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BLOOD SUBSTITUTION AND PROFOUND HYPOTHERMIA: EXTENDING THE SAFE LIMITS OF CARDIAC ARREST. J.E. BAILES, A.M. Elrifai, M.L. Leavitt, S.R. Shih, E. Teeple, M.J. Taylor and J.C. Maroon. Allegheny General Hospital, Pittsburgh, PA 15212.

INTRODUCTION. The use of hypothermia as a metabolic suppressant has been widely accepted. However, limitations of its surgical applications to a safe period of one hr. have restricted the widespread use of this technique. To determine if it is possible to extend the duration and depth of hypothermic procedures, a novel technique was developed and applied in conjunction with complete blood substitution, using an aqueous blood substitute in a dog model. METHODS. Nineteen adult mongrel dogs were anesthetized and cannulated for extracorporeal pump oxygenation. As temp. was lowered, they were exsanguinated and blood substituted lowering the hematocrit to 1%. After 2½-3 hrs. of cardiac arrest and continuous perfusion at a nadir temp. of 1.3° or 7.3°C, rewarming began. When temp. reached 10°C, the perfusate was drained and the animals were autotransfused. The heart started at 19°C and spontaneous respiration resumed at 29°C. RESULTS. Two animals died intra-op. as a result of technical errors, three animals died at 1-4 days of cardiac & pulmonary sequelae, or due to edema. Fourteen animals survived long term. Results indicated that motor behavior, hematological and biochemical parameters showed a faster return to normal in animals exposed to nadir of 7.3°C. CONCLUSION. The time constraints of hypothermic procedures could possibly be extended to 3-4 hrs. without significant ischemic injury. This technique may open new avenues for therapeutic intervention through prolonged suppression of cerebral metabolic activity.

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A NEW MODEL FOR ESTIMATING TOTAL BODY WATER FROM BIOELECTRICAL RESISTANCE *S.F. Siconolfi, and *#K.T. Kear. NASA Johnson Space Center, #KRUG Life Sciences, Inc., Houston, TX 77058

INTRODUCTION Estimation of total body water (T) from bioelectrical resistance (R) is commonly done by stepwise regression models with height squared over R, (H^2/R), age, sex, and weight (W). Polynomials of H^2/R have not been included in these models. We examined the validity of a model with third order polynomials and W. METHODS T was measured with oxygen-18 labeled water in 27 subjects. R at 50 kHz was obtained from electrodes placed on the hand and foot while subjects were in the supine position. A stepwise regression equation was developed with 13 subjects (age, 31.5±6.2 yrs; T, 38.2±6.6 L; W, 65.2±12.0 kg). Correlations, standard error of estimates and mean differences were computed between T and estimated Ts from the new (N) model and those by Lukaski and Bolnochuk [1988] (LB) and Kushner and Schoeller [1986] (KS). Evaluations were completed with the remaining 14 subjects (age, 32.4±6.3 yrs; T, 40.3±8.0 L; W, 70.2±12.3 kg) and two of its subgroups (high and low T). RESULTS The regression equation developed from the model model is

$N = 85.574-(3.911*H^2/R)+(0.076*(H^2/R)^2)-(4.274e\text{-}4*(H^2/R)^3)+(0.113*W)$.

Correlations for all estimates were significant ($p<0.05$). The only significant mean difference was between T and LB. The results are shown below.

	All Subject (n=14)		High T (n=7)		Low T (n=7)	
	r (±SEE)	T(±SD)	r (±SEE)	T(±SD)	r (±SEE)	T(±SD)
N	.98(1.8)	39.4(7.6)	.87(2.4)	46.0(4.2)	.91(0.9)	32.7(1.6)
KS	.98(1.7)	40.7(8.1)	.93(1.8)	47.8(4.4)	.67(1.7)	33.6(1.9)
LB	.98(1.8)	33.6(7.1)	.93(1.8)	39.7(4.0)	.69(1.7)	27.4(2.3)
T		40.3(8.0)		47.2(5.0)		33.5(2.3)

CONCLUSION Third order polynomials in regression models may increase the accuracy of estimating total body water. Evaluating the model with a larger population is needed.

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INDIRECT MEASUREMENT OF EYE-LEVEL BLOOD PRESSURE (BP) DURING +Gz LOADING USING OSCILLOMETRIC METHOD. C. MIZUMOTO*[1], K. SHIMIZU[1], A. NAKAMURA[1], S. YAGURA[1], H. KOBAYASHI[2], H. SHIMAZU[2] and H. ITO[2], 1. Aeromedical Laboratory, JASDF. Sakae-cho, Tachikawa-shi, Tokyo, 190, JAPAN. 2. Dept. of Physiol., Kyorin Univ., Shinkawa, Mitaka-shi, Tokyo, 181, JAPAN.

INTRODUCTION. A new BP monitoring device of the volume oscillometric method (VOM) was developed to measure eye-level BP during G load. We applied this device to the black out monitoring system (BOMS) during HSG. METHODS. The device consisted of electro photosensor for the detection of the volume pulsation of superficial temporal artery and disk shaped rubber cuff mounted in a head band which press the artery. From the oscillation curve of pulse wave and cuff pressure applied to the artery, systolic and mean arterial pressures were recorded and calculated. The subjects equipped with the device were exposed to Gz acceleration (2, 3, 4, 5G for 20sec with GOR, 0.1G/sec). For the black out monitor, pulse wave from artery under constant cuff pressure (20-40mmHg) was continuously recorded and correlation between the disappearance of the arterial pulsation and occurance of occular symptoms (grey out and black out) was examined. RESULTS. During low level of G loads (2-3 G with GOR), eye-level BP maintained normal and constant level. Upon the exposure to 4 to 5 Gz, BP showed sharp decrease with marked fluctuations. The disappearance of the arterial pulsation well corresponded to the occurance of occular symptoms. Results suggested a possibility of non-invasive monitoring of BP by VOM even during the HSG and an applicability of the new device to BOMS of advanced fighter aircraft.

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STUDIES ON RESPIRATORY SENSATION FOR DEFINING ACCEPTABLE LEVELS OF ADDED RESISTANCE FROM RESPIRATORY APPARATUS. Li Fan Zhang. Dept. Aerospace Physiology, Fourth Military Medical University, Xi'an, 710032, P.R.China.

INTRODUCTION. The aim was to carry on a more systematic study of the sensory magnitude and its relationship with various kinds of added resistance, particularly the combined loads with different inspiratory vs. expiratory load ratios. METHODS. A new kind of category scale, the Multistage Evaluation Scale(MES) based on a fuzzy set category judgement model was used to assess the magnitude of respiratory sensation. The equivalent respiratory sensation contours of 2, 3, and 4 JND (Just Noticeable Difference) steps above basal level, respectively, were determined under rest as well as physical activity of light to moderate degree. RESULTS. When the intensity of the total added resistance was kept constant, the perceived magnitudes assessed by MES were dependent upon the phase of the breathing cycle loaded. The psychophysical function obtained with MES could be expressed as a power function. The equivalent sensation contours drawn by quadratic polynomial approximation of experimental data were closely related to the intensity of total load added, inspiratory vs. expiratory load ratio, and degree of physical activity. CONCLUSION. A new way to predict the psycho-physiological effect of various combined respiratory resistive loads has been proposed. The results obtained are of practical significance in defining the permissible levels of added resistance of protective respiratory equipment.

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HEMODYNAMIC CHARACTERISTICS OF Q-G MANEUVER. Hong-zhang Guo*, Shu-yu Cao, Shu-xia Zhang, Bai-sheng Jing. Institute of Aviation Medicine, Beijing 100036 China.

INTRODUCTION. The hemodynamic indices were monitored during performing the Q-G and the L-1 maneuvers for tackling the mechanism of blood pressure rise in the former. METHODS. 8 young men trained for the two maneuvers served as subjects. Beside blood pressure taken with sphygmomanometer, radial pulse wave was recorded and analysed with a calibrated, computerized radial pulse wave form analyser (CVD-1). Therefrom 36 hemodynamic parameters were derived mathematically. RESULTS.(1) Mean arterial pressure was raised 67.2~74.3% above restinglevel; (2) myocardial O2 cosumption and cardiacwork per unit time, increased by about 1.5 times; ventricular pump force, 60.5%;(3) stroke volume, left atrial max. volume and left ventricular end-diastolic volume increased by 2.4, 0.9 and 2.1% respectively; cardiac output (CO), 56.9%, circulating blood volume (CBV), 173.7%; (4) coronary impedance dropped markedly; peripheral impedance (PI) increased by 99.4%; (5) circulating blood half renewal time and mean stagnation time increased by 100%. The responses to the Q-G and L-1 maneuvers, though not totally uniform, were not significantly different from each other except one parameter. CONCLUSIONS. Hemodynamic changes occuring during performing the Q-G and the L-1 maneuvers match with each other. The increase of HR, CO, Pland CBV indicate and explain the rise of blood pressure and these parameters are of help for further investigation on the mechanism of blood pressure rising in Q-G maneuver.

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USE OF THE HOLTER MONITOR DURING FLYING OPERATIONS. R. D. Banks*, G. Gray*. Canadian Forces, CFB Moose Jaw, Bushell Park, Sask, Canada SOH ONO.

INTRODUCTION. Centrifuge cardiac evaluation of aircrew is limited to the +G environment and only partially simulates the physical stressors of the operational cockpit. This study evaluated the use of the Holter monitor as an assessment tool during actual flying operations. A secondary aim involved a comparison study of heart rate in pilots and students under various flight conditions. METHODS. A single blind study matched a group of student pilots with a group of pilot instructors for age, seated height, resting pulse and blood pressure. A total of 15 subjects were placed on the Holter monitor and flew identical missions involving timed maneuvers ranging from -1G to +5G. Technical problems involving use of equipment were identified and solved as they occurred. Quality of tracings was assessed and heart rates during flight maneuvers identified. Comparison was made of heart rates between groups during each maneuver. RESULTS. All technical problems were solved. All tracings were readable and of high quality. Heart rates varied with G-loading as expected, although notable differences occurred between the groups. Heart rates were higher in student pilots at -1G, and higher in instructors at +5G. Students demonstrated lower heart rates when in control of the aircraft. CONCLUSION. The Holter monitor is an effective assessment tool when used in the operational cockpit. Differences in cardiac performance noted during this study are reflective of differences in training and experience.

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EFFECTS OF POSITIVE ACCELERATION ON ATRIAL NATRIURETIC PEPTIDE(ANP), PLASMA RENIN ACTIVITY(PRA) IN HUMAN. J.K. PARK*, Y.M. PARK, SEUL, B.O. PARK*, K.W. CHO. Aeromedical Training Center, Cheongweon, Chungbuk, and Chonbuk National University, Chonju, Korea.

INTRODUCTION. Especially the cardiovascular systems are affected by positive radial acceleration. On accelerated gravity, increase in the levels of stress hormone occurred and secretion of renin from the kidney depends on the blood flow through the glomerulus. ANP released from the atrium and has natriuretic and diuretic effects. The secretion of ANP usually depends on changes of intracardiac volume. The study was done to investigate the changes of secretion of ANP and PRA under the positive acceleration in human. METHODS. The subjects included 14 students of Korean Air Force Academy and 7 pilots. The centrifuge profile was a +6Gz for 30 secs. Blood sampling were performed before and after exposure to accelerated gravity. Measurements of ANP and PRA levels were analysized by radioimmunoassay. RESULTS. Mean levels of PRA increased from 2.23ngAl/ml/h to 4.80($p<0.01$) in students and 2.92 to 4.65($p<0.01$) in pilots after exposure. ANP decreased from 38.2pg/ml to 18.6($p<0.01$) in students and 91.0 to 24.2($p<0.01$) in pilots after exposure. CONCLUSIONS. Positive acceleration causes an abrupt decrease in the circulating blood volume to the vital organs. Diminution of circulating blood volume to the heart and kidney occurred on positive acceleration in human. These results suggests that renin released from the kidney protect the hypovolemic conditions and decreased ANP release from the atrium diminishes natriuresis and diuresis.

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GENDER-BASED CARDIOVASCULAR RESPONSES TO THE VALSALVA MANEUVER. D.D. White* and R.W. Gotshall*. Colorado State University, Exercise & Sport Science and Physiology, Ft. Collins, CO 80523.

INTRODUCTION. Previous studies in this laboratory have shown a gender difference in the cardiovascular (CV) response to standing. Men routinely have demonstrated elevated blood pressure (BP) responses to the stand test, whereas, women maintained BP relative to values when supine. To examine possible gender differences in autonomic and baroreflex function, the CV responses to the Valsalva maneuver (VM) were evaluated in men and women. METHODS. This study continuously measured heart rate (HR), cardiac output (CO), stroke volume (SV), blood pressure (BP), and peripheral resistance (PR) noninvasively throughout the VM. 10 men and 10 women performed the VM (maintained 40 mmHg intrathoracic pressure for 15 sec of straining) while standing. HR, CO, and SV (impedance cardiography), BP (Finapress™ BP monitor), and PR were continuously measured throughout the maneuver. The responses were expressed as changes from prestraining values. RESULTS. By the end of the straining maneuver, men had elevated BP, while women had BP values similar to prestraining (PVM). HR response was not different for the sexes. At the end of the strain, CO reductions were greater in women than men, while increases in PR were similar for men and women. CONCLUSIONS. These results show, by the end of the VM, women maintain BP close to PVM values and men have a hypertensive response. Similar to orthostatic stress, women maintained BP and men overcompensated elevating BP above normal during the CV challenge. Because BP control in women was different from men, women and men should be studied as separate groups when evaluating CV function. This is an important consideration when investigating the effects of microgravity or +Gz on the CV system in women and men.

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SPECTRAL COMPONENTS OF HUMAN CARDIOVASCULAR RESPONSES TO STEP CHANGES IN LOWER BODY NEGATIVE PRESSURE (LBNP) BEFORE AND AFTER 22 HR OF 6° HEAD DOWN BED REST.

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Changes in autonomic outflow to peripheral organs during the development of bedrest induced, orthostatic intolerance have not been determined. Recent studies have indicated that spectral analysis provides an indirect assessment of these changes. Eight male subjects were studied before and after 22 hours of 6° head down bedrest plus Lasix (40 mg, P.O.). Cardiovascular spectra (using an autoregressive technique) were determined for heart rate (HR, ECG), arterial pressure (AP, Finapres), radial artery flow (RF, Hokansen) and respiration rate (RR, BoMed). Spectra were obtained from 2.5 minute segments during control, LBNP (-10, -20, -30, -40, -50 mmHg) and recovery. Bedrest increased HR spectral power in the low frequency (.001 to .041 Hz) range, increased RF power in the low and mid (.04 to .18 Hz) frequency range and increased AP power in the high frequency (.18 to .50 Hz) range. Increasing levels of LBNP decreased HR power and increased RF power in the high frequency range and decreased AP power in the low frequency range. Since spectral power of HR in the high frequency range has been shown to indicate parasympathetically mediated regulation and power in the low and mid frequency ranges indicate a sympathetic / parasympathetic mixture, then both bedrest and LBNP appeared to shift sympathetic / parasympathetic balance toward sympathetic regulation of HR. The interpretation of the spectral content of AP and RF with respect to their autonomic origins remains unclear. Supported by NASA NAG9 298.

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CHRONIC CATECHOLAMINE ADMINISTRATION INDUCES DOSE DEPENDENT CHANGES IN SKELETAL MUSCLE MYOSIN ISOZYMES AND FIBER TYPES DURING HINDLIMB SUSPENSION. B. Girten*, A.J. Merola, W.M. Sherman, G. Wimer, R. Tuttle. Wright State University School of Medicine, Dayton, OH, Ohio State University, Columbus, OH and Gensia Pharmaceuticals, San Diego, CA.

INTRODUCTION. Several dosages of GP-2-128 (GP-2), a new and very potent synthetic catecholamine, were tested to determine the minimum effective dose capable of significantly altering skeletal muscle myosin isozymes and fiber types. METHODS. Adult male Sprague-Dawley rats (n=56) were randomly assigned to one of seven treatment groups. Rats assigned to the control (CON) group were not suspended and received saline injections. All other rats were suspended using the Morey-Holton tail suspension method and were given injections of either saline (SAL) or one of five dosages of GP-2 (.02, .04, .06, .08, .10 ug/kg). Each animal received two intraperitoneal injections per day, given approximately one hour apart, for 12 of the 14 days. Fiber types of the soleus (SOL) and gastrocnemius (GAST) muscles and myosin isoenzyme profiles of the GAST were determined by histochemical techniques and by gel electrophoresis, respectively. RESULTS. ANOVA and Tukey's post hoc tests ($p<0.05$) indicated a significantly lower percent slow twitch fibers (% ST FIB) in the suspended SAL (SUS/SAL) vs SAL/CON. This change was effectively attenuated by all concentrations of GP-2. Although there were no significant group differences in % ST FIB in the GAST, the % of slow myosin 1 (% SM1) in the GAST of the SUS/.10 group did indicate that the .10 ug/kg dose was effective in supressing the suspension induced decrease in the % SM1 while the other doses were not. Despite some differences in group comparisons between % ST FIB and % SM1 in the GAST, there was a significant correlation between these two measures (r=.63). CONCLUSION. Overall, the data indicated that incremental increases in GP-2 resulted in graded dose response increases in % ST FIB and % SM1 and greater attenuation of detrimental skeletal muscle changes produced by conditions which simulated weightlessness in rats.

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EFFECTS OF 3 WEEKS CENTRIFUGAL ACCELERATION IN RATS.

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INTRODUCTION This study was performed to clarify the effects of gravity on physiological parameters in rats exposed to 3 weeks centrifugal accelerations. **METHODS** The Wistar rats were exposed to either 1G, 1.6G and 3G (n=4 each) continuously for 3weeks. To provide hypergravity, a centrifuge having an arm radius of 1.3m was used. **RESULTS** During this period, daily changes in body weight, urine volume, food intake, water intake and urinary excretion of catecholamine were measured. In addition, water balance was determined by urine volume and water intake. Body weights in groups 1.6G and 3G decreased by 7% on the 2nd day and by 14% on the 5th day, respectively. They, however, recovered to the pre-exposure control level by the end of the experiment. Food intakes in groups 1.6G and 3G decreased by 68% and 78% on the 1st day, respectively, and recovered to the pre-exposure level on the 12th day. Thereafter, they remained unchanged. Water intakes in groups 1.6G and 3G decreased by 62% and 98% on the 1st day, respectively, and returned to the pre-exposure level on the 3rd day. **CONCLUSION** It is suggested that body weight and daily intake of food and water decrease in response to acute exposure to hypergravity and that the rate of decrease is influenced by the intensity of gravity.

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EFFICIENCY OF CONTINUOUS BLOOD PRESSURE MONITORING DURING LBNP TEST. S.Yumikura*[1], C.Sekiguchi*[1], A.Miyamoto*[1], K.Enomoto[2], R.Maru[2], N.Yamaguchi[2], and K.Yajima*[2]. 1) NASDA, 2) Nihon University School of Med. Tokyo, Japan

PURPOSE and METHOD: To evaluate the efficiency of continuous blood pressure (BP) monitoring during the LBNP test, the continuous BP monitoring system (FInapress) was used during 30 mmHg LBNP tests. The cases of presyncopal episodes induced by LBNP (n=6) were then analyzed and compared with the intermittent (1-minute interval) hemodynamic impedance cardiography monitoring and 2-minute interval BP monitoring. RESULTS: Neither 1-minute interval impedance cardiography (EDVI, HR, SVI, and CI) nor 2-minute interval BP monitoring could indicate the immediate hemodynamic response during the presyncopal episode. However, continuous BP monitoring showed a remarkable decrease of BP and HR during the presyncopal episode. The average duration from the beginning of BP decrease to the LBNP termination was 39.5 sec. Δdecreases in systolic BP and HR were 43 mmHg, and 27.8 bpm respectively. Since the fall of BP and HR occurred within a minute in most cases, even the 1-minute interval hemodynamic monitoring does not provide sufficient safety during LBNP tests. Continuous (beat-by-beat) BP monitoring is necessary.