EDITORIAL

The 100th Anniversary of Air Medicine

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In the history of medicine, there have not been so many disciplines with the purpose of “glancing beyond the horizon” in both direct and metaphoric sense. One of these sciences is air medicine, which celebrates its 100th anniversary this year.

Air medicine (AM) is a modern high-tech division of medical science aimed at solution of the problems of medical support for flights of aircrafts of different types. This branch of medicine studies the interaction between the human body and unusual environmental conditions during professional flight work and develops the measures for high efficiency and safety of human flights by various aircrafts.

AM has fundamental medical and biological bases, systematic methodology, and pronounced practical and economic significance. Air medicine is not a kind of transport medicine.

It is based on a great many laws of occupational medicine but has a fundamental specificity, because flight work is one of the most complex and dangerous kinds of occupational activities. It is connected with leaving Earth’s surface and high-speed motion in a three-dimensional space. It is inherently characterized by human exposure to the combined effects of physical, chemical, psychic and biological factors, information loads, and the necessity to make decisions under the conditions of time deficit accompanied by intense psychoemotional stress (Fig. 1).

The foundations of air medicine were laid by I.M. Sechenov and D.I. Mendeleev, coryphaei of Russian science. In 1875, Mendeleev first suggested the concept of an airtight cabin for flights in the upper atmosphere after analyzing the causes of the death of the crew of the Zenit aerostat; he himself ballooned to a height of 3000 m. On the basis of the physiological analysis of the same tragedy, Sechenov reported, at the

Fig. 1. Major groups of flight work factors and physiological systems involved in implementation of their effects.

Fig. 2. Syndrome-like states under the major unfavorable factors of light work.

Fig. 3. General biological regularities of age-specific working capacity of a pilot. Calculation chart of the ratio of chronological and biological age.

11th Congress of Naturalists and Physicians, on the pulmonary gas exchange at a drop in barometric pressure. AM owes the basic knowledge of blood circulation control necessary for the analysis of acceleration effects during the flight to the classical studies by the Russian physiologist Academician I.P. Pavlov, started as early as in 1877.

However, it is accepted that the birthday of air medicine in Russia is July 14, 1909. On that day, the question of necessary medical examination of pilots was raised at the meeting of the All-Russian Flying Club.

The Flying Club decree states: "It is recognized to be necessary to permit the club members to perform flights only after medical examination."

In a year, the War Department of Russia issued Order no. 481 containing "The List of Diseases and Physical Handicaps Preventing the Service of Officers, Low Rank Men, and Civilian Mechanical Engineers in Aeronautical Units on Board the Balloons and Airplanes" and established the first physical evaluation board. The first scientific institution for investigation of the problems faced by air medicine, the Laboratory of Air Medicine, was founded in Russia in 1912 by S.E. Mintz, senior physician of the aviation school.

Involvement of aviation in the First World War posed an acute problem of employment and selection of a vast number of people fit for flight work in terms of the state of health. The first mention of the regular appointment of aviation medical officer dates back to the autumn of 1918, when the position of medical officer was established in an aviation detachment during the defense of the city of Tsaritsyn. A medical officer in the aviation detachment was bound to perform special examination of pilots, their way of life and nutrition; special nutritional regulations for flight personnel were established at that time as well.

The problems of medical screening and psychological tests of persons entering aviation schools were of particular significance for air medicine. The selection for aviation services was first carried out according to the principle of comprehensive clinical examination of candidates and individual personality assessment.

An air medical officer is a specialist supposed to ensure occupational health and reliable performance of all people responsible for flight work efficiency and flight safety. A medical officer should pay attention to the study of methods for diagnosing premorbid states and diseases with asymptomatic (latent) progress. An air medical officer usually deals with a healthy person who should meet the enhanced requirements for flying. Therefore, an air medical officer should be active and persistent in taking necessary preventive measures. An important feature of this activity is the ability to think scientifically, from making decisions about pilot's readiness for a particular flight to giving expert opinion on their flight fitness.

Numerous studies by AM specialists have shown that the influence (especially repeated and long-term) of flying occupational factors is accompanied by a syndrome-like set of changes at the molecular, cellular, and tissue levels (Fig. 2). They result in the following two major unfavorable processes: accelerated biological aging (Fig. 3) and partial health insufficiency (table).

Occupational specificity of aircrews is that a generally poor state of health rather than a disease per se may threaten the safety of aircrews, passengers, and population under the airplane routes. Hence, the key

concept of AM introduced in 1986 by V.A. Ponomarenko, member of the Russian Academy of Education, is occupational health as the ability of the body to preserve the given compensatory and protective properties that provide the capacity for work under all conditions of occupational activity.

The schematic diagram of interrelationship between the structural elements of occupational health and longevity is shown in Fig. 4. The components such as biological age (basic component) and functional states (dynamic component) are a kind of criteria for the effects of different factors on human body. At the same time, it is advisable to use biological age for estimation of chronic/cumulative exposures and the functional states for estimation of acute exposures, including extreme exposures going beyond maximum permissible standards.

Occupational health includes three most important components (Fig. 4): occupationally important qualities, functional reserves, and the genotypic/phenotypic state of a person. The concept of professional longevity of pilots and cosmonauts is formed with due regard for the necessary level of education and training of specialists, as well as the reliability and safety of activity, which will be mentioned hereinafter.

Flight work practice shows a clear interdependence of occupational health and flight safety (Fig. 5).

Reliability is the probability of obtaining certain results in occupational activity without health damage and saving an aircraft. The reliability of activity is the basis of flight safety.

All the above is the subject of medical accidentology.

Flight safety is the task of a functioning aviation system on preventing or countering the threat of flight accidents.

The aviation system includes people, aviation, and special equipment combined structurally and functionally for flight performance and comprehensive mission support. This system is conventionally divided into five elements: (1) the mission management team; (2) the pilot/operator; (3) the aircraft (AC); (4) the external environment; and (5) the mission support group.

The key element in each component of this system is a person with definite professional knowledge, skills and abilities, first and foremost the flight personnel.

An air medical officer is enlisted in the mission support group of the functioning aviation system and directly participates in the medical support of flights.

The medical support of flights is a system of organizational, therapeutic and preventive, physiological and hygienic, and psychological measures taken to maintain the high level of occupational health and working capacity of the flight personnel and mission support group.

Thus, the field of interest of air medicine includes occupational health, specific states of the human body under flight conditions, unusual conditions of occu-

The ratio of morbidity rate in pilots and ground persons

Disease	Ratio
Urolithiasis	6 : 1
Myocardiodystrophy and other diseases of cardiovascular system (CVS)	4 : 1
Functional diseases	4 : 1
Bradyacuasia	3.7 : 1
Vasomotor rhinitis	3.2 : 1
Degenerative and dystrophic diseases of back-bone	2.7 : 1
Immunodeficient and autoimmune diseases	2 : 1
Gastrointestinal diseases	1.5 : 1

pational activity of aircrew members, and specific occupational conditions during normal flights and particularly during in-flight emergencies.

The goal of research in air medicine is to provide reliable flight performance and flight safety, to develop measures for the maintenance of occupational health and longevity of flight personnel, and to preserve high working capacity during all kinds of flights.

The objectives of aviation medicine are as follows:

(1) Investigation of the influence of different flight factors on the human body with consideration for occupational activity; development of physiological and hygienic requirements for the life support systems of aircrafts.

Fig. 4. Schematic diagram of interrelations between structural elements of occupational health and longevity.

Fig. 5. Occupational health of a pilot and flight safety: the influence of diseases on performance efficiency.

(2) Investigation of the specificity of human activity during emergency situations and development of medical requirements for special and personnel survival equipment.

(3) Investigation of specificity of occupational activity of the crews of different types of aircrafts and different mission support groups. Development of medical guidelines for enhancing flight safety and efficiency of preparation of aircrafts, equipment, and devices with regard to the human factor.

(4) Determination of psychophysiological capacities of pilots during aircraft operation; elaboration of the medical and technical requirements for indication and signaling systems during flight and control.

(5) Investigation of the causes of flight emergencies and flight accidents associated with the state of health and disturbance of working capacity of aircrews; elaboration of medical requirements for accident risk reduction.

(6) Substantiation of medical standards and guidelines for selection and training of aircrews, mission management teams, and the personnel of mission support groups; substantiation of physiological and hygienic requirements for flight simulators.

(7) Development of the methods and medical and technical requirements for the medical facilities monitoring the health and working capacities of aircrews and mission support personnel.

The first (general) group of research methods of the air and space medicine includes physiological, clinical, electrophysiological, psychological and other methods of health control. The research methods of the second (specific) group are divided into two subgroups. The first one includes the methods used under laboratory conditions. These are the modeling of flight

factors and pilot's activity in ground-based simulators and its separate elements at control panel mock-ups, test benches and facilities. The second subgroup includes experimental studies under flight conditions in specially equipped flying test beds.

During flight experiments, the requirements for medical equipment considerably increase. It must be space-saving, reliable during the work under the influence of occupational factors (G-loads, vibrations, noises, etc.), light-weight, and providing reliable recording of medical and biological parameters by conventional methods and, if necessary, by the method of telemetry.

The principal duty of an air medical officer, i.e., health care, maintenance of occupational work capacity and prolongation of occupational longevity of flight personnel, is fulfilled through a set of measures in three main fields: medical, psychophysiological, and physiological-hygienic.

The medical field includes a set of therapeutic and preventive measures. Their pivot is organization and implementation of medical supervision. It is based on three basic principles: continuity, succession, and individual-oriented approach.

The problems of psychophysiological training are a significant field of activity of air medical officers. They go beyond the limits of theoretical investigation of the bases of air medicine and community health. This range of problems is associated with practical formation in pilots of occupationally important qualities providing higher tolerance to flight factors, physical and mental stability during flight work.

The most important element of the work of air medical officer is the sanitary and hygienic control of nutrition under ground conditions and on board the plane, recreation arrangement, and the control over observance of storage regulations for pilot's special equipment and conditions of working with toxic and technical liquids. It is also necessary to control the availability of airfield medical station and the level of its equipment with medical and technical facilities and to continuously check the food and medical packs of seat kits.

In recent years, all of these problems have been included into the global system of ergonomic provisions of the human factor in aviation (Fig. 6). It is obvious that air medical officers are engaged in the work long before the moment when pilots start to perform their daily occupational activities.

In the case of international flights, medical officers must do medical surveillance of aircrews performing flights to problem countries in respect of quarantine infections, carry out chemoprophylaxis, and control prophylactic immunization of crew members.

It should be emphasized that aviation has been gaining height and speed owing to the efforts of air physiologists and physicians.

Fig. 6. The system of ergonomic, including hygiene–sanitary, management of the models of aviation and space equipment at all stages of its “lifecycle”: TTR, tactical and technical requirements; RS, requirements specifications; ED, experimental design; ST, state testing; FDT, flight development tests; WDD, working design documents.

High-altitude, anti-G and shockproof equipment in its medical substantiation provided pilots with health, necessary level of capacity for work, and flight safety.

The results of fundamental research in air medicine enabled the flights at high altitudes and hypersonic velocities, delivered pilots from altitude and decompression sicknesses, traumatism and death because of the loss of consciousness. Over 15000 most complicated experiments with people and hundreds of thousands of experiments with animals were required to develop physiological substantiations of high-altitude equipment for high performance aircrafts. As a result, the frequency of flight accidents for the above reasons is no more than 0.2–0.5% of all accidents and crashes.

Thus, AM is a young independent scientific and practical discipline, which has its own subject, goals and objectives, and specific methods of research. Its development always advances today’s requirements, with due consideration of the prospects of aviation development. It may be confirmed by development of space medicine, which has originated within the air medicine and now ensures opportunities for long-term spaceflights.

“Aerospace medicine, as well as human reserves, has no limits, but there are scientific laws of physiology, hygiene, psychology, and medical ethics,” wrote Prof. S.A. Bugrov in 2001.

Investigation of these laws is the subject of air medicine.