CLINICAL AEROSPACE MEDICINE IN THE 21ST CENTURY. S.R. Mohler. Wright State University, Dayton, Ohio 45411.

INTRODUCTION. Advanced non-invasive diagnostic techniques will change the usual practices for the 21st Century Flight surgeon. Cerebral and cardiovascular disease, even in the incipient stages, will be readily detectable at the time of the periodic physical examination. The same will be true for other potentially disqualifying conditions. Brief, highly sensitive and specific cognitive and psychomotor office-based testing will be accomplished at the time of examination, including the assessment of the sensory system. In the 21st century pilot population, the use of addictive substances will be virtually unknown, the result of education and screening (and rehabilitation programs when necessary). The self-destructive, suicidal addictions (including nicotine, alcohol, amphetamines, and others) will be understood as incompatible with those who elect to undertake the privilege of flight. The 21st century approach will be that of individual assessment, emphasizing (1) Freedom from an impairing disease, (2) Capacity to perform as demonstrated by objective flight and high fidelity simulator assessment, and (3) Motivation to fly. CONCLUSION. As a result of advances in medicine, aircraft design and airspace characteristics, various medical standards of the "Golden Age" 20th Century will be dropped. These include uncorrected distant vision, color vision, pure tone audiometry (the spoken voice test substituted), upper date-of-birth limits, limits on persons requiring exogenous insulin (insulin pumps will be available), and certain other conditions. The main disqualifying conditions will be in the psychiatric and attitudinal realms.

THERMAL STRESS IN AEROSPACE MEDICINE: HOT ISSUES, COLD FACTORS. Harry C. Holloway. Uniformed Services University of the Health Sciences.

The initial explorations of the planetary systems beyond the moon are likely to be undertaken in the first four decades of the 21st Century. Preparing for the social, psychological, and psychiatric problems to be faced must be initiated now if we are to adequately establish the risks which these matters pose and the counter measures to deal with those risks. Previous experience tells us that solving these problems would include analysis of complex physiologic, toxicologic, sociologic, and psychological variables that may interact within complex technological systems. This paper will emphasize the nature of the work that must be undertaken in the next two decades.

ACCELERATION PHYSIOLOGY AND COUNTERMEASURES. B.N. Kutz. KHUN Life Sciences, San Antonio, TX 78279-0644.

Methods to enhance man’s survivability in the sustained high or low G environments continue to be at the forefront of aeromedical research. Several acceleration protection research efforts are being actively pursued in programs with high visibility. A new reentry G-suit for NASA which features uniform pressure for high G environments promises to increase G-protection during shuttle reentry without the discomfort of an abdominal bladder (AB). This suit concept should also be adaptable for the National Aerospace Plane’s (NASP) reentry G-protection requirements. It is hypothesized that this novel G-levels encountered in these environments do not significantly increase hematologic and psychologic health and thus the requirement for an AB is negated but the need to prevent blood pooling in hypovolemic crewmembers is critical. The same G-protection principle used in these suits, i.e., lower body uniform pressure, is also the basis for a new advanced technology anti-G suit (ATMAG) soon to be flight-tested by the USAF. The AB is an absolute necessity in ATMAG since it is to be worn in fighter-type aircraft with high G onset rates which cause a rapid increase in heart-to-eye distance, decreased eye-level blood pressure and subsequent G-induced loss of consciousness (G-LOC). The USAF is now in the process of fielding COMBAT EDGE, an ensemble which uses positive pressure for G-protection (PBG) in combination with the current anti-G suit. PBG offers relief to tactically aircrew from the fatiguing affects of acceleration in air-to-air combat. Preliminary studies have demonstrated that PBG is even more effective when used with ATMAG.

AEROSPACE MEDICINE RESEARCH IN THE 21ST CENTURY - AIRCREW PROTECTIVE EQUIPMENT. R.M. Harding. SAF Institute of Aviation Medicine, Farnborough, Hampshire, United Kingdom.

In the 21st century, the hazards associated with flight by humans will be just as they have always been, and aircrew protective equipment will still be part of the flight medical support service. Thus, protection against pressure changes, hypoxia, accelerations, and other flight motion effects will still be needed; and research in these areas will continue to refine our already substantial body of knowledge. In this discussion paper, examples will be presented of the research needs for advanced oxygen systems (eg the innovative advanced personal protective clothing (APPC) of the National Aerospace Plane (NASP) reentry G-protection requirements), for advanced head-mounted devices (eg the relatively simple protective helmet of today could easily become a behemoth if the requirement for additional systems proceeds unchecked and uncoordinated), for advanced personal protective clothing (eg the stress protective suit of the national aerospace plane’s reentry G-protection requirements. It is hypothesized that this novel G-levels encountered in these environments do not significantly increase hematologic and psychologic health and thus the requirement for an AB is negated but the need to prevent blood pooling in hypovolemic crewmembers is critical. The same G-protection principle used in these suits, i.e., lower body uniform pressure, is also the basis for a new advanced technology anti-G suit (ATMAG) soon to be flight-tested by the USAF. The AB is an absolute necessity in ATMAG since it is to be worn in fighter-type aircraft with high G onset rates which cause a rapid increase in heart-to-eye distance, decreased eye-level blood pressure and subsequent G-induced loss of consciousness (G-LOC). The USAF is now in the process of fielding COMBAT EDGE, an ensemble which uses positive pressure for G-protection (PBG) in combination with the current anti-G suit. PBG offers relief to tactically aircrew from the fatiguing effects of acceleration in air-to-air combat. Preliminary studies have demonstrated that PBG is even more effective when used with ATMAG.


The initial explorations of the planetary systems beyond the moon are likely to be undertaken in the first four decades of the 21st Century. Preparing for the social, psychological, and psychiatric problems to be faced must be initiated now if we are to adequately establish the risks which these matters pose and the counter measures to deal with those risks. Previous experience tells us that solving these problems would include analysis of complex physiologic, toxicologic, sociologic, and psychological variables that may interact within complex technological systems. This paper will emphasize the nature of the work that must be undertaken in the next two decades.


OVERVIEW. SpaceLab Life Sciences 1 was the first Space Laboratory dedicated to life sciences research. It was launched into orbit in early June 1991 aboard the space shuttle Columbia. The data from this flight have greatly expanded our knowledge of the effects of microgravity on human physiology and biology. These studies were collected in-flight, not just pre and post. Principal goals of that mission were the measurement of rapid and semichronic (8 days) changes in the cardiovascular and respiratory systems during flight and then to measure the rate of readaptation following return to Earth. Results from the four teams involved in that research will be presented in this panel.

In addition to the cardiovascular-pulmonary research, extensive metabolic studies were conducted on the payload crew. These studies encompassed fluid, electrolyte and energy balance, renal function, histology and muscle and skeletal changes. Finally, the crew participated in several neuroendocrinological studies. Overall, the mission was an outstanding example of life sciences research and its impact on the human response to the space environment.

Introduction. Prolonged exposure to microgravity has long been suspected to cause serious cardiovascular deconditioning, but has not been adequately documented with small-volume (hemodynamic) experiments (Houston J Med, 47:365-372, 1976). Our goal was to quantify this deconditioning in subjects whose activities in space included near-daily periods of vigorous exercise (wave/wave, male) and during which steady state heart rate, blood pressure, gas exchange and cardiac output (by a rebreathing technique based on that of Farhi et al, Resp Physiol, 28:141-159, 1976) were determined. Subjects were studied in both the erect and supine positions using the average of 5-4 successive measurements. Results. Significant (P < 0.05) changes were found in the erect subjects, both at rest and exercise on the day of reentry: at rest, heart rate increased to 133% of preflight values while cardiac output dropped to 75%. Blood pressure was maintained. Calculated stroke volume decreased to 36%, while total peripheral resistance increased to 146%. These changes were also evident during exercise, although work did not cause further deterioration. Conclusions. 1) The subjects seemed able to vasocostrain sufficiently to maintain blood pressure in the face of the decreased cardiac output; 2) many changes of note, which cannot be proven now because of the limited number of subjects, may become statistically significant after the number of subjects is increased by repeating the studies on the SLS2 mission.

CARDIOVASCULAR ADAPTATION TO 0-G: RESULTS FROM SPACELAB LIFE SCIENCES ONE. R.A. Coffey*, J.C. Buckley*, L.A. Lane, R.B. Levine, D.E. Waterpaugh, C.G. Blohmeyer, University of Texas Southwestern Medical Center, Dallas, Texas 75235-9034.

A study was performed on the 0-G-1 mission (5-9 June 1981) to examine the 0-G-1 effects on microgravity with a complex set of measurements. In summary: heart rate (HR), blood pressure (systolic and diastolic), cardiac output (rebreathing), and systemic and pulmonary vascular resistance were significantly increased in 0-G as compared to 1-G. Postflight HR returned to preflight values by 7 days postflight. Postflight systolic blood pressure was increased by 30% by 5 days postflight with a return to preflight values by day 7 postflight. Cardiac output was maintained by increased stroke volume as postflight stroke volume increased by 33%. Pre- and postflight blood pressure (systolic and diastolic) were not significantly different. Significant changes were observed in all measured variables (p < 0.05). The results of this study suggest that cardiovascular adaptation may occur during spaceflight in humans.

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EFFECTS OF WEIGHTLESSNESS ON HUMAN BAROREFLEX FUNCTION. Janice M. Fritsch and Dwain L. Eckberg. NASA-JSC, Houston, Texas 77058 and VA Medical Center, Richmond, Va 23249.

Impaired cardiovascular function, characterized by orthostatic intolerance and reduced exercise capacity, is a result of post-flight baroreflex dysfunction. It has been suggested that postflight baroreflex dysfunction may contribute to cardiovascular deconditioning that is characterized by a decreased ability to maintain blood pressure in the face of decreased cardiac output. The present study was designed to quantify postflight baroreflex dysfunction by measuring the response to vasoconstriction and vasodilation in the renal and carotid circulation.

METHODS. Subjects were studied on the SPACELAB 1 mission and were on the ground for 7 days after landing. Measurements were made before, during, and after flight using a computerized analysis system that allowed the determination of baroreflex sensitivity using a variety of techniques. The methods include: 1) the response to graded changes in blood pressure; 2) the response to graded changes in heart rate; 3) the response to graded changes in muscle sympathetic nerve activity; and 4) the response to graded changes in renin release.

RESULTS. The response to graded changes in blood pressure was significantly decreased in the postflight subjects as compared to the preflight subjects. The response to graded changes in heart rate was significantly decreased in the postflight subjects as compared to the preflight subjects. The response to graded changes in muscle sympathetic nerve activity was significantly decreased in the postflight subjects as compared to the preflight subjects. The response to graded changes in renin release was significantly decreased in the postflight subjects as compared to the preflight subjects.

CONCLUSIONS. The decreased response to graded changes in blood pressure, heart rate, muscle sympathetic nerve activity, and renin release in the postflight subjects as compared to the preflight subjects suggests that postflight baroreflex dysfunction may contribute to cardiovascular deconditioning that is characterized by a decreased ability to maintain blood pressure in the face of decreased cardiac output.

LUNG FUNCTION TESTS ON SLS-1 CRESTMEMBERS. Harold J. B. Guy*, G.K. Friese, and J.A. West, Univ. of California, San Diego 92193-0931.

INTRODUCTION. A headward fluid shift and reduction of topographic gradients should alter lung function at 0-G. METHOD. We tested resting lung function on the SLS-1 crew repeatedly before, during (4 payroll crew: days 2, 4, 5, 9, 3 orbiter crew: day 4), and after flight. RESULTS AND CONCLUSIONS. CO diffusing capacities (Dlco) were measured in 6 volunteers (Males were elevated and almost constant throughout the mission (~15% pre-flight standing control), and were higher than the control values in all cases. Membrane diffusing capacities (Dm) were elevated on day 5 (~150% of the pre-flight standing values in all cases) and fell slowly but were still ~125% control on day 9. This fall was greater than that seen in head-down tilt studies. Vital capacities were only decreased on day 4 (0% control, similar to KC-135 G data). Resting lung volumes (FRC) were intermediate between standing and supine FRCs, consistent with the absence of gravitational depression and elevation of the diaphragm. Single breath N2 washout/argon bolus tests showed Phase IV rises (argon +, N2 +/-) at volumes near those seen pre-flight. Cardiogenic oscillations of N2 and CO were still ~50% of pre-flight. The slope of the N2 alveolar plateau (phase III) was reduced ~25%. Thus lung function is still far from uniform, and airways closure can still occur, at 0-G. Ongoing analyses of SLS-1, SLS-2 and -3 data will allow further definition of the sources of this inhomogeneity.

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Hyperbaric oxygen therapy is becoming a mature medical entity. As an adjunctive therapy for a variety of conditions and the primary indication for a few, HBO as a field is experiencing healthy growth. Once over-promoted and poorly substantiated, HBO is slowly beginning to establish a much-needed base of controlled clinical trials; the changing attitude recognizes that HBO is adjunctive care in most cases. The American Board of Preventive Medicine has accepted HBO as a sub-specialty of Preventive Medicine, contingent on the establishment of an HBO fellowship program. HBO can reduce by more than half the need for subsequent amputations. The use of HBO is growing at an exponential rate.

ECONOMIC AND ADMINISTRATIVE CHARACTERISTICS OF THE CLINICALLY BASED HYPERBARIC MEDICINE PROGRAM. Dick Clarke. Richland Memorial Hospital, Columbia, South Carolina.

No longer limited to regional referral centers, hyperbaric medicine facilities are now in place across the continuum of health care institutions. The increasing acceptance of hyperbaric medicine as a useful adjunctive therapeutic modality in cancer and other patients has been, in part, due to continuing clinical experience, and a requirement to reduce total health care costs. The free standing clinic concept has largely disappeared, primarily as a result of reimbursement policies. Hospitalized patients are treated in either single-attended-patient type HBO chambers filled with air instead of O2, allows the higher pressure, and has a small leak for an attendant. Hyperbaric chambers are increasing in DOD installations, with a major new Naval facility planned to supplement existing USAF and Army installations. HBO can reduce by more than half the need for subsequent amputations. The use of HBO as adjunctive therapy for osteoradionecrosis, especially of the mandible, is now accepted. Thermal burns heal faster and at considerably less cost when HBO is used adjunctively.

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ECONOMIC AND ADMINISTRATIVE CHARACTERISTICS OF THE CLINICALLY BASED HYPERBARIC MEDICINE PROGRAM.