Respiration in Space: A Warning

Cadavers with liquid-filled lungs may save the lives of astronauts on future spaceflights.

"Brain cortex, spinal cord, liver, testes, kidney, lung, muscle." This, according to Dr. Robert E. Davies, a biochemist at the University of Pennsylvania, is the list, in descending order, of sensitivity of human tissues to oxygen, at least judging by isolated tissue slices in the laboratory. Lung tissue falls near the bottom of the list. In the intact animal, however, the situation is different, Dr. Davies says; the lung is "extremely sensitive" to increases in oxygen pressure.

The lung, in fact, is extremely sensitive to a number of things, such as dust, heat and pressure. These can produce effects that are troublesome enough on earth, but in the unnatural environment of a long-term spaceflight very little is known about them except by deduction. So little absolute data is available that a panel of scientists has filled a 207-page report to the National Academy of Sciences with recommendations for research on respiration in space.

Release of the contents of the Academy's Space Sciences Board report, which will not be available generally for about two months, was triggered by the accident at Cape Kennedy on Jan. 27, in which the first three-man Apollo crew was burned to death in a pure oxygen fire during a simulated launch sequence.

Although the panel consisted primarily of physiologists, the scientists looked into the problem of cabin fires because of their relationship to the kind of artificial atmosphere astronauts would be breathing. The report was completed before the fire and is being used by the National Aeronautics and Space Administration in planning for its post-Apollo program.

The only anticipated serious effect of weightlessness on the respiratory system, according to the report, is the increased possibility that astronauts might inhale dust and other solid particles floating in the space cabin. The panel recommended studies of the expected composition and concentration of such particles, as well as of ways to remove them and instruments to measure them in space.

The lack of adequate measuring instruments, in fact, was singled out by the panel as a particularly sore point. During the conferences that led to the report, "there were frequent instances where the need for a measurement was recognized but no suitable method or instrument . . . was known to exist." Among the desired instruments were those to measure inhaled and exhaled gas volumes, changes in the volume of the lungs, solid and gaseous contaminants in the atmosphere, and capillary blood flow in the lungs.

One of the panel's most dramatic suggestions sprang from the belief that the sheer, physical strength of the lung may be the thing that limits the acceleration forces to which the human body can be subjected. To find out just how high that limit is, the panel proposed subjecting cadavers to high acceleration and measuring their lungs' "tear strength."

Coughing would become particularly important during long terms of weightlessness, the panel reported, due to increased inhalation of dust particles. "On theoretical grounds," said the report, "the air velocity with a cough would probably be greater, but the decreased density of the gas might make the cough less effective." So, said the panel, somebody should study coughing at low pressure, and if possible, at zero gravity.

Astronauts would keep track of each other's health if some of the panel's ideas are followed, including training the spacemen to use observations of the veins of the neck together with "respiratory maneuvers" as an index of blood pressure in the left atrium of each other's hearts.

To survive high acceleration forces of more than 15 times normal earth gravity, the scientists recommended study of two extreme techniques: collapsing the lungs completely, or else, for flights in the distant future, filling them with a liquid to prevent collapse of blood vessels and tissues.

Infection is another problem. "The human body is an excellent growth medium for viruses, bacteria, fungi and other microorganisms," reported panelist Dr. Joseph C. Ross, chief lung disease researcher at Indiana University Medical Center. "These may be present in nasal secretions, sputum, urine, feces, sweat and other secretions, and on the surface of the skin." Furthermore, the risk of infection increases with the size of the crew; with the "less than ideal facilities for personal hygiene" that are available in space; and with the possible "altered viability" of some microorganisms, meaning that they might actually start to thrive in the spacecraft, given a long enough time to get used to it.

Here the panel recommended not only that the spacecraft be made and kept as sterile as possible, but that the crewmen for any given mission be selected on the basis of similar immunologic patterns, even including cross-matching of blood types, and that crews be quarantined together before their flights to allow cross-immunity to develop as well as to prevent exposure to infection.

Drugs may have their own contribution to make. There are already many types that affect respiration and respiratory structures that could be studied during weightlessness on flights with primates.

A major topic of the report is the two-gas/one-gas controversy for spacecraft atmospheres. The Apollo fire and several others took place in pure oxygen. The panel firmly recommended the use of a two-gas system, despite its necessarily heavier and more complicated design, because of (1) the reduced danger of fire; (2) lessened chances of aural and pulmonary atelectasis (collapsed lung); (3) the possibility that ventilation and heat dissipation in the space cabin might require a total gas pressure greater than the ceiling recommended for oxygen pressure; and (4) a 'possible, but unproved physiological need" for at least low pressures of nitrogen.

Nitrogen, in fact, was the panel's choice over helium, but it recommended that other inert gases such as neon also be investigated. The desirability of using different concentrations of gas for different circumstances, such as prelaunch, in-flight, reentry and post-flight should also be studied, the scientists said.

They further recommended that oxygen pressure within spacecraft be the same as that of the oxygen in earth's atmosphere at sea level—about three pounds per square inch—and that even lower-than-normal pressure be investigated for emergency use in case the cabin develops leaks or the oxygen supply runs short. Still another problem may turn out to be that low-pressure oxygen offers significantly less protection for astronauts against radiation, particularly against proton radiation such as that emitted by the sun during high solar activity.