From Aviation Medicine to Space Medicine

By H. Strughold, M.D., Ph.D.

Department of Space Medicine, USAF School of Aviation Medicine, Randolph Field, Texas

SPACE MEDICINE appears with a special program of papers, for the first time, on the public platform of a scientific society—the Aero Medical Association. For this reason, it would seem that a few introductory remarks are appropriate. It is a privilege, and indeed a source of great pleasure, that this task has been delegated to me.

Space medicine, at first glance, undoubtedly appears to many people as a capricious or whimsical idea in aviation medicine. However, upon closer examination, it proves to be a very logical step in development. When we view it from a historical standpoint, starting with the predecessors of aviation medicine, we gain a better understanding of its scope and meaning.

Aviation medicine, throughout its forty years of development, has benefited by the experiences gained in high mountain physiology. As a science, high mountain physiology is nearly one hundred years old. Mountain sickness, however, was first described by José de Acosta in 1588. The first mention of this uncomfortable effect of thin air can be traced back to Greek literature, since it was Aristotle who observed that men could not live on the top of the 10,000 foot Mount Olympus in Thessaly without breathing through a wet sponge. High mountain physiology, with all of its descendants, could very well claim as its birthplace, a holy mountain dedicated to Zeus or Jupiter.

Logically, Twentieth Century aviation medicine in its early years, was more or less concerned with the problems of cadet selection, reaction time, orientation, crashes, et cetera. The early issues of the Journal of Aviation Medicine tell this story. However, with the passing of time, interest in higher altitudes increased more and more. Experiments in low pressure chambers and explosive decompression chambers opened the way into the tropopause and stratosphere. Extreme explosive decompression experiments [1,6,9,12,18,19] and the medical evaluation of the balloon flight of the Explorer II[2] had already touched the area of space medicine. Aviation had attained a very high level in safety, efficiency, and comfort, as a result of the accomplishments of aviation medicine.[1,4,9,11,21] Only high-powered propeller planes and jet planes could still bring some progress in speed and high altitude flying.

It was in this situation that the first rocket appeared in the sky and—within five years—exceeded all altitude records by twenty times. This was not only a signal for the engineering world, but a challenge to all sciences concerned with the human factor. This

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new revolutionary development becomes quite clear when we review the records of altitudes reached—during the past 150 years—by means of the balloon, airplane, and rocket. We note that the balloon and airplane, both depending upon air, are—in a way—confined to two-dimensional movement in the horizontal plane around the globe, whereas, only the rocket has really conquered the vertical—the third dimension—moving away from the earth. Considered from a global point of view, this shift in dimensions is the most conspicuous mark in the new development of flight. A new frontier has now been opened—the "vertical" frontier.[5]

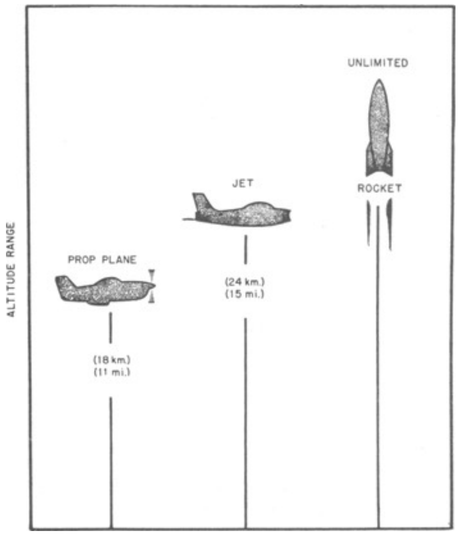

Fig. 1. The vertical extent of the operational areas of propeller, jet, and rocket craft.

Figure 1 shows the vertical extent of the operational areas of propeller, jet, and rocket craft. The ultimate limit for propeller-driven planes is about 18 km. or 60,000 feet; for jet planes, about 24 km. or 80,000 feet; and rockets are limited only by their fuel capacity. With regard to speed, propeller-driven and jet planes have attained velocities in the neighborhood of the speed of sound. Rockets have practically no limitations of speed.

The limiting factor in height and speed, for conventional planes including jets, is the atmosphere. However, in the realm of the rocket, flying is no longer dependent upon air as a supporting medium. Thus, the factors with which we must deal in rocket flight are not properties of the atmosphere, but rather attributes of free space.

For this reason, a most logical step, and a daring one too, was the creation of a new branch of aviation medicine, space medicine. In anticipation of this development, a special department, the Department of Space Medicine, was founded in 1949 by Major General Harry G. Armstrong, at that time Commandant of the USAF School of Aviation Medicine at Randolph Field, Texas. Problems concerning rocket flights were also being studied by the Aeromedical Laboratory at Wright Field about the same time.

The first open discussions in the field of space medicine were held at two earlier meetings, one called by General Armstrong in 1948 at the USAF School of Aviation Medicine, Randolph Field, Texas[3] and another organized by Dr. Andrew Ivy and Dr. John D. Marbarger in 1950 at the University of Illinois in Chicago.[20]

At the 1950 meeting of the Aero Medical Association in Chicago, the creation of a Space Medicine Branch of this organization was proposed; and at the 1951 meeting in Denver, this branch was finally established with Colonel Paul A. Campbell as its chairman. The foundation of this branch was a necessity in order that we could have a medical counterpart of the various rocket societies, space flight societies, astronautical and interplanetary societies, which are exclusively technical in nature. It must be recognized that these societies, which exist in more than half a dozen countries, have shown great activity and success during recent years. The human factor in space flight, however, is as important as the technical factor.

Today the Space Medical Branch of the Aero Medical Association offers a special program. Space medicine is no longer the diffuse area which it may have appeared to be a few years ago. The scope of its problems is now clearly defined. They have been clarified by the introduction of a new concept of the boundaries between the atmosphere and space, based on the function which the atmosphere has for man and craft.[13,23] This functional consideration demonstrates that at relatively low altitudes the various functions of the atmosphere cease, one after the other. Consequently, the various space factors take over. Such levels are properly called space equivalent altitudes (Fig. 2). In mentioning only a few of them, we meet space equivalent conditions with regard to

Anoxia at 52,000 feet;

Body fluid boiling at 65,000 feet;

Heavy primaries of cosmic radiation at 120,000 feet[22,16]

Ultraviolet solar radiation at 135,000 feet;[17]

Optical appearance of the sky at 400,000 feet;[13] and

Meteorites at 500,000 feet.[24]

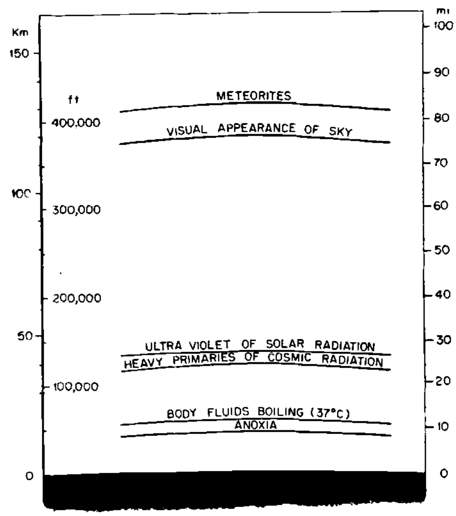

Fig. 2. Space equivalent and semi-equivalent conditions within the earth's atmosphere. (For further details see text).

It may be added that only the earth with its magnetic field, its radiation and its bulk, modifies some of these conditions, making them different from those found at greater distance. Since the bulk of earth affords protection from one-half of the cosmic radiation and meteorites, we may, in these particular cases, speak of semi-equivalent conditions of space.

Space equivalent stages within the atmosphere must be considered in regard to the necessity for sealed cabins, and also with regard to pure radiation climate above a certain altitude.[7] Further, conditions characteristic of space originate in the motion of the craft; here, weightlessness is the most outstanding phenomenon.[8,14,15] This problem was first discussed by H. Haber in a seminar at the Aeromedical Center in Heidelberg in 1946.[10]

This approach, based on a functional concept of the atmosphere, clearly indicates that a differentiation must be made between two distinct regions of the physical atmosphere: the lower section is the realm of conventional flight where the properties of the atmosphere can be utilized; the upper section, beginning as low as 50,000 feet, where the functions of the atmosphere gradually become ineffective, has many properties in common with free space. It is indeed amazing to observe that various environmental factors of space penetrate down to rather low altitudes. The usable portion of the atmosphere is a very thin shell. The so-called upper atmosphere of the physicist is equivalent to free space, for all practical purposes.

A symposium on the physics and medicine of the upper atmosphere was held in San Antonio, Texas, in November, 1951.[25] This meeting, which was organized by Brigadier General Otis O. Benson, Jr., Comandant of the USAF School of Aviation Medicine, and Dr. Clayton S. White, Director of Research of the Lovelace Foundation, must be considered an important step toward clarifying the medical problems involved in flight in the highest strata of the atmosphere, where the various benefits derived from the presence of air fall short. The problems of flight in this area are different from those encountered in free space. For this reason, the area was designated by a special term, namely, the aeropause (K. Buettner).[25] In a way, flight at present is in an amphibian stage, in a phase of transition between conventional aviation and future space flight.

The technical development clearly points to the final conquest of free space. We must be prepared to meet the necessities of this day. The field of space medicine must in time be promoted to eventually cope with the human problems which will most certainly arise.

REFERENCES

1. Armstrong, H. G.: Principles and Practices of Aviation Medicine. Baltimore: Williams and Wilkins Co., 1943.
2. Armstrong, H. G.: The medical aspects of the National Geographic Society—U. S. Army Air Corps Stratosphere Expedition of Nov. 11, 1935, J. Aviation Med., 7:55, 1936.
3. Armstrong, H. G.; Haber, H., and Strughold, H.: Aeromedical problems of space travel; J. Aviation Med., 20: 383, 1949.
4. Bauer, L. H.: Aviation Medicine. Baltimore: Williams and Wilkins Company, 1926.
5. Benson, O. O.: The Medical Problems of Flying. XIII Congress International de Medizine et de Pharmacie Militaries, Paris Tome I:227, 1951.
6. Benzinger, T.: Explosive Decompression. German Aviation Medicine, World War II, Vol. I, U. S. Government Printing Office, Washington 25, D. C.
7. Buettner, K.: Bioclimatology of manned rocket flight. Space Medicine. Ed. by J. Marbarger. Chicago: Illinois University press, 1951.
8. Campbell, P.: Orientation in space. Space Medicine, Ed. by J. Marbarger. Chicago: Illinois University Press, 1951.
9. Fulton, J. F.: Aviation Medicine in Its Preventive Aspects. London: Oxford University Press, 1948.
10. Gauer, O., and Haber, H.: Man Under Gravity-Free Conditions. German Aviation Medicine, World War II, Vol. I, U. S. Government Printing Office, Washington 25, D. C.
11. Grandpierre, R.: Elements de Medicine Aeronautique, l'expansion scientifique Francoise, Paris, 1948.
12. Gelfan, S.; Nims, L. F., and Livingston, R. B.: Explosive decompression at high altitudes, Federation Proc. 6:110 1947.

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13. Haber, H.: The human body in space, Scientific American, 184:16, 1951.
14. Haber, H., and Haber, F.: Possible methods of producing the gravity-free state for medical research, J. Aviation Med., 21:395, 1950.
15. Haber, H., and Gerathewohl, S. J.: Physics and psychophysics of weightlessness. J. Aviation Med., 22:130, 1951.
16. Hess, V., and Engster, S,: Cosmic Radiation and Its Biological Effects. New York: Fordham University Press, 1949.
17. Krebs, A. T.: Possibility of biological effects of cosmic rays in high altitudes, stratosphere and space. J. Aviation Med., 21:481, 1950.
18. Lovelace, H. R. II, and Gagge, A. J.: Aeromedical aspects of pressurization for military and commercial aircraft. Science, 13:143, 1946.
19. Luft, U. C.; Clamann, H. G., and Adler, F. F.: Alveolar cases in rapid decompression to high altitudes. Appl. Physiol., 2:37, 1949.
20. Marbarger, J. P.: Space Medicine. Urbana, Illinois: University of Illinois Press, 1951.
21. Ruff, S., and Strughold. H.: Grundriss der Luftfahrtmedizin. Verlag A. Barth, Leipzig, 1944.
22. Schaefer, J.: Evaluation of present-day knowledge of cosmic radiation at extreme altitude in terms of the hazards to health. J. Aviation Med., 21:375, 1950.
23. Strughold, H.; Haber, H.; Buettner, K., and Haber, F.: Where does space begin? J. Aviation Med., 21:349, 1951.
24. Whipple, F. L.: Meteors and the earth upper atmosphere. Rev. Modern Physics, 15:246, 1943.
25. White, S., and Benson, O. O., Jr.: Physics and Medicine of the Upper Atmosphere. Albuquerque: University of New Mexico Press, 1952.