-565-

CLINICAL AEROSPACE MEDICINE IN THE 21ST CENTURY.*S.R. Mohler. Wright State University, Dayton, Ohio 45401.

INTRODUCTION. Advanced non-invasive diagnostic techniques will characterize the tools of practice 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.

-566-

Human Space Exploration in the 21st Century: Psychosocial 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 managing these problems would include analysis of complex physiologic, toxicologic, sociological, 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.

-567-

THERMAL STRESS IN AEROSPACE MEDICINE: HOT ISSUES, COLD FACTS. S. A. Nunneley,* Armstrong Laboratory, Brooks AFB TX 78235.

Heat and cold have beset flight operations since humans first learned to fly. The challenges for today and tomorrow often relate to operational constraints and the subtle effects of thermal stress on performance. Some current concerns: 1) *Protection from climatic extremes.* Survival support for aircrew members implies using only minimal equipment or supplies, and providing them in a manner which avoids interference with normal flying operations. An example is the design of antiexposure suits which prevent immersion hypothermia while maintaining comfort in the cockpit. Possibilities include tailoring insulation to specific person-mission profiles and using variable insulation or active heating instead of bulky, conventional materials. 2) *Extension of physiological tolerance.* Moderate heat or cold may be the "last straw" for human tolerance of a multistress environment. Astronauts landing after an extended shuttle mission might have to undertake emergency egress where environmental heat exacerbates the circulatory decompensation caused by time in orbit; effective countermeasures may include in-flight exercise, plasma volume expansion before reentry, and garments designed to prevent dependent pooling. 3) *Prevention of performance effects.* Elimination of thermal stress may be required to ensure optimal performance of complex tasks and to maintain maximal tolerance for other environmental stressors such as acceleration and hypoxia. Where thermal control of the work space proves inadequate or impractical, personal conditioning may be useful. Conclusion: Elimination of thermal stress as an adverse factor in aerospace operations demands collaboration among specialists in aerospace medicine and aircraft design, as well as experts in clothing and personal conditioning, human factors and sustained operations.

-568-

ACCELERATION PHYSIOLOGY AND COUNTERMEASURES. R.W. Krutz*. KRUG 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 employs uniform pressure (UP) to the lower extremities 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 the low G levels encountered in these environments do not significantly increase heart-to-eye distance 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 (ATAGS) soon to be flight-tested by the USAF. The AB is an absolute necessity in ATAGS 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 tactical aircrews from the fatiguing effects of acceleration in air-to-air combat. Preliminary studies have demonstrated that PBG is even more effective when used with ATAGS.

-569-

AEROSPACE MEDICINE RESEARCH IN THE 21ST CENTURY - AIRCREW PROTECTIVE EQUIPMENT. R M Harding.* RAF 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 aeromedical armory. 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 aircraft of the next century will depend for their life support systems upon our understanding of more efficient on-board oxygen delivery), for advanced head-mounted devices (eg the relatively simple protective helmet of today could so easily become a behemoth if the requirement for additional systems proceeds unchecked and uncoordinated), for advanced personal protective clothing (eg the needs of pressure garments for altitude and G protection), and for advanced warning systems for disorientation and other human factor influences. But how is all this to be achieved? As human and economic resources continue to be in short supply, there will be an increasingly important place for collaborative research: no longer will it be possible, or desirable, for each laboratory to "go it" entirely alone. Standardization of research tools and methodologies will be essential, and the part played by memoranda of understanding and international bodies such as AGARD, ASCC and AsMA will be vital.

-570- N95-16769

110354

SLS-1 THE FIRST DEDICATED LIFE SCIENCES SHUTTLE FLIGHT. Robert W. Phillips, NASA Headquarters Code SB, Washington D. C. 20546.

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 as data 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 cardiopulmonary 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-cardiopulmonary research extensive metabolic studies were conducted on the payload crew. These studies encompassed fluid, electrolyte and energy balance, renal function, hematology and musculoskeletal changes. Finally, the crew participated in several neurovestibular studies. Overall, the mission was an outstanding success and has provided much new information on the lability of human response to the space environment.

-571-

EFFECTS OF NINE-DAY EXPOSURE TO MICROGRAVITY ON CARDIOPULMONARY FUNCTION. L.E. Farhi*, A.J. Olszowka, D.R. Pendergast, M.A Rokitka and B.E. Shykoff, State University of New York at Buffalo, Buffalo, NY 14214

Introduction. Prolonged exposure to microgravity has long been suspected to cause serious cardiovascular deconditioning, but has not been adequately documented, with one major exception (Buderer *et al (Aviat. Space Environ. Med.*,47:365-372, 1976). Our goal was to quantitate this deconditioning in subjects whose activities in space included near-daily periods of physical exercise on a bicycle ergometer. Methods. Three normal subjects (one female, two males) were studied repeatedly before a nine-day space mission (SLS1) and following reentry. In each case, the protocol consisted of three test periods (rest and two levels of exercise) during which steady state heart rate,blood pressure, gas exchange and cardiac output (by a rebreathing technique based on that of Farhi *et al., Respir. Physiol.*, 28:141-159,1976)) were determined. Subjects were studied in both the erect and supine positions. Each data point is the average of 4-5 successive measurements.Results. Significant ($P < .05$) 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 value, while cardiac output dropped to 75%. Blood pressure was maintained. Calculated stroke volume decreased to 56%, 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 vasoconstrict sufficiently to maintain blood pressure in the face of the decreased cardiac output; 2) many other trends, 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.

-572-

CARDIOVASCULAR ADAPTATION TO 0-G: RESULTS FROM SPACELAB LIFE SCIENCES ONE. F.A. Gaffney*, J.C. Buckey*, L.D. Lane, B.D. Levine, D.E. Watenpaugh, C.G. Blomqvist. University of Texas Southwestern Medical Center, Dallas, Texas 75235-9034.

Experiment 294 on the SLS-1 mission (5-14 June 91) examined the crew's adaptation to microgravity with a complex set of measurements including heart rate (ECG), blood pressure (Karotkoff and Finapres), cardiac output (rebreathing), leg volume, venous compliance (venous occlusion plethysmography), and cardiac dimensions (quantitative 2-dimensional echocardiography). Testing occurred inflight, and on the ground during a variety of interventions including lower body negative pressure tests, autonomic function tests using isoproterenol and phenylephrine infusions, supine and standing tests, upright maximal exercise, and a 24-hour head down tilt study. Central venous pressure, a critical parameter for quantitating the fluid shifts in microgravity, was also obtained for the first time before, during and after flight with a specially-designed fluid-filled catheter system. Results show that entry into microgravity was not associated with a detectable rise in CVP. Postflight maximal exercise was decreased on landing day, yet had returned to preflight levels by 7 days postflight. Significant degrees of orthostatic intolerance was seen postflight in all crewmembers. Excessive venous pooling did not appear to explain the observed deterioration in aerobic capacity and orthostatic intolerance. The cardiovascular changes associated with microgravity appear much more complex than previously believed.

N95- 16770

110355

-573-

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 space travel. We hypothesized that postflight baroreflex dysfunction may contribute. We studied the vagally mediated carotid baroreceptor-cardiac reflex responses of 6 astronauts before, during, and after the ten day SLS-1 mission. A series of R-wave triggered pressure and suction steps (from 40 to -65 mmHg) were delivered to a neck chamber during held expiration. Resulting R-R interval changes were plotted against carotid distending pressure (systolic - neck pressure), and curve parameters calculated. After an initial rise, the operational point declined consistently during the flight and reached a nadir on landing day, but had recovered to preflight levels by L+4. Slope and range of the response declined throughout the flight, were slightly recovered by the time measurements were made on landing day, but still were reduced on L+4. These data indicate that space flight results in a significant impairment of the carotid baroreceptor cardiac reflex response.

-574-

LUNG FUNCTION TESTS ON SLS-1 CREWMEMBERS. Harold J. B. Guy*, G.K. Prisk*, and J.B. West, Univ. of California, San Diego 92092-0931.

INTRODUCTION. A headward fluid shift and reduction of topographic gradients should alter lung function at 0-G. METHODS. We tested resting lung function on the SLS-1 crew repeatedly before, during (4 payload crew: days 2,4,5,9. 3 orbiter crew: day 4), and after flight. RESULTS AND CONCLUSIONS. CO diffusing capacities (DlCO) and pulmonary capillary blood volumes (Vc) were elevated and almost constant throughout the mission (~125% pre-flight standing control), and were higher than the control supine values. Membrane diffusing capacity (Dm) was increased, allaying any fears of interstitial pulmonary edema at 0-G, at least at rest. Cardiac stroke volumes (N2O rebreathing) were ~150% of the pre-flight standing values on flight day 2, and fell slowly but were still ~125% control on day 9. This fall was slower than that seen in head-down tilt studies. Vital capacities were only decreased on FD2 (~95% control, similar to KC-135 0-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 CO2 were still ~50% of preflight. 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 D-2 data will allow further definition of the sources of this inhomogeneity.

-575-

HYPERBARIC OXYGEN THERAPY: NO LONGER WITCHCRAFT.
R.W. Hamilton* Hamilton Research Ltd., Tarrytown, NY 10591-4138. Garrett R. Tucker. USAF Medical Center, Wright-Patterson AFB, OH 45433-5300.

Hyperbaric oxygen therapy is becoming a mature medical entity. As 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 subspecialty. HBO equipment includes large steel, air-filled, 6-atmosphere "multiplace" chambers with multiple locks, compressors, a control panel, water deluge system for fire safety, and mask breathing system, as well as smaller, 3-atm, portable acrylic plastic single-lock "monoplace" chambers filled with 100% oxygen. A new hybrid "single-attended-patient" type is filled with air instead of O_2, allows the higher pressures, and has a small lock for an attendant. Hyperbarics is increasing in DOD installations, with a major new Naval facility planned to supplement existing USAF and Army installations. Major HBO preparations were made—but fortunately were not needed—for *Desert Storm*. HBO is primary care for gas lesion diseases (decompression sickness and embolism) and certain CO poisonings, and is well accepted in gangrene. New advances focus on wound care, including convincing results in the use of HBO to reduce the need for leg amputations of diabetics; 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.

-576-

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 carefully selected patients is based upon sound mechanistic rationale, limited but 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. Hospital based hyperbaric programs are evenly divided as either divisions of existing departments (most commonly Respiratory, Emergency, and Surgical services) or full fledged departments. There are advantages to each, but, the successful program is unlikely to be limited to professional case management by a single specialty group. Many early programs relied upon physicians with experience in undersea and aviation medicine. Now, clinical hyperbaric training programs and many surgical and primary care specialties are being developed. Chamber operations are undertaken by nurses, respiratory therapists and specifically trained technicians. A recent certification program has introduced minimum standards of training for the "Hyperbaric Technologist." HBO capital requirements are based upon a careful institutional analysis of clinical and financial factors. Referral expectations, present and potential competition, and payor class can be matched to a variety of delivery systems and their respective operating costs. The choice of a monopatient vs. multipatient approach is dictated more by economics than clinical case management; new equipment developments allow critically ill patients to be treated effectively in single place chambers.