MEDICAL SUPPORT OF SPACE FLIGHT

BY HUBERTUS STRUGHOLD, M.D., PH D

Medicine, at the beginning of recorded history, was essentially what we today would call "general practice." During the course of its development this basic medical profession branched out into a number of specialties, some based on different methods of treatment such as internal medicine and surgery; others, specialized with regard to the various anatomical organs and functional systems such as gynocology, neurology, cardiology, and so on; still others are related to a specific occupation and environment such as industrial medicine, tropical medicine, etc. One of the most important of these branches in the category of environmental medicine is that of aviation medicine which had its beginning some 40 years ago and - without a doubt - has considerably aided the engineers in the conquest of the air ocean with regard to safety and efficiency.

And now, with the rocket at our disposal, the conquest of space is in sight. This undertaking will require even more medical support.

The further development will be determined by the speed that will be attained.

As soon as the orbital velocity of about 18,000 mph at which the gravitational force of the earth is balanced, has been reached, we shall have the manned counterpart of the small research satellite. This phase of space flight can be called circumplanetary space flight. At still higher speed, the escape velocity of 25,000 mph will carry the vehicle into the depths of interplanetary space. This final phase is interplanetary space travel. For this remote phase we use the word travel and for this phase only.

The time table of this development of course will be determined by technology and the progress in the field of chemical and nuclear fuel. But we in the medical field must be prepared for all possibilities.

The medical problems involved in the primary stages of space flight are basically the same as in the final stages. The difference is essentially a matter of the duration of the flight.

One of the most important task in Space Medicine is the climatization of the cabin. This cabin must be - as already mentioned - a completely closed compartment, and it is required even as low as 80,000 feet. This means that the problems of space flight lie immediately at our doorstep.

The sealed cabin is a closed ecological system which must provide all the physiological necessities of a habitable climate like that found close to the ground and without resorting to the outside atmosphere. It must perform all the various vital functions that are ordinarily taken care of by the air around us at sea level or in moderate altitudes. This is, to a great extent, an engineering problem. But Space Medicine must provide engineers with the knowledge of the physiological requirements.

Under the conditions of space flight a man may consume in respiration about 0.7 kg. of oxygen per day which must be replaced in such a way that the oxygen pressure does not fall below 100 mm Hg. FIG. 2. This is about the minimum permissible limit for efficiency; it should not exceed the permissible maximum of 350 mm Hg. because oxygen concentrations above this level are toxic. The fact that we can tolerate a rather wide range in oxygen pressure (from 100 to 350 mm Hg.) facilitates the oxygen problem in space flight considerably. Whereas oxygen disappears in the process of respiration, carbon dioxide is produced and accumulated in the cabin's air. Carbon dioxide above 3 volume percent, however, is toxic. To be on the safe side, it is advisable to keep its concentration below 1 volume percent by removing the excess with absorbing chemicals. There is a natural process in our atmosphere which produces oxygen and consumes

carbon dioxide. This is photosynthesis found in green plants. Studies sponsored by the School of Aviation Medicine, Randolph Air Force Base, Texas, are presently under way, carried out by Dr. J. Myers of the Department of Zoology, University of Texas in Austin, Texas, to utilize this process for the climatization of a closed system. So far it has been found that 5 pounds of the alga chlorella pyrenoidosa can meet the respiratory requirements of one man. Primitive plants of this type appeared on our planet one and one-half billion years ago. They might have been responsible for an early build-up of an initial stock of oxygen in the oxygen free protoatmosphere. And now the same biological process may some day be used in the climatization of artificial satellites of the Earth either in the natural or in an artificial form of photosynthesis.

That the climatization of a space cabin must also include barometric pressure control, temperature, humidity, and odor control, can be mentioned only briefly.

The multitude of factors involved in the climatization of a space cabin requires a complex instrumentation for automatic control. The School of Aviation Medicine, USAF, Randolph Air Force Base, Texas, now has an experimental sealed chamber, a space cabin simulator, in which we can study the changes of the cabin's air caused by the presence

of occupants and the means to control these factors. FIG. 3. Only 4 weeks ago my coworkers, Dr. J. Gaume and Dr. E. Roth, carried out an experiment of 24-hour duration; soon we will be able to extend the time to 3 days or even weeks. This space cabin simulator, an important space medical research tool can also serve as an indoctrination chamber in handling the situation in case the automatic control fails or the cabin develops a leak.

Actually, our Earth is a giant space ship with 2.8 billion occupants, moving with an orbital velocity of 18.6 miles per second through the vacuum of interplanetary space. And its atmosphere is practically a closed ecological system too; it is sealed off by the Earth's gravitational pull which prevents the heavier vital elements from escaping into space. And what we must do if we leave this planetary mother space ship is to just simulate in the space cabin craft, all the life sustaining and life protecting processes which the earth performs for us on a gigantic scale.

There is, however, one ecological factor which can be simulated in the space cabin only with great engineering difficulties. This is the normal gravitational force of the earth. In supersonic and hypersonic flight the gravitational pull of the earth is reduced or even nullified by centrifugal forces, resulting in reduction of weight or

even weightlessness. This is perhaps the most revolutionary feature in the coming development of human flight. Intensive studies are presently carried out by Major David G. Simons at Holloman Air Force Base, New Mexico and Dr. S. Gerathewohl in Randolph Air Force Base, to study experimentally during parabolic flight maneuvers in jets, the effect of weightlessness upon orientation and general well being. It seems that a certain percent of the people can adapt themselves to the state of weightlessness. The final solution of this problem is decisive for the possibility of space flight for a longer period of time. If we cannot adapt ourselves to zerogravity then the engineer must provide for artificial gravitation, which, however, poses additional technical problems.

In conclusion I would like to say that after careful consideration of all the available experimental space medical data, all the medical problems involved in space flight appear to be not insurmountable; unless there are still factors in space completely unknown to us; this however is unlikely. This is both encouraging and challenging; but nevertheless continued effort in the field of Space Medicine must be made to meet this challenge.

In pertinent basic and applied research, special attention should be given the physics and chemistry of the

atmosphere in its entire extension and of space; the earth as a reradiating and light reflecting planetary body, communications with the earth through the ionosphere, the physical and physiological day night cycle, the principles of a balanced closed ecological system, photosynthesis, psychology under claustrological conditions, aerothermodynamics, aerochemodynamics, aeroelectrodynamics, astrodynamics, simulation of cosmic rays, simulation of meteoric hits, the anatomy and physiology of the various gravireceptors, graviperception visual orientation under weightless conditions and the nature of gravitation. These are some of the medical problems on the vertical research frontier.

HS/mbn 18 May 1956