments must arise from all the available information regarding an individual airman.

GENERAL CONSIDERATIONS

1. An arrhythmia is of concern when it may affect flight performance or alter cardiac output, coronary blood flow, cerebral blood flow or maintenance of blood pressure. It is important to weigh the potential impact of such alterations on a pilot's ability to respond to the various stressful conditions of flight activity. Some arrhythmias are so severe that the prudent physician would regard them, in themselves, as prohibitive of flight status in any category.

2. The natural history of arrhythmias is fraught with variability

and intermittency, often with long hiatuses. It may be necessary to determine or discover, by long-term monitoring or stress testing, the latency and frequency of subsymptomatic, intermittent disturbances.

3. Emphasis must be place on due consideration of a subject's age; a possibly innocent variant of normal at age 20 years could represent a potentially serious abnormality at age 50.

4. A regular pattern of examination by history and by objective testing is essential, and should be supplemented by special monitoring or more sophisticated testing when necessary. Experience indicates that the population at risk is especially motivated to appear healthy, and may minimize or disregard symptoms that may be cardiac in origin.

5. The role of specialized invasive cardiac diagnostic studies in assessing the cause or possible implication of a given abnormality is unclear. These studies include cardiac catheterization, ventricular function, ventricular angiography, coronary arteriography, His bundle recording and other electrophysiologic studies. They may occasionally be justified and help in making decisions in problem cases.

DISTURBANCES OF SINOATRIAL NODAL FUNCTION AND INTRAATRIAL CONDUCTION

Included in this category are the following:

1. Sinus arrest
2. Sinoatrial (S-A) block
3. Sinus arrhythmia

4. Sinus tachycardia
5. Sinus bradycardia
6. Intraatrial conduction disturbances
7. "Wandering" pacemaker
8. Escape supraventricular ectopic rhythms and beats
9. Bradycardia-tachycardia syndrome

Documentation

The diagnosis of these disturbances is made from the electrocardiogram. It is advisable to obtain, if available, all past tracings for comparison to determine whether the arrhythmia is new or has previously existed. In patients with intermittent abnormalities, stress testing and ambulatory electrocardiographic monitoring may be helpful. Invasive studies, including atrial pacing and His bundle recordings, should be considered in doubtful cases.

Recommendations

General: All persons with symptoms of syncope, presyncopal sensation and palpitation are disqualified for initial license and recertification.

Specific:

1. Sinus arrest manifested by persistent absence of a normal P wave will be disqualifying for initial license and recertification.

2. Sinoatrial block will be disqualifying for all categories in all persons with symptoms or with evidence of prolonged abnormality of sinoatrial impulse formation or conduction, or both.

3. Sinus arrhythmia does not disqualify.

4. Sinus tachycardia: Persons whose heart rate at rest is consistently faster than 95 beats/min should be further evaluated.

5. Sinus bradycardia: Persons with a heart rate at rest slower than 45 beats/min should be further evaluated.

6. Intraatrial conduction disturbances do not disqualify.

7. "Wandering pacemaker" does not disqualify.

8. Ectopic escape beats and rhythms are secondary phenomena, and judgment is based on the primary abnormality.

9. Bradycardia-tachycardia is a disqualifying diagnosis. It usually implies abnormality of sinoatrial or atrioventricular conduction, or both, associated with organic heart disease.

SUPRAVENTRICULAR ECTOPIC IMPULSES AND RHYTHMS

Definition

Included in a listing of supraventricular ectopic rhythms are:

1. Atrial flutter and atrial fibrillation.

2. Supraventricular premature impulses: conducted, nonconducted and aberrantly conducted.

3. Supraventricular tachycardia (atrial or junctional), characterized by narrow QRS complexes at a rate of 150-250/min, which may be paroxysmal or nonparoxysmal.

4. Accelerated ectopic supraventricular rhythms (heart rate less than 100 beats/min, narrow QRS configuration with or without definable P waves).

5. Multifocal atrial tachycardia (chaotic atrial tachycardia)

characterized by changing P wave configuration, with at least three different P wave contours and varying P-P intervals without a pattern.

6. Atrial and junctional parasystole, resulting from competitive discharge of an independent and protected supraventricular ectopic focus.

7. Supraventricular escape rhythm.

Documentation

Most frequently these dysrhythmias are noted in "routine" electrocardiograms. When suggestive cardiac symptoms are provided by the applicant, monitor tape recordings are indicated in an effort to document the possible specific arrhythmia.

Recommendations

1. Supraventricular premature impulses, occurring infrequently and as single ectopic beats in the asymptomatic person, may be disregarded.

2. Supraventricular tachycardias of any variety, documented by clinical episode or electrocardiogram, should be regarded as rendering the applicant unfit for initial license. This need not apply for a single episode occurring in a context of acute self-limiting illness, and considered after careful evaluation unlikely to recur. An episode of supraventricular tachycardia occurring in the licensed airman should prompt extensive cardiac evaluation for possible underlying disease. Particular consideration should be given to persons over the age of 40 years. In such persons, extensive noninvasive and invasive studies may be necessary to allow a reasonable judgment regarding recertification.

3. Accelerated ectopic supraventricular rhythms may occur in the normal person. Cardiac evaluation is required to rule out underlying cardiac disease.

4. Atrial or junctional parasystolic ectopic impulses should be regarded in the same manner as supraventricular premature impulses.

5. Supraventricular escape rhythms represent the emergence of a subsidiary pacemaker because of slowing of the dominant (sinus nodal) pacemaker; they commonly arise in the atrioventricular junction. On occasion, the discharge rate of the "escape" focus may be similar to that of the sinus nodal discharge, and isochronic dissociation of the two may exist for variable periods. Escape rhythms should not be regarded as a primary arrhythmia but as secondary to a defect in sinus nodal function. Their significance is thus predicated on judgment regarding sinus nodal dysfunction.

VENTRICULAR ECTOPIC IMPULSES AND RHYTHMS

Definition

General: Ectopic impulses are thought to originate below the bifurcation of the His bundle. In general, the terms ectopic beats, premature contractions and extrasystoles are used interchangeably.

Specific:

a. Uniform contour--usually means a single focus (unifocal).

b. Various contours (multifocal or multiform).

c. Parasystole--an independent rhythm resulting from regular discharge of a protected ectopic ventricular focus.

d. Ventricular tachycardia--a series of three or more ventricular ectopic beats.

e. Accelerated ventricular rhythm--competition between the inherent idioventricular rhythm, which has increased to approximately the same rate range as the normal sinus rhythm (between 60 and 90/min) so that as minor variations occur in the sinus rate, the idioventricular pacemaker breaks through to dominate.

f. Ventricular escape--ventricular pacemaker becoming evident in the presence of some disturbance in the formation or conduction of the supraventricular impulse.

g. Postextrasystolic T wave changes--a change in amplitude or direction of the T wave in the first complex or in several complexes after an extrasystole.

Documentation

Ventricular ectopic impulses are documented in the electrocardiogram. However, it is sometimes difficult or impossible to make the electrocardiographic distinction between ventricular ectopic beats and aberrantly conducted supraventricular beats without a discernible P wave.

Recommendations

1. Singly occurring ventricular ectopic beats at rest or with low levels of activity are frequently seen in apparently healthy persons without other evidence of heart disease. Their incidence increases with age in persons without heart disease but also increases in those with heart disease. Persons who are symptomatic or who require treatment are

clearly not qualified for flying duties. Asymptomatic persons (those with no more than simple awareness of extrasystoles) with rare to occasional ventricular ectopic beats should be qualified for entry and retention in flying duties. Although the guideline is admittedly arbitrary, when 24 hour electrocardiographic monitoring indicates that more than 10 percent of beats occur as ventricular ectopic beats, a thorough cardiac evaluation, including coronary angiography, should be performed. In persons 40 years of age and over being considered for recertification, additional information from cardiac catheterization and coronary arteriography is recommended.

2. Other high risk features of ventricular ectopic beats should be disqualifying for all flying duties. These include multifocality, R on T phenomenon and beats with a wide QRS complex (greater than 0.18 second).

3. Ventricular ectopic beats associated with exercise also occur frequently in apparently healthy persons and have no unique significance or predictive value in screening for latent coronary artery disease.[1] The site of origin of the ventricular ectopic beats, their variable coupling multiformity, their occurrence two in a row and parasystole are not believed to have prognostic significance.

4. Ventricular escape rhythm in the setting of atrioventricular block is a secondary phenomenon, and a decision concerning fitness to fly would rest on the primary condition.

5. Ventricular tachycardia of all varieties should be disqualifying.

6. Accelerated ventricular rhythms require thorough investigation before being considered of no significance.

7. Postextrasystolic T wave changes as an isolated finding are of uncertain significance but probably of little importance.

ATRIOVENTRICULAR CONDUCTION DISTURBANCES

Definition

Atrioventricular (A-V) conduction disturbances may be due to delay or interruption in the conduction of the cardiac impulse and may be classified as follows:

1. First degree A-V block. The upper limit of the normal P-R interval cannot be defined precisely without specifying the subject's age and heart rate but may be arbitrarily regarded as 0.22 second at a normal heart rate.

2. Second-degree A-V block includes (a) Wenckebach periods (Mobitz type I); and (b) Mobitz type II with normal or prolonged P-R interval.

3. High-degree A-V block and complete A-V block. A-V block usually promotes the appearance of subsidiary escape pacemakers, with resulting A-V dissociation. Escape rhythms may be A-V junctional or ventricular.

Documentation

In most instances, an electrocardiographic diagnosis suffices. It is advisable to obtain, if available, all past tracings for comparison to determine whether the conduction disturbance is new or whether it previously existed. In patients with intermittent abnormalities, it may be helpful to perform a stress test and prolonged ambulatory monitoring.

Invasive studies, including atrial pacing and His bundle recordings, should be considered in doubtful instances.

Causes range from functional and temporary, such as drug-induced disturbances, to reversible and irreversible organic diseases of the conduction system.

Recommendations

1. Reversible types of A-V block appearing in a specific acute illness and in response to drug therapy need not be disqualifying.

2. Persons with first degree A-V block at the time of application or acquired between the ages of 20 and 40 years, with no other evidence of cardiovascular disease, can be accepted for initial or renewal licensure. Persons with first degree A-V block, acquired after age 40 years, should be considered for initial or renewal licensure only after careful evaluation, including stress testing.

3. Established or intermittent second degree A-V block should be disqualifying for all categories. A possible exception is Mobitz type I (Wenckebach) block in persons under age 30 years, when the block can readily be reversed with minimal pharmacologic or physiologic intervention.[2]

4. Established or intermittent complete A-V block: All applicants with congenital A-V block or acquired high degree or complete A-V block should be considered unfit for licensure.

5. Escape rhythms and A-V dissociations in the setting of A-V block are secondary phenomena; the decision would depend on the primary condition.

INTRAVENTRICULAR CONDUCTION DISTURBANCES AND PREEXCITATION

Definition

The electrocardiographic abnormalities considered here include those produced by an abnormal sequence of activation of the ventricles due to delayed or premature activation. Patterns showing intraventricular conduction defects can be categorized as follows:

1. Minor conduction alterations (notches or splintering of the QRS complex without prolongation).
2. Incomplete right or left bundle branch block.
3. Complete right or left bundle branch block.
4. Monofascicular, bifascicular or trifascicular block.
5. Unclassifiable conduction defects (wide QRS complexes without typical bundle branch pattern).
6. Intraventricular conduction defects combined with evidence of ventricular hypertrophy.
7. Intraventricular conduction defects combined with evidence of myocardial infarction.
8. Preexcitation syndromes.

Documentation

The great majority of conduction defects are a permanent feature of the electrocardiogram, so that an electrocardiographic examination suffices. If available, all past tracings should be compared to determine whether the conduction defect is new or existed previously. In applicants with intermittent abnormalities, a stress test and ambulatory electrocardiographic monitoring may be helpful. Invasive studies, including atrial pacing and His bundle recording, should be considered in doubtful cases.

Causes of intraventricular conduction defects range from minor congenital imperfections of the conducting system to serious manifestations of myocardial disease and may include such temporary influences as drugs or metabolic imbalance.

Recommendations

In general, conduction disturbances have to be considered in the context of the clinical data. However, the following guidelines are suggested:

1. Minor conduction alterations with no other evidence of cardiac disease may be presumed normal and should be ignored.

2. In persons with incomplete or complete right bundle branch block of presumably congenital origin (found at a young age) in whom careful clinical and radiographic examinations (preferably echocardiographic studies also) reveal no underlying heart disease, it is highly probable that the conduction defect is an unimportant variant.[3] Serious consideration should be given to passing such applicants for licensure.

3. Applicants with acquired incomplete or complete right bundle branch block (with previously normal electrocardiogram) require comprehensive noninvasive cardiac evaluation. Candidates for initial licensure should be disqualified. However, if no other evidence of cardiac disease

is present, a tentative recommendation for licensing of the young person might be given, with frequent follow-up examinations.[4]

4. Applicants with complete left bundle branch block discovered on initial licensing examination should be disqualified. In a person with a previously normal electrocardiogram applying for relicensure, evidence of left bundle branch block requires extensive evaluation. Although apparently normal subjects may have left bundle branch block, the probability of cardiac disease is much higher than in subjects with a normal electrocardiogram.[4] The possibility of performing invasive studies such as coronary arteriography together with evaluation of left ventricular function should be considered. If these results are entirely normal, such subjects could be considered for relicensure.

5. Left anterior fascicular block, as defined by left axis deviation, is subject to the same recommendation as in (2).

6. Left posterior fascicular block is subject to the same recommendation as in (4).

7. Combined fascicular blocks (right bundle branch block with left anterior or posterior hemiblock with or without prolonged P-R interval) should disqualify applicants for initial licensing. Relicensure may be considered in pilots under the age of 50, but only after a complete evaluation including coronary arteriography and electrophysiologic studies.

8. Intraventricular conduction defects are subject to the same recommendation as in (4).

9. A preexcitation pattern (Wolff-Parkinson-White complexes) should disqualify applicants for initial licensure. The Wolff-Parkinson-White

and Lown-Ganong-Levine syndromes (defined by the electrocardiographic abnormalities and the presence of tachyarrhythmias) should disqualify applicants for relicensure.

PACEMAKERS

It is recommended that patients with pacemakers be denied entry at any age to pilot training of any category; the same applies to relicensure. The reasons include the high frequency of some degree of underlying heart disease[5,6]; the possibility of breakthrough of competitive rhythms or tachyarrhythmias[7,8]; increased vulnerability to acceleration[9] or to other stresses (of a variable and as yet unknown degree)[10-12]; the continuing incidence rate of ± 5 percent of sudden pacing failure for any reason (electrode as well as pulse generator)[13,14]; the increased vulnerability to radiofrequency interference in a cockpit or airport; the factor of time required to ground an aircraft safely (many minutes); the theoretically increased public risk of the case of catastrophe; and the very small number of candidates potentially involved.

This interdiction should not be construed as applying to "piloting" of ground vehicles with the exception of mass transport vehicles (where the very small risks to the individual driver are magnified by the number of persons transported). Most patients sustain loss of pacing without immediate blackout. Ground level vehicles can be stopped or extracted from traffic in seconds to minutes. The stress factors are known and small, the number of persons involved is limited, and experience with a reasonable number of drivers is good.

REFERENCES

1. Froelicher VF, Thomas MM, Pillow C, et al: Epidemiologic study of asymptomatic men screened by maximal treadmill testing for latent coronary artery disease. Am J Cardiol 34:770-776, 1974

2. Douglas JE: Aeromedical consultation service case report: evaluation of asymptomatic flying personnel with intermittent supraventricular arrhythmias. Aerospace Med 43:323-330, 1972

3. Lancaster MC, Schechter G, Massing GK: Acquired complete right bundle branch block without overt cardiac disease. Am J Cardiol 30:32-36, 1972

4. Rotman M, Triebwasser JH: A clinical and followup study of right and left bundle branch block. Circulation 51:477-484, 1975

5. Furman S, Escher DJW: Principles and Techniques of Cardiac Pacing. New York, Harper & Row, 1970

6. Escher DJW, Furman S: Pacemaker therapy for chronic rhythm disorders. Prog Cardiovasc Dis 14:459-474, 1972

7. Escher DJW: The treatment of tachyarrhythmias by artificial cardiac pacing. Am Heart J 78:829-832, 1969

8. Furman S, Escher DJW, Parker B: The failure of triggered pacemakers. Am Heart J 82:28-38, 1971

9. Cohen GH, Brown WK: Changes in ECG contour during prolonged +Gz acceleration. Aerospace Med 40:874-879, 1969

10. Bateman SC, Goldsmith R, Jackson KF, et al: Heart rate of training captains engaged in different activities. Aerospace Med 41:425, 1970

11. Mumin D, Cuddy TE, Sinha SN, et al: Inhibition of demand pacemakers by skeletal muscle potentials. JAMA 223:529, 1973

12. Parsonnet V, Feldman S, Parsonnet J, et al: Arrhythmias induced by exercise in paced patients. Am Heart J 87:76-82, 1974

13. Furman S, Escher DJW, Parker B: Results of long term pacemaker implantation. In, Cardiac Arrhythmias (Dreifus LS, Likoff W, ed). New York, Grune & Stratton, 1973, p 599

14. Furman S: Transtelephone observation of implanted cardiac pacemakers. Med Instrum 7:196-202, 1973

☆U.S. GOVERNMENT PRINTING OFFICE: 1978 O—279-952/6596