Recent Developments in Aviation and Aerospace Medicine

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IN THE HISTORY of the world's industrial development, no industry has grown more rapidly than aviation except numerical computation by electronic means. In 1903 the Wright brothers flew the first powered aircraft. By 1912 the first commercial airline, KLM, was operating between London and Amsterdam twice a week. In 1960, a total of 60 million tickets were sold to more than 10 million passengers who flew on U.S. owned and operated aircraft alone; the business air fleet far exceeded in numbers the entire U.S. Air Force, and the combined commercial and business fleets were fewer in numbers than the aircraft privately owned and operated for pleasure.

In October 1957 exploration of extraterrestrial space within our solar system became a reality. Only 4 years later, orbital traffic control is needed and man has gone into outer space and survived. Aerial mapping and surveying have almost outmoded the civil engineer surveyor. More than 4,000 companies seed, fertilize, and disinfect our crops. Forestry is dependent on aviation for both disease control and fire control, and few major airports can keep up with traffic growth. Every one of these situations has inherent medical problems. The study of these was called aviation medicine in the 1930–58 period and is now called aerospace medicine.

The Federal Aviation Agency

From about 1926 until 1958 commercial aviation was controlled by the Civil Aeronautics Board, a quasi-judicial arm of Congress, and by the Civil Aeronautics Administration, a division of the executive branch under the U.S. Department of Commerce. In that period aviation grew so rapidly that adequate control, in the interest of public safety, was virtually lost. The medical criteria for certification of pilot and traffic control personnel changed virtually not at all in 20 years. Almost anyone could get a medical certificate to pilot a plane from almost any physician. If, by chance, a physician thought someone should not fly, his decision often could be waived by the Civil Aeronautics Board.

In 1956 President Dwight Eisenhower asked Edward P. Curtis, a former Air Force general, to take a critical look at civil aviation. He reported that all major airports were overloaded with traffic. Schedules were unrealistic. Medical control of aircrew personnel was almost nonexistent, and there was no research seeking solutions to a multitude of problems. He recommended that a new set of statutes be enacted. In August 1958, by an act of Congress, the Federal Aviation Agency replaced the CAA, and the functions of the CAB were limited and defined more clearly.

In 1959 an adequate medical department was created under Dr. James L. Goddard, who reported directly to Elwood R. Quesada, the Federal Aviation Administrator. The physical requirements were stiffened for flyers and traffic control operators. Definite restrictions as to who might fly, when, and where were prescribed, and an upper age limit was set for

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pilots who carry passengers on the scheduled airlines. All pilots must now be examined by physicians accredited by the medical department of the FAA, and these certified examiners must show continuing interest in aviation medicine by participation in educational programs conducted or sponsored by the Agency's medical department. Adequate medical advisory panels exist to help the Civil Air Surgeon and the Administrator to arrive at proper medical decisions.

Medical research on a wide variety of projects is underway on a contract basis, and a new facility for intramural research is being built near Oklahoma City. Major accidents are being thoroughly investigated by trained teams, and pathologic examinations are made by trained personnel supplied by the Armed Forces Institute of Pathology. A recent FAA project is a study on medical requirements of airports of various sizes. Only a few airports have any medical facility of any kind; many lack even a first-aid room.

Passenger Research

While the Armed Forces have done exhaustive research on healthy flyers between the ages of 18 to 45, little concern has ever been given to the average passenger who buys a ticket. It has been tacitly assumed that if a situation is satisfactory for Air Force pilots, it is therefore safe for anyone. The fact is that from intrauterine fetuses of only hours' or days' existence to octogenarians of both sexes in all degrees of health, these assumptions may or may not be correct. For example, no one really knows what mild hypoxia for a few hours does to a 3-week-old fetus nor what such an experience does to the senile arteriosclerotic who can just get by at sea level.

With the sanction of the FAA, the National Institutes of Health is now supporting studies on passenger safety in jet travel at the Ohio State University Aviation Medicine Research Laboratories. Patients with various degrees of pulmonary pathology and with various amounts of lung surgically removed are exposed to the simulated cabin attitudes of jet travel, given a meal, and are monitored for any untoward reactions. Patients with diverse types and states of heart disease, diabetes, cerebral arteriosclerosis, glaucoma, and arthritis will participate in similar experiments. Persons with colostomies also are studied.

In addition, healthy subjects are being exposed to the pressure changes associated with a window blowout or a failure of the pressurization pumps. This experience has its disturbing features when the subject passengers are sober and is quite disturbing if they have consumed much alcohol.

FAA is carefully evaluating escape systems and escape gear. In another investigation by the Agency, pilots in the 45–60 age range are being exposed to potential hazards of a significant order to see how they react when compared with younger men.

MATS, the Air Force passenger carrier, has done postflight followup studies and showed that thrombophlebitis must be watched with care if passengers are going to fly long distances.

To learn whether or not flight affects mother or infant in any way, an epidemiologic study is contemplated by the Ohio State University group comparing 10,000 women who have flown in various stages of pregnancy with 10,000 who have not.

All of these studies are being carried out, not with the intent of restricting flying for anyone, but rather to provide adequate data for the engineers and designers of planes so they may make air travel totally safe for all.

Business Aviation

The National Business Aircraft Association acts as the parent body to advise American industrial organizations about the use of aviation in business. U.S. corporations now own about 30,000 planes and fly executives and business associates an estimated 3 billion miles per year. Some companies have medical departments and prescribe flight standards far more rigid than those applicable to most commercial airlines. Others have little or no medical supervision. To assist them, one of my associates, Dr. Charles Billings, is preparing a medical manual to aid corporate personnel in handling the medical aspects of flying. Our goal is, of course, to provide the least restriction compatible with complete comfort and safety. This project is financed jointly by the FAA and Ohio State University.

Crop Dusting

One of the most hazardous of all types of flying is crop dusting. In a high-wing monoplane or an old biplane, crop dusters fly from 18 inches to 6 feet off the ground at 62 to 100 mph 16 hours a day for 5 months of the year. Every time they go above 100 feet or come down to reload, they lose money. Such flights are generally illegal, and for each one, special waivers must be obtained. These men fly back and forth through a multitude of noxious agents, the toxicity of which they rarely know, and not infrequently serious accidents occur.

The physical requirements and training standards for this sort of flying are not the highest in the land, and under certain circumstances a flyer can get by with only a class III ticket or even none at all. Only 2 or 3 men in the entire 40,000-man FAA organization have had intimate experience with crop dusting, and none of these is a toxicologist or industrial hygienist. Only a few persons in the business know very much about the toxic hazards to pilots, farm animals, and other forms of life.

This is also being corrected. A number of agricultural schools are testing better ways to seed, dust, and fertilize from the air. FAA is seeking better stall warning systems for the flyers. The seasoned experts are coming each year to the Ohio State School of Aviation to teach others how to dust crops safely. Courses in toxicology are becoming part of the training program, and medical supervision by experts is gradually being accepted. One cannot sell the seasonal crop duster pilot on physicians. He will say emphatically that he doesn't need one. But, if the physician is also a flyer and goes to this crop duster course, pretty soon the professionals begin to want to know how the physicians might help them. When told what their risks really are, they go all out to get help.

Manned High-Altitude and Space Flight

At present nearly everyone is interested in space flight, and they should be because man will thoroughly explore space in part of our solar system, and he will do it within our lifetimes. However, he will not explore the stars in spaceships in the foreseeable future. The nearest true star is so far away that at 25,000 mph it would take 80,000 years to get there, and if he went at speeds which could make the trip in 10 years, the laws of energy, mass, and velocity would change him into a nonliving thing.

For a thousand years or more in the universities of the world, students have been getting advanced degrees for research on what often seemed to be such ridiculous and obscure subjects as "The size of the penumbra of the moon in the various stages of earth and sun orbits" or "How many miles further away from us does the moon go each hundred years and why?" "What is correct time to the 10,000th of a second?" "How deep is the dust on the moon?" "Does the slight atmosphere of the moon contain only CO_2 or some water as well?" "Do the Moon, Mars, and Venus have active volcanoes?" "Where does the SO_2 go if there is no atmosphere?" "How much ozone is in the ionosphere?" "What and why are northern lights?" These Ph.D. dissertations, thousands of them, are now all important to successful manned space flight.

Studies of the medical problems of flight in our upper atmosphere, 10 to 100 miles up, are carried out largely with a research machine. Part rocket and part airplane and man controlled, it is called the X–15. A few studies in this area are also done in helium-filled balloons. True space studies are carried out with sealed capsules propelled by rockets.

The men who go up in these ships are exposed to vacuums which would cause their blood to boil if they were unprotected. Temperatures drop to $-60°$ or even $-100°$ F. and then rise to more than 250° F. as the air friction of reentry makes the plane's surface a dull cherry red. Astronauts must not only tolerate but function well in the presence of accelerations and decelerations of from 0 to 4,000 mph. The pilot is weightless for periods of from a few seconds to a few minutes. He is exposed to solar and cosmic radiations unknown on the earth's surface. Finally, as he returns to earth he is transiently exposed to serious low-frequency, high-amplitude vibration and buffeting. Is he frightened? Yes, he is, but no more so than the team of physicians who, on the ground, are electronically monitoring his every action and reaction.

A single example of a problem to be solved is this one: From the points of view of maximum tolerance to acceleration while in flight or with a blast escape mechanism and as a focal point from which to function effectively in a weightless state, it is highly desirable to have the pilot strapped fairly tight into a contour seat at a selected angle. However, when he is vibrated at from ¼ to 2 inches' amplitude at frequencies of from 4 to 30 cycles per second, he could stand the stress far better if he were free enough to allow his musculature to absorb the vibration. If the body is tightly bound, shearing forces develop which can easily tear mediastinal structures. Standing fluid waves may develop in the aorta and great vessels which hamper or transiently stop blood flow.

A great deal of discussion has been given to the question of why should man go into space, a totally hostile environment. Could we not learn just as much by nonliving sensors and avoid the risks?

Whatever one's philosophy may be on this question, man already has orbited around the earth, and will go into orbit around the Moon, land on the Moon, and perhaps also on Mars and Venus after a great deal more close-range study of these two planets.

The hazards of the environment of outer space provoke serious thought. Consider a few of them:

1. No one in this country knows anything about the physiological and psychological effects of prolonged weightlessness. We have not been able to simulate it on the ground. Air exposures to it have been measured in seconds. Water submersion studies have a number of drawbacks and, in fact, are not truly weightlessness as found in space. Most of what we think we know about the return of blood to the heart through the venous system suggests that it is mediated through muscular contractions or posture against the forces of gravity. What will happen in space? Since the presentation of this paper, Lt. Col. John Glenn's orbital flight has already told us much about weightlessness for a few hours. But no informed scientist is certain of the effects when exposures are increased to days or weeks.

2. Outer space is deadly silent. Man has never been able to build a room of zero decibels. Close approaches have caused test subjects to fall asleep. What will happen in a spaceship when man hears only radio signals from earth against a background of absolute silence?

3. Man on earth has never been able to look directly at the sun on a clear day without the protection of a smoked glass even though he sees it through 60 to 100 miles of air full of dust particles and water droplets. What will happen to rods and cones and to vision in outer space? Looking toward the sun, the astronaut will see blinding brilliance but, facing elsewhere, only absolute blackness except for stars thousands of light-years in the distance. It will be a colorless world of white and black with nothing to cause the spectrum and shades in between. He will be able to see a 3,000-mile segment of earth but will be looking from an empty atmosphere through 100 miles of air, dust, water, and clouds. What will he really be able to see? Consider the Snellen Chart. Then calculate the size of the object you could see from 200 miles of distance while traveling at 18,000 mph.

4. A fairly standard satellite day, based on our Vanguard orbits, is about 61 minutes and a satellite night about 33 minutes. What does this do to man's diurnal variations? What should be the astronaut's work, eat, and rest schedule?

5. How does one design a work area for an astronaut when the temperature of the external environment while in the shadow of the moon will be colder than −150° F. but which on reentry into the atmosphere may reach 3,000° F.?

6. Imagine the calculations necessary to shoot yourself in a rocket from the east coast of Florida at 2 p.m. on Tuesday to hit a certain visible moon crater at 2 a.m. on Friday sufficiently gently not to break a single wire in your transistor radio. The takeoff must be slow enough not to exceed 10 g acceleration for more than a few seconds. The work environment must duplicate your office on earth plus a few hundred electronic gadgets. Water spilled

from a glass floats around the room, as do you if you leave your desk, and when you try to step forward, you go backward or tumble end over end. Your secretary is soon a quarter of a million miles away, and the flicked ashes from your cigarette ignore the ashtray. One window looks like the inside of a furnace for molten glass and the opposite one appears to be painted black. Figure out how to maneuver food from a container to your mouth.

Be sure that you provide yourself with 70° F. temperature and 50 percent relative humidity throughout the trip, that O_2 remains at 20 percent and 150 mm. Hg, that there is no air pollution of any kind, and that the CO_2 stays at less than 0.05 percent. Don't forget Dr. Van Allen's little bands, for if you do forget you might as well walk past an unshielded cobalt 60 unit. Make certain you are able to provide us on earth with all of the capacities of the human brain while on your trip, else why should we send you? Design, make, and test all your gear. It had better be right because no one will give you insurance.

This is what the aerospace life science teams which include aerospace medical men are pondering.

Education in Aerospace Medicine

Training for the specialty of aviation medicine in the military services is provided by the Navy and the Air Force but is limited to career officers.

In the civilian world, only the Harvard School of Public Health and Ohio State University have accredited programs, and only the Ohio one is presently accredited for the 3 full years of academic, research, and service training. Many universities, however, contribute through contract research. The need for highly trained personnel in and out of the services is large and the supply is small. Few young men are interested in entering the field; yet those in it would do nothing else.

Conclusion

Aerospace medicine is the study of the hazards to health, safety, and productivity of all those concerned with human flight. Its purposes are entirely preventive in character. It is a legitimate specialty, much like occupational medicine, but in a highly specialized area, and, for the most part, very much unlike public health administration.

National Need in Sewage Treatment Facilities

Although U.S. cities spent more money in 1961 than ever before to control water pollution, there were 5,290 communities with inadequate or no sewage treatment facilities on January 1, 1962, an increase of 163 over the previous year, according to a report by the Conference of State Sanitary Engineers. The cost of building the needed facilities is estimated at more than $2 billion.

Of the 50 States and 4 other jurisdictions reporting on the adequacy of their treatment facilities in filling current needs, 26 reported improvement, 4 reported no change, and 24 reported greater unmet needs in January 1962 than in January 1961.

Of the 5,290 communities that reported having inadequate facilities, 4,244 needed new plants, 633 required enlarged facilities, and 413 required new and more effective treatment methods. Most of the communities had populations of 5,000 or less, but 132 had populations between 25,000 and 100,000, and 52 had populations above 100,000.

Under the Federal Water Pollution Control Act, cities can receive Federal aid amounting to 30 percent of the cost of building a sewage treatment facility, up to a limit of $600,000. Cities joining in a single project may share a single grant, up to $2,400,000. During 1961 some $560 million worth of construction was undertaken by U.S. cities. Federal funds are now assisting at the ratio of $1 in Federal aid for every $5.50 provided by municipalities.