Available online at www.sciencedirect.com
SCIENCE DIRECT®
PERGAMON
Acta Astronautica 56 (2005) 839–850
ACTA ASTRONAUTICA
www.elsevier.com/locate/actaastro

Microbiological status of cosmonauts during orbital spaceflights on Salyut and Mir orbital stations

V.K. Ilyin*

RF SRC Institute for Biomedical Problems RAS, 76a Khoroshevskoye Shosse, Moscow 123007, Russian Federation

Available online 29 March 2005

Abstract

The main feature of the human–microorganism eco-system forming in the environment of manned space vehicles is the periodic accumulation of the potential for pathogenicity. This process is characterized by the activation of opportunistic pathogens, representatives of which grow in large number within the system, settle in various niches, and demonstrate expansion, intruding into microbiocenoses of open biotopes of humans who, until contamination, have been clean of these microorganisms. Clones (similar to hospital strains) arising out of these populations exhibit the ability to spread "epidemically" within isolated teams.

1. Introduction

The 21st century was marked by the penetration of humans into secluded areas both on Earth and in the near-Earth space, as a result of intensive interaction of biosphere laws with the human mind. The exploration and utilization of both deep water environments and outer space require the immediate involvement of humans who have to face increasingly heavy emotional and physical stresses while in these environments. In addition, occupations associated with increased neuroemotional strain also tended to increase in number. These can be exemplified by the introduction and operation of new vintages, developmental testing of different items, etc. Progressive urbanization and unfavorable environments are felt keenly by the human organism, which responds by changing the homeostatic parameters; in turn, these changes cause strain to the systems controlling adaptation that steadily modify metabolic and physiological processes. Changes in metabolism due to extended exposure to extreme factors occur in the systems controlling adaptation that are specifically sensitive to a given external agent.

As the duration of space missions continues to lengthen, the problem of protecting crews aboard long-operating stations from infections becomes of paramount importance. We can anticipate a high intensity of development of nosocomial strains on the International Space Station, where full or partial rotation of crews coming from different spots of the world will be a frequent event. On the other hand,

* Corresponding author. Tel.: +7 095 1950025; fax: +7 095 1952253.
E-mail address: ilyin@imbp.ru.

0094-5765/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.actaastro.2005.01.009

there are indications of definite inhibition of colonization resistance in spacecrews on mission. This dictates the necessity to search for effective ways to strengthen the colonization resistance in spacecrews. Analysis of the data on the probiotic correction of human microflora in an artificial climate constitutes a part of this work [1].

Safety from infection in space flight is one of the major issues of the spacecrew medical support program. After many years of research, investigators in this discipline demonstrated the activation of human opportunistic pathogens during stays in pressurized modules designed for different purposes. Many authors point to the high probability of infectious diseases in the specific environment of space vehicles. It was emphasized that crew automicroflora can be an agent of infection. The distinguishing feature of these microorganisms is the ability to provoke infectious diseases under certain conditions, particularly against degraded immunologic reactivity and the unique microbiological community establishing in pressurized habitats. In these cases, the main etiologic agents of infectious diseases are human microflora and, possibly, cross-infection when an agent is imparted from a carrier to a susceptible organism. Two types of infection sources can be considered—anthropogenic and non-anthropogenic. As for the first type of infections, these are predominantly obligate and opportunistic pathogens carried by humans in a closed environment.

Investigations of human microflora before and after space flight were first attempted by Alekseeva [1]. Experimental data of this author suggested certain shifts in the composition of oral, fauces, and cutaneous microflora of the Vostok crews. The possibility of adverse shifts in spacecrew microflora was verified in numerous model studies with isolation of human volunteers in closed environments. Of much interest were data from the 18-day mission aboard the space vehicle Soyuz-9 in 1970. Results of the investigations showed that, after landing, the most profound changes leading to dysbacteriosis had occurred to the nasal and cutaneous microflora.

The review devoted to results of the US Apollo program [2] stated shifts in composition of cutaneous microflora toward prevalence of gram-positive cocci (Staphylococci and Streptococci), partial suppression of anaerobic microbes, and temporary colonization of the upper respiratory tracts by exogenous microorganisms, largely Staphylococci, due to, perhaps, microbial interchange.

Based on the literature, a list of microorganisms that may trigger infectious diseases of a cosmonaut's respiratory tract and integument can be defined. To begin with, these will be pathogenic Staphylococci, Streptococci, and representatives of the Enterobacteriaceae family; *Clostridium*, *Pseudomonas aeruginosa* and fungi will enter the list, too.

During life on a space station, the composition of the normal microflora of cosmonauts alters significantly; this results in deterioration of their body's resistance to infectious agents. Thus, in the one-year experiment with medical/engineering human subjects the intestinal bifidobacteria and lactobacilli were found to sharply decrease and then disappear, enzyme and antagonistic activities were reduced, colibacillus strains were exchanged, and some organisms exhibited increased toxicity. Microbiological findings of ground-based simulations were supported by results of investigations in real space flights. For instance, according to Taylor [2], examination of the Apollo and Skylab crews evidenced loss in anaerobic and gain in aerobic microorganisms of various types. Of particular value are data concerning isolation of opportunistic pathogenics like *Staphylococcus aureus*, *Klebsiella phneumoniae*, *P. aeruginosa*, and Enterobacteriaceae from cosmonauts. The importance of these investigations has been confirmed by recent data indicating that these are the microbes that give rise to a number of infectious diseases. In view of the above, special emphasis should be placed on the principles of chemotherapy of spacecrews afflicted with infection, and the sensitivity of bacterial cultures to antibiotics. The sensitivity to antibiotics of opportunistic pathogens isolated from crew members in 7- and 96-day space flights was noted to have changed.

In a 7-day space flight, one cosmonaut was found to have *S. aureus* with significantly strengthened resistance to antibiotics (penicillin G, ampicillin, oleandomycin, lincomycin). Minimal retaining concentrations of the drugs grew from 10 to 100 times during the flight but returned to baseline values after. In a 96-day space flight, selection of tetracycline and ampicillin resistant Staphylococci in one of the crew members was thought to be most probably associated with administration of ampicillin by a crew member and