approaches and to explore eventually adapting cerebral mechanisms that may arise from training.

Learning Objectives

1. The participant will be able to understand how repeated exposures to bouts of training may influence adaptations on cerebral mechanisms in high-performance pilots by affecting variations of intracranial pressure.
2. The participant will be able to develop and promote therapeutic strategies in pathologies specific related to the performance of high-performance pilots.

Wednesday, 09/01/2021 ***4:00 PM***
Grand Ballroom

[S-59]: PANEL: THE 12TH ANNUAL RAM BOWL

Sponsored by American Society of Aerospace Medicine Specialists

Chair: Allen Parmet
Co-Chairs: Jan Stepanek, Rebecca Blue

[316] THE 12TH ANNUAL RAM BOWL

Allen Parmet[1], Rebecca Blue[2], Jan Stepanek[2], Robert Johnson[3], Roy Allen Hoffman[4]
[1]Universtiy of Southern California, Kansas City, MO, USA; [2]Mayo Clinic, Scottsdale, AZ, USA; [3]University of Texas Medical Branch, Galveston, TX, USA; [4]US Navy, Falls Church, VA, USA

(Education - Program / Process Review)

PANEL OVERVIEW: *The12th Annual RAM Bowl features teams from the Air Force, Navy, Army, Mayo Clinic, Wright State, University of Texas and an International team competing for the Louis H. Bauer Trophy. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field. Multiple tools are available for developing appropriate didactic knowledge in aerospace medicine, public health, epidemiology, biostatistics and health care management. Teams compete in a college bowl format that tests aerospace medicine competencies including the flight environment (atmosphere, radiation, vibration, acceleration, and microgravity), clinical aerospace medicine, aircraft and space vehicle systems/operations, accident investigation, historical events, aerospace physiology, human factors, ergonomics, medical standards, Federal Aviation Administration regulations, passenger transport, restraint and escape, cockpit resource management and Aeromedical transportation. Questions are divided into toss-up questions and bonus questions. Multiple rounds of competition will lead to the selection of this year's victor and awarding of the Louis H. Bauer Trophy, sponsored by the American Society of Aerospace Medicine Specialists.*

Learning Objectives

1. The contest will enable participants to prepare for ABPM examinations in Aerospace Medicine.
2. Attendees will receive an intense review of Aerospace and Preventive Medicine.

THURSDAY, SEPTEMBER 2, 2021

Thursday, 09/02/2021 ***8:15 AM***
Grand Ballroom

55TH ANNUAL HARRY G. ARMSTRONG LECTURE
Serena Aunon-Chancellor

The Future of Science in Low Earth Orbit

Thursday, 09/02/2021 ***9:30 AM***
Governor's Square 12

[S-60]: POSTER: SAFETY & ENVIRONMENTAL MEDICINE

Chair: Ernest Prochazka
Co-Chair: Jaime Harvey

[317] ALUMINIUM CONTENT IN `CREW MEALS´

Roland Nowak[1], Michael Kempf[1]
[1]Dt. Lufthansa AG, Frankfurt am Main, Germany

(Original Research)

INTRODUCTION: The aluminum contents in crew meals have been measured and compared with existing data to estimate and evaluate the uptake of aluminum by crew members. Results were also compared to existing official data on common aluminum contents of typical foods in Germany. **METHODS:** Lufthansa Crew Meals are produced by the Lufthansa Service Company. The Meals are packed hot into sealed aluminum boxes right after been cooked and subsequently cooled at least 39 degrees F, the so called `Cook&Chill´ Process. The food packages are the handled entirely in a cold chain until the food trays are reheated in the stove on board the plane. All meals tested were heated to 338°F for 25 minutes after the above mentioned `Cook&Chill´ process. Values reported, represent total aluminum content composed of the natural content in the food plus the potential migration from the aluminum trays. **RESULTS:** Extensive tests at an accredited food safety laboratory reported total aluminum contents of between 2 and 5 mg/kg in most of the meals. The calculated incorporation of aluminum per person per week is about 9 mg, based on a typical `Crew Meal´ of 500 g and a typical 3,5 days per week on board a plane. **DISCUSSION:** In 2013, the European Council recommended a maximum of 5 mg/kg of aluminum in food, based on the principial that this should be reasonably achievable (ALARA-Principle). However, so far no medical reasons have been established for such a limit. The tolerable weekly ingestion (TWI) recommended by the European Food Authority (EFSA) is 1 mg per kg body weight. `Crew Meals´ contribute on average approximately only 13% of the tolerable dose of aluminum ingestion per week as recommended by EFSA (Tolerable maximum 70 mg for a person of 70 kg weight per week). The migration of aluminum, from the trays into the food during the `Cook&Chill´ process, is estimated to by fairly low based on standard food science. During chilled distribution virtually no aluminum migration from the trays into the food is expected. Limiting the re-heating process and avoiding longer warm holding periods is expected to further reduce aluminum migration into the food. However, the extend of aluminum migration into the food can differ by food types. In particular, foods high in natural acids seem to leach out more aluminum during the heating process. Bioavailability of aluminum is very low due to the fact that less than 1 percent of aluminum passing the gut is absorbed into the body.

Learning Objectives

1. The aluminum content of meals produced in Germany is low. It varies with the natural acids in the food.
2. The `Cook & Chill´ process does not cause a significant migration of Aluminum from the tray into the food.
3. Heating of `Crew Meals´ in the stove on board for 30 minutes is save.

[318] SUPPLY WITH VITAMIN D OF PILOTS AND AVIATION PERSONNEL OF THE GERMAN ARMED FORCES. FIRST RESULTS.

Torsten Pippig[1]
[1]Centre of Aerospace Medicine of German Air Force, Fuerstenfeldbruck, Germany

(Original Research)

INTRODUCTION: The main source for vitamin D3 in humans is the own synthesis in the upper layers of the skin with sunlight (80–90 %). Around 10–20 % of vitamin D3 needs are covered by nutrition. 25-OH-VitD is the storage form of the vitamin D3 in the serum. A level, of at least 30 ng/ml is considered sufficient. **METHODS:** In this study, the vitamin D3 values in serum of 2176 subjects (license required-personnel of the Bundeswehr) are evaluated during the investigation

period from 01 December 2017 until 30 November 2018. Moreover were considered age, gender, place of employment, body mass index, uric acid, C reactive protein and clinical data (bone diseases, bone fractures) in relation to the vitamin D level of the subjects. **RESULTS:** A total of 71.6 % of all subjects (N = 1557) had a decreased level of vitamin D3, less when 30 ng/ml. Vitamin D3 deficiency (< 20 ng/ml) was found in 25.8 % (N = 648) of the „healthy" subjects. In this study age, gender, body mass index (BMI), uric acid (HSR), C reactive protein (CRP), and place of employment- as well place of residence (postal code regions) in Germany were unrelated to the vitamin D3 deficiency. The known seasonal and monthly variations, depending on the hours of sunshine per month, were confirmed in this study. **CONCLUSION:** When interpreting the data, it should be noted that these are snapshots (point prevalence) of the vitamin D status, as the vitamin was measured only once each during the study per person. With the available data, it is therefore not possible to conclude a long-lasting deficiency. For this reason, in the following studies, the subjects with a low vitamin D deficiency will be further investigated over the course of the year, with further laboratory parameters and clinical symptoms.Because vitamin D is also involved in other metabolic processes, involved in the control of genes and the formation of proteins, this vitamin might have an important role in the prevention of chronic diseases.

Learning Objectives

1. Vitamin D deficiency. Normal and pathological levels. Source. VitD level during the year.
2. Vitamin D might have an important role in the prevention of chronic diseases.

[319] SIMULATOR-BASED ASSESSMENT OF USABILITY OF NEW FLIGHT REFERENCE CARDS FOR EMERGENCY PROCEDURES

Jason Boggs[1], Carmelo Morabito[1], Claire Goldie[1], Kathryn Feltman[1], Christopher O'Brian[1], Jerry Murphy[1]
[1]US Army Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Original Research)

INTRODUCTION: The U.S. Army Aeromedical Research Laboratory implemented a test plan in coordination with U.S. Army Aviation Center of Excellence, Directorate of Evaluation and Standardization, Aviation Missile Command, Systems Readiness Directorate, and Aviation Flight Test Directorate. The purpose was to assess novel Flight Reference Cards (FRCs) for Army aircrew that were developed to support the updated approach to Emergency Procedures (EPs). A human factors evaluation was completed to assess the FRCs during EPs across five simulator airframes. **METHODS:** Phase 1 evaluated the human factors elements of the FRCs for each airframe with Standardization and Maintenance Examiner pilots. Phase 2 compared the FRCs to the current checklist on the human factor elements of interest with minimally experienced pilots. Phase 1: Six experienced aviators performed a series of flights in a simulator where they were evaluated in their handling of a sample of EPs using the FRCs. The utility of the FRCs was evaluated (usability, legibility, clarity, ability to maintain appropriate levels of crew coordination, and impacts on pilot workload) in each of the following simulators: CH-47F, UH-60M, UH-60 A/L, AH-64D, and AH64E. All participating pilots received training in the emergency response method (ERM) and familiarized themselves with the layout and content of the FRCs. Phase 2: Nine minimally experienced pilots were selected to participate to capture the effectiveness of the FRCs for the general aviator. Phase two used the same procedures as described in phase one with the addition of using the Green Book checklist. Pilots performed separate EPs using both the current checklist and FRC. **RESULTS:** The key findings suggest the FRCs are easy to use, promote crew coordination and teamwork, and facilitate fault diagnosis and EP management, in line with the ERM. The FRCs did not negatively impact pilot workload or safe handling of the aircraft during an EP. The layout of the FRCs is intuitive and superior to the Green Book Checklist, evident by the reduced times taken to locate the correct EP cards for the given scenarios. **CONCLUSION:** A preliminary evaluation of the new FRCs suggests that the FRCs are more usable than the current Green Book Checklist and do not present any significant human factors issues. The FRCs facilitated more teamwork, communication, problem solving and decision making than the Green Book Checklist, and better supported EP management.

Learning Objectives

1. Determine that the use of FRCs does not significantly increase workload.
2. Identification of any effects on safe control of the aircraft or maintenance of effective crew coordination produced by use of the FRCs.
3. Identification of any technical/procedural errors produced by use of the FRCs.

[320] COMPARATIVE EVALUATION OF THREE PULSE OXIMETRY SYSTEMS UNDER SIMULTANEOUS HYPOXIC EXPOSURE

Stephanie Warner[1], Dain Horning[1], Katherine McEwen[1], Samantha Keller[1], Jesse Leiffer[1]
[1]Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: The Department of Defense (DoD) is currently developing pulse oximetry systems for commercial use in alternative environments. The TheraTactics Enhanced Pulse Oximeter (TT-EPO), Holistic Modular Aircrew Physiologic Status (HMAPS) Monitoring System, and Standalone Performance Yielding Deliberate Risk (SPYDR) are in various stages of technology readiness level (TRL) and are competing for similar applications across the DoD. A comparative arterial blood gas verification test was completed for these three systems under simultaneous hypoxic exposure. **METHODS:** Twelve subjects were recruited. The protocol followed Food & Drug Administration (FDA) guidelines for validation of commercial pulse oximetry equipment. A radial arterial catheter was placed in the wrist of each subject to measure oxyhemoglobin saturation (SpO_2). Subjects were outfitted with the HMAPS, TT-EPO, and SPYDR systems. Subjects had two control blood samples taken, hypoxia was induced, and two blood draws were taken approximately 30 seconds apart, after SpO_2 readings stabilized, at each of the varying levels of oxyhemoglobin saturation ranging from 100%-70%. Parallel SpO_2 readings from candidate oximeters were recorded electronically throughout the protocol. **RESULTS:** Comparative data from each candidate pulse oximeter system was taken as 5 second averages corresponding to the point of arterial blood gas analysis. Accuracy was evaluated via Bland-Altman analysis, linear regression, and calculation of root mean square error (A_{RMS}). The candidate systems A_{RMS} were calculated as: TT-EOP=1.82, HMAPS=2.44, and SPYDR=3.89. **DISCUSSION:** Although a direct comparison of these systems can provide insight into each device's accuracy and performance, consideration must be given to its use-case, maturity (TRL), and availability in order to determine which is "best". The TT-EPO was the most accurate of the three systems, but it is still undergoing development and integration into DoD environments. The HMAPS performed well, considering its tricep-mounted location, has a high usability, and fairly mature TRL. The SPYDR had the highest A_{RMS}, as there was some variability across readings compared to the arterial blood gas values. However, it is readily available for commercial use and has a high TRL. These pulse oximeter systems have strengths and weaknesses; a particular device may be best suited depending on the nature of the application (DoD research, training, and/or aviation realms).

Learning Objectives

1. The audience will learn about the protocol procedures that followed FDA guidelines for the validation of commercial pulse oximetry equipment.
2. The audience will be able to distinguish the performance of three leading pulse oximetry systems being developed for use across the DoD.

[321] U.S. ARMY MEDEVAC STANDARD MEDICAL OPERATING GUIDELINES UPDATE – TRANSFUSION AND DAMAGE CONTROL

Mark McPherson[1], Emily Simmons[2], Nicole Powell-Dunford[1]
[1]USAARL, Ft. Rucker, AL, USA; [2]U.S. Army School of Aviation Medicine, Ft Rucker, AL, USA

(Education - Program / Process Review)

BACKGROUND: Standardization of air ambulance prehospital guidelines is an increasingly important aspect of quality assurance. En route transfusion with blood and blood products is one aspect of damage

control resuscitation, a multifaceted approach to hemorrhage control and initial resuscitation prior to undergoing surgical procedures. While transfusion of blood products can be lifesaving, it is fraught with risk if conducted incorrectly, making standardization of training and execution particularly important. In this learning activity, the evolution of U.S. Army Medical Evacuation's (MEDEVAC) standardized medical operating procedures (SMOGs) pertaining to transfusion and damage control will be discussed. **OVERVIEW:** With the advent of U.S. Army MEDEVAC's deployed transfusion program in 2012, a standardized procedure for transfusion was established, but not in the context of an overarching guideline addressing damage control. Furthermore, the 'Vampire' protocol was not nested as part of a U.S. Army-wide standardization program or fielded in the garrison environment. Along with the implementation of the Army's critical care flight paramedic program came a movement to further professionalize the medical evacuation community through a unified group of SMOGs that could be trained and used in both the garrison and deployed environments. Previous to the SMOG implementation, local guidelines were developed by flight surgeons with widely disparate training and experience in prehospital medicine, potentially resulting in sub-optimal outcomes. Recently, the Medical Evacuation Concepts & Capabilities Division at Ft. Rucker has established an annual review board to assess all SMOGS, to include those related to damage control and transfusion. The U.S. Army Aeromedical Research Laboratory, in conjunction with the U.S. Army School of Aviation Medicine, now participates in the annual literature review and SMOG updates for these topics. **DISCUSSION:** The damage control and transfusion SMOGs enable flight medics to provide evidence-based, efficient, step by step assessment and treatment for en route patients with uncontrolled hemorrhage. Updates are undertaken no less than annually by aerospace medicine subject matter experts. Such updates should be disseminated across the U.S. armed forces as well as to our international partners.

Learning Objectives

1. The audience will recognize a U.S. Army MEDEVAC Standardized Medical Operating Guideline that is undergoing an update this year.
2. The audience will recognize drivers for evidence based en route care guidelines.
3. The audience will understand how often the transfusion and damage control SMOGs updates are undertaken.

[322] FOOTWEAR AND THE MANAGEMENT OF COMMON BIOMECHANICAL PROBLEMS AMONGST CABIN CREW

Margaret Grace[1]
[1]*Glasgow Caledonian University, Glasgow, United Kingdom*

(Education - Tutorial / Review)

INTRODUCTION: Common lower limb mechanical problems tend to exist among cabin crew populations. Many of such problems can either contribute or be the sole cause of an industrial injury resulting in long term absence or failure to perform designated duties. Management of such injuries can sometimes be complex, largely due to expectations from various individuals. **TOPIC**: In all instances a holistic approach must be taken, involving the patient themself and, since many crew industrial injuries are lower limb related, an aviation specialist podiatrist and physiotherapist should be called upon to assist with rehabilitation. Whilst orthotic therapy is often a preferred treatment option in improving lower limb mechanics and helping to rehabilitate, footwear considerations are often overlooked. Aviation podiatrists must therefore consider footwear, orthotic therapy, physical therapies and also education when dealing with such issues. **APPLICATION:** Often, a misconception exists that 'flat shoes are best'. Too often, female cabin crew are granted permission to wear a flat shoe both on and off the aircraft, in the belief by all parties (including the patient themself) that their donning a flat shoe is aiding their recovery. In many instances, however, certain biomechanics actually benefit from wearing shoes that have a small heel. Considering the common mechanical problems encountered, an overview of suggested shoe styles (heel heights) and orthotic interventions is detailed along with the following rationale: During flight, a flat or wedge cabin shoe is recommended. Off the aircraft, a lower block heel court shoe, which locks the mid foot into a supinated position during gait therefore offering some degree of protection to the structures that make up the Lisfranc Complex, or a narrow, high heel court shoe is recommended. Orthotics addressing underlying foot mechanics, over-pronation, or hypermobility with specialized top-coat materials to reduce shearing stress must be prescribed. Such footwear recommendations are given based on the assumption that cabin crew need to wear a higher heeled court shoe off the aircraft and a flat shoe on board the aircraft. This advice given is therefore subject to uniform standards at particular airlines.

Learning Objectives

1. The participant will be able to understand and identify common lower limb biomechanical issues among cabin crew.
2. The participant will understand and be able to suggest how common biomechanical issues can be dealt with appropriately.
3. The participant will understand what different interventions are available in dealing with lower limb biomechanical symptoms and will be able to suggest an appropriate treatment regime incorporating such interventions.

[323] PEDIATRIC EMERGENCY MEDICINE AEROSPACE MEDICINE SURVEY

Sathyaseelan Subramaniam[1], Jennifer Chao[2], Anna Barnes[3], Amy Kreykes[4]
[1]*Summerlin Hospital Medical Center, Las Vegas, NV, USA;* [2]*SUNY Downstate Medical Center, Brooklyn, NY, USA;* [3]*The Meadows, Las Vegas, NV, USA;* [4]*University of Texas Medical Branch, Galveston, TX, USA*

(Original Research)

INTRODUCTION: Commercial airline travel reached 4 billion passengers in 2017, many of them children. Pediatric emergency medicine physicians (PEMPs) are experts in the emergent care of children and have a duty to provide safe discharge instructions. Parents of pediatric patients frequently raise the question of 'fitness to fly' at discharge from the emergency department. There is no data on PEMPs confidence and accuracy in providing 'fitness to fly' recommendations. The objectives of our study were to assess PEMPs (1) confidence in providing 'fitness to fly' recommendations (2) knowledge on recommendations for 'fitness to fly' in 5 different clinical scenarios. **METHODS:** An IRB approved, 10-question survey of PEMPs confidence and knowledge in 'fitness to fly' recommendations was sent via email on 08/22/20 to a national PEM Listserv (2377 members) encouraging voluntarily participation. The survey closed on 10/12/20. Scenarios and answers were derived from published public guidelines by AsMA's Medical Guidelines for Airline Travel. Aerospace medicine physicians reviewed the suitability of scenarios and answers. Respondents with 60% or fewer correct answers to scenarios were deemed 'not knowledgeable' in 'fitness to fly' recommendations. A sample size of 250 participants was required to obtain a confidence level of 90% with a margin of error of 5%. **RESULTS:** 312 PEMPs participated. 12 were excluded for incomplete responses. A majority of PEMPs (67%) are not confident making recommendations on 'fitness to fly'. A majority (78%) of PEMPs are not knowledgeable in 'fitness to fly' recommendations. Reassuringly, 98% of respondents recommended that a newly diagnosed COVID-19 patient should not fly. 77% of respondents correctly listed a term, healthy 17-day-old as safe to fly. Only 42% correctly recommended that a patient with an active asthma exacerbation, not fly. 37% of respondents incorrectly answered that a sickle cell patient with an acute vaso-occlusive crisis, and hemoglobin of 8.1g/dL, as 'fit to fly'. **DISCUSSION:** A majority of PEMPs are not confident, or knowledgeable in 'fitness to fly' recommendations. PEMPs would benefit from learning basic aerospace medicine concepts during fellowship training. This will likely increase PEMPs confidence and knowledge, allowing safe discharge instructions be provided to patients regarding 'fitness to fly'. Aside from usual biases inherent in surveys, the ongoing COVID-19 pandemic likely influenced responses.

Learning Objectives

1. The audience will learn that this survey was conducted to assess pediatric emergency medicine physicians' confidence and knowledge in making recommendations for 'fitness to fly' in pediatric patients.
2. The study revealed that pediatric emergency medicine physicians are not confident in their ability to make recommendations on 'fitness to fly'.
3. The study revealed that pediatric emergency medicine physicians are not knowledgeable in making recommendations on 'fitness to fly' in pediatric patients in typical clinical scenarios seen in the emergency department.

[324] ATRIAL SEPTAL DEFECT IN AN AIRCREW

Mohammed Siraj Abdul Hameed[1]
[1]*Armed Forces Aeromedical Centre Dharan, Dharan, Saudi Arabia*

(Education - Case Study)

INTRODUCTION: The case report describes an AWACS aircrew having diagnosed with Atrial Septal Defect becoming symptomatic. **BACKGROUND:** CHD can be simple to complex. Advances in Rx have led to improved mortality. Some CHD conditions may present in those with already flying duties. Appropriate occupational risk assessment has become paramount to ensure flight safety. **CASE PRESENTATION: A** 28-yr-old aircrew with 5 yr service in AWACS presented to the flight line clinic in Oct 2018 with chest pain for a week. Pain was mild in intensity pricking in nature aggravated by climbing stairs or exertion. Associated with mild shortness of breath as well. Assessed by a cardiologist with echo and TEE as well where he was told that he has OS ASD around 2.5 cm with left to right shunt, with severely dilated right atrium and right ventricle. The patient was operated for ASD on January 2019 thru angiography. And placed on Asprin for 6 months and told to avoid exertion and given follow up after 6 months. Cardiologist opinion post 8 months Post ASD correction was good LV function EF 55%. Normal right side with no pulmonary hypertension. Can resume his normal activity and work. But the patient expressed concerns for his health and return to flying duties as he mentions that on occasions he would get symptomatic with mild chest pain and shortness of breath. ECG was normal Echo showed no residual shunt and LVF 50%. O2 sats 100%. Plan: Follow up and Holter and echo. No SBE prophylaxis. Advised no physical exertion and continue aspirin till then. **DISCUSSION:** This 28-year-old patient showed good post-surgery outcome but regard to flying category concerns were: 1) Late closure of ASD is associated with a poorer outcome due to AF, thromboembolism, and onset of RHF; 2) Needs of meds currently and in future Preop echo with The risk of hypoxia equivalent to heavy exercise and risk of rapid decompression, if back flying; 3) Needs of meds currently and in future; 4) Advise to avoid strenuous physical exercise. It is decided to ground aircrew with regular follow up.

Learning Objectives

1. The participant will learn About Occupational risk assessment of Aircrew with ASD.
2. Aeromedical concerns of aircrew with ASD and possible complications and flight safety issues.

[325] SELECTION OF AIR TRAFFIC CONTROLLER TRAINEES

Krisztina Szabo[1], Mate Petrekanits[1], Botond Szucs[1]
[1]*PHARMAFLIGHT International Science and Service Center, Debrecen, Hungary*

(Original Research)

INTRODUCTION: The 2-year training period for air traffic controllers puts a heavy financial burden on the training organization and means a continuous high workload to the trainees. Even bigger problem is the high percentage of dropouts during the training, which makes the whole procedure more expensive. To select the best candidates – thus reducing the number of drop-outs - we have been involved in the multistage selection process of the Hungarian ANSP, HungaroControl. **METHOD**: monitoring and evaluating certain physiological parameters can contribute to a better assessment of an individual. The candidates, after FEAST 2 test came to our center for a sleeping assessment, and a standard aeromedical examination, anthropometry, 6-min physiological evaluation, dry electrode EEG and cognitive function test. During a 6 min interval we evaluate the candidates' physiologcal state. We use HRV (heart rate variability), which gives information of the autonomic nervous system, electric and mechanical state of the heart, and possible inflammations. Arteriography demonstrates characteristics of large arteries and endothelial function. It reveals several parameters: augmentation index (AIX, optimal range < -30 %) traces the degree of pulse wave reflection, state of peripheral circulation, and is related with cardiovascular mortality. Pulse wave velocity (PWV, optimal range < 7 m/s) represents the speed of pressure wave on aorta generated by the heart's contraction, which is crucially affected by the elasticity of the aorta. PWVao is a solid, independent, proven risk factor of cardiovascular mortality. Diastolic area index (DAI, 50-60%) represents the diastolic proportion of cardiac cycle, gives information on pressure properties of the left coronary artery. With dry electrode EEG we monitor brain wave range combinations. During sleeping assessment by using a special device we get valuable information about sleeping habits, heart rate, breath frequency, deep sleep time, apnea time, sleep efficiency. **RESULTS**: We evaluated the findings of 85 candidates and wrote a detailed report of all the candidates for HungaroControl. Based on our report a "ranking" can be given, and it was an important data for HungaroControl in the recruitment decision. **DISCUSSION**: We are waiting the feedback from HungaroControl about the trainees who were recruited based upon our ranking, to see how they met the training requirements and whether the rate of drop-out could be reduced.

Learning Objectives

1. The presentation will underline the reason for a thorough selection method, based on physiological monitoring, that is independent from the applicant's previous preparations.
2. The audience will learn about the importance of monitoring certain physiological parameters, and their preclinical significance.

[326] CULTIVATING HIGH PERFORMANCE AND DESENSITIZATION FROM SKYDIVING FOR FAVORABLE OUTCOMES: A CASE REPORT

Tee Jeter[1], Jeffrey Peel[2]
[1]*University of Nevada- Reno, Reno, NV, USA;* [2]*Renown Regional Medical Center, Reno, NV, USA*

(Education - Case Study)

INTRODUCTION: In this case report, we present a circumstance in which a skydiver committed a fatal mistake in judgement, and we highlight an opportunity for harnessing stress-reactivity for a greater cause, rather than a detriment. **BACKGROUND:** Skydivers experience robust idiosyncratic and physiological stress responses. Speculation exists that extensive prior experience with a stressor may shift the activation of emotion-regulation neurocircuitry. Over time, adrenal hyperactivity and memory consolidation in the amygdala, not only leads to neural plasticity, but can result in desensitization and hazardous behavior. **CASE PRESENTATION:** A 49-year-old experienced skydiver, jumped from a Beechcraft King Air at an altitude of 14,000 feet. Freefall was uneventful, followed by deployment of his parachute without incident. Medical history positive only for hypertension. Other relevant information includes: clear weather, 85 degrees Fahrenheit, ground wind speed 4 mph; no new or unfamiliar gear; jumper was licensed by the U.S. Parachute Association and had over 7000 jumps in 20 years. On approach under canopy, jumper made a series of intentional rapid turns, called "hook turns," including a 180 degree return on final, causing a hard impact on landing. He subsequently suffered innumerable bone fractures, crush injuries, internal hemorrhage and died soon after being airlifted to a Level 1 Trauma Center. The jumper was under a square, steerable and stable canopy and a thorough Federal Aviation Administration investigation concluded no equipment failure or liability, other than human error. **DISCUSSION:** When skydiving becomes mundane, jumpers steadily max out the capabilities of gear, altitude and judgement—often by flying smaller canopies and performing high-speed turns. This case illustrates the point that persons in high performance occupations should be on the lookout for desensitization and neurasthenia. We must remain cognizant of the many barriers to recognize this, to include naivete, unfamiliar beliefs and seemingly top performance that continually pushes the limit. Additionally, we can take cues from this case and seek to advance our knowledge in order to constructively utilize high performance and so-called desensitization. Rather it be destructive, we can identify certain behaviors and exploit them for maximal production and performance in any given field.

Learning Objectives

1. Have a better understanding of the downstream effects of desensitization in high performance professions.
2. Learn from a case in which an experienced skydiver committed a fatal mistake in judgement.
3. Seek out opportunities to utilize high-performance emotional adaptations for positive results.

[327] AEROSPACE MEDICINE AND HUMAN PERFORMANCE-OFFICIAL JOURNAL OF THE AEROSPACE MEDICAL ASSOCIATION

Frederick Bonato[1], Pam Day[1], Debra Sventek[1]
[1]*Aerospace Medicine and Human Performance, Alexandria, VA, USA*

(Education - Tutorial / Review)

INTRODUCTION: Aerospace Medicine and Human Performance (AMHP) has existed under other titles since 1930. It is the world's most cited and respected journal in its field, publishing articles pertaining to health, safety, and human performance related to all aspects of flight, spaceflight, and related topics. Publication in AMHP is a worthwhile achievement, and can benefit authors and readers alike. Here the process of preparing and submitting manuscript to AMHP is described. **TOPIC**: This poster provides authors with a systematic overview of the journal and some guidance on writing an informative, readable manuscript and submitting it to AMHP using our web-based system, Editorial Manager. It describes various article types as set forth in the Information for Authors and how each type should be formatted. Guidance is provided in avoiding some common pitfalls that can delay or even prevent eventual acceptance of a manuscript. **APPLICATION**: In following these guidelines, authors can maximize their potential for publishing in AMHP and hence of contributing to the advancement of the fields related to aerospace medicine and human performance.

Learning Objectives

1. The audience will learn about the different publishing opportunities available through AsMA's Official peer-reviewed journal, Aerospace Medicine and Human Performance.
2. The audience will learn some helpful tips on getting a manuscript accepted for publication in Aerospace Medicine and Human Performance.

Thursday, 09/02/2021 ***10:00 AM***
Governor's Square 14

[S-61]: PANEL: HUMAN PERFORMANCE AND NEUROLOGICAL EFFECTS OF HYPOBARIA: RESULTS OF THE LAST FIVE YEARS OF INTERNATIONAL RESEARCH

Chair: Paul Sherman

Panel Overview: *This panel presents the results of ongoing international collaborative research to enhance our understanding of the effects of hypobaric exposure upon the human brain. A strong association has been demonstrated between white matter injury and exposure to USAF operational non-hypoxic hypobaric conditions. The first presentation reports the initial results of the longitudinal MRI brain evaluation program in U-2 pilots post CARE. A brief review of the current evidence of both diffuse axonal injury in normal appearing white matter in U2 pilots as well as subcortical white matter lesions is included. The second presentation discusses effects of age, flight exposure hours and prior history of NDCS on neuroimaging/neurocognitive results in our U-2 pilot cohort. The third presentation reviews the initial results of fighter pilot brain MRI imaging from The Canadian White Matter Hyperintensity Study. The last two presentations discuss the initial findings of MRI examinations and functional evaluation in altitude chamber instructors exposed to repetitive hypobaric exposure in a European Multinational Study.*

[328] U-2 PILOT LONGITUDINAL BRAIN MRI SCREENING PROGRAM: INITIAL RESULTS

Paul Sherman[1], Holly Chapapas[2], Bianca Cerquira[2], John Sladky[3]
[1]*USAFSAM, Joint Base San Antonio Lackland, TX, USA;* [2]*KBR Aerospace, Joint Base San Antonio Lackland, TX, USA;* [3]*59th Medical Wing/959th Medical Group, Joint Base San Antonio Lackland, TX, USA*

(Original Research)

INTRODUCTION: We previously reported increased subcortical and periventricular white matter (WM) injury and decreased white matter integrity associated with repetitive occupational exposure to non-hypoxic hypobaric conditions high-altitude U-2 pilots. A longitudinal brain MRI screening program began in 2014 for high altitude pilots upon entry into the platform and every 3 years while flying. The cabin altitude restriction effort (CARE) decreased cabin altitude from 9,000 m (28,000-30,000 ft) while operating above 21,000 m to approximately 4,500 m (15,000 ft). **METHODS:** Pilots underwent advanced MRI brain examinations at Wilford Hall Ambulatory Surgical Center [Siemens 3-T Verio magnet] and David Grant Medical Center [General Electric Discovery MR750 3-T magnet] which included 3-D fluid attenuating inversion recovery (FLAIR) and 3-D T1, high resolution (0.8-mm isotropic) sequences. MRI exams were reviewed by two neuroradiologists. 3-D FLAIR imaging was quantitatively evaluated for white matter hyperintensity (WMH) volume. **RESULTS:** 27 pilots completed two or more MRI brain examinations. All exams were available for review for 26 pilots. Of those 26 subjects, 22 subjects had complete imaging sequences that met quality standards for analysis. Of the 22 pilots, n= 17 had two MRIs; n= 4 had three MRIs, and n=1 had four MRIs; total of 50 MRI brain exams. Average change from baseline in total FLAIR volume was -0.025 cm^3 (1.6% change from baseline). Average change from baseline in subcortical FLAIR volume 0.015 cm^3 (1.2% change from baseline). Average change from baseline in peri-ependymal FLAIR volume -0.040 cm^3 (-0.4% change from baseline). **DISCUSSION:** Since the CARE modification there has been a significant reduction in reported NDCS events. There was no significant interval change in white matter hyperintensity volume as measured by FLAIR MRI. There does not appear to be increased white matter injury as assessed by WMHs alone. Consideration should be made to include diffusion tensor imaging with fractional anisotropy assessment for the U-2 pilot MRI brain protocol.

Learning Objectives

1. Understand the effects of acute and chronic hypobaria upon the brain.
2. Understand the purpose and initial results of the U-2 longitudinal brain MRI program

[329] MRI/DTI VS. NEUOCOGNITIVE RESULTS IN U2 COHORT: EFFECTS OF AGE, NDCS, & EXPOSURE HOURS

Bianca Cerquiera[1], Holly Chapapas[1], John Sladky[2]
[1]*KBR Aerospace/USAFSAM, Joint Base San Antonio Lackland, TX, USA;* [2]*59th Medical Wing/959th Medical Group, Joint Base San Antonio Lackland, TX, USA*

(Original Research)

INTRODUCTION: Repeated exposure to extreme hypobaria is associated with increased white matter hyperintensities (WMH) in humans as observed on T2-weighted imaging and decline of axonal integrity as measured by fractional anisotropy (FA) in U2 pilots along with changes in neurocognitive function (executive function, memory, processing speed) compared to Air Force pilots flying other platforms. This analysis assessed whether age, flight hours and/or prior history of neurological decompression sickness (NDCS) influenced FA values within WM tracts or neurocognitive performance in U-2 pilots. **METHODS:** MRI and neurocognitive data obtained from 103 U-2 pilots prior to the implementation of the CARE program were analyzed. FA values within multiple white matter tracts were obtained from diffusion tensor imaging (n=103). Neurocognitive data was obtained through Multi-dimensional Aptitude Battery (MAB-II) evaluation (n=102) and MicroCog evaluation (n=101). A generalized linear model was utilized to investigate independent effects of age, exposure hours, and prior history of NDCS on either FA, MAB-II metrics, or MicroCog metrics. **RESULTS:** Higher age correlated with lower FA values for white matter average, corpus callosum body, corona radiata, and thalamic radiation tracts. Exposure hours had no effect on FA values and prior NDCS was only significant for reduced value in the internal capsule. Exposure hours correlated directly with improved scores in both picture completion and object assembly testing on MAB-II, and increased reasoning scores on MicroCog. Age had no effect on MAB-II scores but demonstrated increased scores in both attention and decreased scores in spatial processing on MicroCog. History of NDCS revealed reduced MAB-II values in performance and full-scaled intelligence quotient scores, similarities, picture arrangement and object assembly which assess visual spatial abilities. NDCS had no impact on MicroCog testing. **DISCUSSION:** Increased age was the primary determining factor in reduced FA values, both global and of specific

tracts, while longer exposure duration was shown to be predictive of higher scores in certain cognitive domains of both the MAB-II and MicroCog. Pilots with prior NDCS had reduced overall global IQ performance and visual spatial skills on MAB-II but no significant changes on MicroCog, reflective that the two neurocognitive tests stress different cognitive domain functions and are complementary and not reduplicative.

Learning Objectives

1. Understand the impact that age, prior history of NDCS and flight exposure hours has on white matter integrity.
2. Understand the impact that age, prior history of NDCS and flight exposure hours has on neurocognitive testing.

[330] FIGHTER PILOT BRAINS: MRI AND NEUROCOGNITIVE FINDINGS FROM THE CANADIAN WHITE MATTER HYPERINTENSITY STUDY

Joan Saary[1], Sandra Black[2], Oshin Vartanian[3], Shawn Rhind[3], Joel Ramirez[2], Gary Gray[4], Bradley MacIntosh[2], Fuqiang Gao[2], Maged Goubran[2], Alex DiBattista[3], Miriam Palmer[4]

[1]Canadian Forces Environmental Medicine Establishment and the University of Toronto, Toronto, ON, Canada; [2]Sunnybrook Research Institute, Toronto, ON, Canada; [3]Defence Research and Development Canada, Toronto, ON, Canada; [4]Canadian Forces Environmental Medicine Establishment, Toronto, ON, Canada

(Original Research)

INTRODUCTION: Increased subcortical white matter hyperintensities (WMH) have been identified in brain imaging of pilots and altitude chamber workers with exposure to altitude. Neither the cause nor the operational relevance of these findings is yet clear. This study uses high-resolution magnetic resonance imaging (MRI) brain scans to quantify WMH in a potentially hypobaric exposed Royal Canadian Air Force population and identify operationally and clinically relevant correlates of WMH including cognitive function and peripheral biomarkers. **METHODS**: Participants with possible exposure to low ambient pressure at altitude from flying high performance aircraft attended 2 days of testing that included questionnaires on exposure history and known correlates of WMH; physical exam; cognitive testing; MRI scans including a cerebrovascular reactivity (CVR) resting state functional MRI and diffusion tensor imaging (DTI) of the white matter; blood sampling for peripheral biomarkers; cardiac risk markers; and an agitated saline contrast echo. MRI sequences are being completed with a 3 Tesla magnet. The Research Ethics Boards of Defence Research and Development Canada (DRDC) and Sunnybrook Health Sciences Centre approved the research protocol. **RESULTS**: We present whole brain descriptive and regional volumetric MRI data and neurocognitive assessment, from 26 volunteers. Participants were all male non-smokers with a mean age 35. Mean flying hours of 1633 with mean 775 hrs on CF-18. Periventricular white matter volume was .248 mL added to 0.082 mL of deep WMH for a total of 0.330 mL (median .288 mL). Total WMH was correlated with age ($r=.45$, $p<.05$). Regionally it was located primarily in occipital and frontal regions. Neurocognitive assessment showed average crystalized and above average fluid intelligence. Short-term memory and executive functions were normal, with better working memory than is generally observed in military settings. Microcog scores were all normal, but not correlated with intelligence scores. **DISCUSSION:** This is the first study of its kind to present MRI findings and estimates of WMH prevalence from this particular military occupational population of fighter pilots. WMH burden appears to be higher than volumes found in some comparable populations previously reported in the literature e.g. U-2 pilots. Next steps include detailed analysis of exposure correlates with WMH burden, and analysis of biomarker data.

Learning Objectives

1. The participant will learn about the prevalence and volume of white matter hyperintensities in the brains of fighter pilots.
2. The participants will gain knowledge about neurocognitive test results in fighter pilots.
3. The audience will learn about the components of the Canadian White Matter Hyperintensity Study.

[331] FUNCTIONAL EXAMINATIONS IN ALTITUDE CHAMBER INSTRUCTORS WITH REPETITIVE HYPOBARIC EXPOSURES - PRELIMINARY FINDINGS IN A EUROPEAN MULTINATIONAL STUDY

Carla Ledderhos[1], Sven Kuehn[2], Sven-Erik Soenksen[1], Andre Gens[1], Frank Weber[1]

[1]GAF CAM, Fürstenfeldbruck, Germany; [2]Bundeswehr Central Hospital, Koblenz, Germany

(Original Research)

Various studies revealed subcortical White Matter Hypertensities (WMH) on MRI brain scans occurring after repetitive hypobaric exposures in both humans and animals. In the aeromedical context this phenomenon has been described in U-2 pilots first. However, very soon it became obvious that other groups of persons with occupational exposure to hypobaric hypoxia are affected too and that the appearance of WMH is irrespective of the occurrence of DCS in their case history. Since the functional consequences of these changes are still unknown it is not surprising that the increased prevalence of WMH in pilots, hypobaric chamber instructors (CI) and astronauts causes concerns for their health. Therefore, a study in CI was initiated at the GAF CAM to identify both, the prevalence of WMH and the potential functional implications of repetitive nonhypoxic hypobaric exposures. The subjects examined are CI from various European high-altitude chambers exposed to the relevant altitudes. A matched group (CS) lacking such exposures is used as control. Apart from a detailed personnel history developed within the NATO STO group RTG-274 "The Impact of Hypobaric Exposure on Aviators and High-Altitude Special Operations Personnel" 3T MRI scans of the brain and the spinal cord are performed. The functional tests focus on the sensory pathways with recordings of visual and auditory evoked potentials. In addition, balance regulation using posturography and psychometric tests are conducted. Furthermore, optical coherence tomography is performed to document the fundus of the eye, including the optic nerve and the retinal vessels. 50 subjects (21 CI, 29 CS) have been studied so far. There are no differences in the mean number and volume of WMH in both groups. 56% of CI but only 46% of CS revealed more than 5 WMH in the brain. Most WMH (58 % of all WMH) were located in the frontal lobe. In both groups the occipital lobe was free of WMH. The same was true for the spinal cord. Data obtained so far reveal a correlation between age and number as well as volume of WMH in the brain. A tendency for functional differences appears only to occur regarding psychometrics. However, data evaluation is still in progress. To our knowledge this study is the first one to focus on functional consequences of WMH in the brain and the occurrence of WMH in the spinal cord due to repetitive hypobaric exposures in CI. The results obtained will allow to better assess the occupational risk for CI.

Learning Objectives

1. The participant will be able to understand the functional consequences of structural changes of white matter due to repetitive hypobaric exposures.
2. The audience will learn about different kinds of psychometric testing.

[332] REVIEW OF UK RESEARCH INTO DECOMPRESSION STRESS AND BRAIN WHITE MATTER CHANGE

Des Connolly[1]

[1]QinetiQ, Farnborough, United Kingdom

(Education - Program / Process Review)

BACKGROUND: U.S. Air Force data suggest an association between occupational exposure to intensive decompression stress and white matter change on magnetic resonance imaging (MRI) brain scans of U-2 pilots and altitude chamber workers. **DESCRIPTION:** This review examines outcomes of UK research and how these have contributed to establishing safe systems of altitude chamber work. UK research has encompassed: meta-analysis of MRI data in healthy divers and non-divers, to evaluate the influence of hyperbaric decompression stress; retrospective MRI survey of altitude chamber instructors and research subjects, to evaluate the legacy of UK hypobaric chamber exposure over the last 20 years; and prospective MRI study of participation in a series of altitude chamber oxygen system assessments, to satisfy duty of care to volunteer subjects. Divers, with no history of

decompression sickness, have a greater prevalence of white matter change than non-divers (Odds Ratio 2.654, 95% Confidence Interval 1.7 to 4.1). Of 20 participants in 1417 altitude chamber research and training exposures (>15,000 ft), 17 (85%) had normal MRI scans while 3 (15%) exhibited excess white matter change, unrelated to any metric of decompression stress. Five participants who each undertook from 23 to 26 exposures to altitudes between 18,000 and 40,000 ft exhibited no change in white matter status between study entry and exit MRI screening. **DISCUSSION:** Five-yearly hypobaric hypoxia familiarization has not promoted white matter change in the UK cohort (N=33), while past history of mild traumatic brain injury (MTBI) is the only factor positively associated with excess white matter change (Fisher Exact Test P=0.0031). The findings in healthy divers are consistent with an association between intensity of decompression stress and white matter injury, but predominantly brief and infrequent exposures, even to high altitude, do not cause white matter change. In the UK, managed programs of altitude chamber exposure are conducted using safe systems of work, screening volunteers for low risk studies by excluding past concussive head injury, or using brain MRI to detect those with pre-existing white matter change. Occupational exposure to intensive decompression stress, sufficient to risk decompression sickness, remains a possible cause of white matter injury.

Learning Objectives

1. To enhance understanding of safe levels of altitude exposure, based on evidence indicating that human exposure to relatively brief and infrequent decompression stress has not caused white matter change in a UK cohort.
2. To appreciate the derivation of safe systems of research work involving altitude chamber exposure in the UK.
3. To understand the association between past mild traumatic brain injury (concussion) and white matter change in the UK cohort screened using magnetic resonance imaging (MRI).

Thursday, 09/02/2021 ***10:00 AM***
Governor's Square 15

[S-62]: SLIDE: VISION, ILLUSIONS, AND DISORIENTATION

Chair: Jeffrey Hovis
Co-Chair: John Harrell

[333] DESCRIPTIVE ANALYSIS OF IN-FLIGHT ILLUSIONS IN YOUNG FIGHTER PILOTS

Kwo-Tsao Chiang[1], Chung-Yu Lai[2], Chun-Ming Lin[3]
[1]Kaohsiung Armed Force General Hospital Gangshan Branch, Taiwan, ROC, Kaohsiung, Taiwan (Greater China); [2]National Defense Medical Center, Taipei, Taiwan (Greater China); [3]The 5th Tactical Fighter Wing of ROCAF, Taiwan, ROC, Hualien, Taiwan (Greater China)

(Original Research)

INTRODUCTION: Spatial disorientation (SD) remains a major threat to flight safety and the leading cause of Class A mishaps and fatalities in military aviation. SD has contributed to 12–33% of Class A mishaps in U.S. military aviation, with near 100% fatality rate. However, there were few investigations in young fighter pilot group about their experience of in-flight illusions. We try to figure out their prevalence of in-flight illusions and how they cope with the condition. **METHODS:** This is a cross-sectional study conducted between July 2018 to June 2019. Young fighter pilots who had just completed basic jet fighter training voluntarily participated in the study. An open-ended questionnaire was used to investigate their experience of in-flight illusions and how they cope with it. SPSS 22.0 software was applied for entry, storage, and analysis of data. **RESULTS:** All of the 60 distributed questionnaires were valid (completion rate was 100%) . Subjects were all male pilots and the mean age was 24 years old. The mean flight time was 180 hours with about 100 hours in jet-trainer. In-flight illusions were experienced by 68.3% (N=41) of participants, with 75.6% and 61.0% of the illusions occurred in cloudy/night circumstances and under degraded visibility conditions, respectively. Most illusions were vestibular in nature, with 65.9% of respondents experienced the leans. Only 9.8% of the illusions were visual illusions. The majority (68.3%) of respondents recovered from SD by trusting their instruments. With regards to the disappearance of false sensation, only 31.7% were by continuously using instruments, majority (63.4%) of them needed regaining visual reference to get correct orientation. **DISCUSSION:** In this study, we found that in young fighter pilots, the most common illusion was the leans and that visual illusions were relatively rare. Although most young fighter pilots can recover from SD by relying on instrument, but regaining visual reference is needed for the false sensations to disappear. We will extend this investigation to senior experienced pilots to explore the incidence of in-flight SD and coping strategies.

Learning Objectives

1. In this study, we found that in young fighter pilots, the most common illusion was the leans and that visual illusions were relatively rare.
2. Although most young fighter pilots can recover from SD by relying on instrument, but regaining visual reference is needed for the false sensations to disappear.

[334] ADDING PERCEPTUAL THRESHOLDS TO THE OBSERVER MODEL OF ORIENTATION PERCEPTION

Jamie Voros[1], Henry Williams[2], Daniel Merfeld[3], Torin Clark[1]
[1]University of Colorado Boulder, Boulder, CO, USA; [2]Wright-Patterson AFB, Dayton, OH, USA; [3]The Ohio State University, Columbus, OH, USA

(Original Research)

INTRODUCTION The *observer* model [1] is the current state of the art in simulating human spatial orientation in full six degrees-of-freedom, for any given dynamic, passive motion scenario. The model combines visual and vestibular cues to predict perceived orientation. Here, we add a dynamic decision-making element to the model to produce a decision-making variable relevant for perceptual thresholds. In our context, a perceptual threshold refers to the smallest movement that a human can reliably distinguish the direction (i.e., "Did I move left or right?"). Perceptual thresholds include decision making in that the human must perceive orientation and then make a decision regarding the perceived orientation. In a laboratory setting, this may be a verbal report (e.g., "I moved left") and in an operational scenario these decisions may manifest themselves as a motor control response (e.g., a pilot controlling their helicopter in response to perceiving they are drifting backwards instead of maintaining a hover). **METHOD** We extended the *observer* model in order to simulate translation motion perceptual thresholds that were consistent with existing laboratory experimental data on population perceptual thresholds in translation across the full range of motion durations that have been previously tested. **RESULTS** The model's predictions, however, were less consistent with recent helicopter flight data where higher thresholds were observed. Unlike in a laboratory setting, the helicopter motions included substantial vibrations and additional motions beyond the single desired axis of translation. Yet, when this was accounted for in the model, it continued to predict thresholds that were lower than that observed in the helicopter experiment. This suggests that the helicopter experiment had methodological or other factors (e.g., divided attention or pilot expectations) that altered the perceptual thresholds measured. **DISCUSSION** We present an extension of the *observer* model that for the first time includes a dynamic decision-making aspect, in an effort to capture perceptual thresholds. We have shown the model to be consistent with patterns observed with perceptual thresholds as measured in the laboratory. **REFERENCE:** [1] Clark TK, et al. Mathematical models for dynamic, multisensory spatial orientation perception. *Progr Brain Res.* 2019; 248: 65–90.

Learning Objectives

1. The participant will be able to determine the difference between orientation sensing and orientation perception. While our sensory organs are able to sense our physical spatial orientation, there is a further layer of processing that occurs before orientation is perceived.
2. The participant will be able to understand how modelling can be applied to neurophysiological sensing, perception and decision making.

[335] SENSITIVITY AND SPECIFICITY OF CONE CONTRAST SENSITIVITY: A COMPARISON BEWTEEN THREE TESTS

Julie Lovell[1], Neda Tahvillan[1], Annie Ku[1], Tayde Contreras[1], Jessica Carachure[1], Lydia Geabou[1], Jared Sies[1], Dung Nguyen[1], Logan Skrobarcek[1], Jeff Rabin[1]
[1]*University of Incarnate Word, San Antonio, TX, USA*

(Original Research)

INTRODUCTION: Accurate color vision is essential for hue discrimination in cue limited settings. Several computerized color contrast sensitivity (CS) tests are available but data on agreement between tests is lacking. Our purpose was to compare sensitivity and specificity of the cone contrast test (Innova CCT modified to include lower contrasts), NCI and Konan systems for detecting type & severity of hereditary CVD. **METHODS:** 25 color vision normal (CVN) & 25 color vision deficient (CVD) subjects (mean age 27 ± 9), confirmed by Ishihara and anomaloscope testing, were recruited from the local community. Each provided written informed consent in accord with our IRB-approved protocol which addressed occupational color performance. Subjects were tested with right and left eye on the CCT, Konan and NCI systems in random order. Each test presents letters (CCT) or Landolt Cs visible only to red (R), green (G) or blue (B) cones in staircase fashion to determine cone CS thresholds. **RESULTS:** Since there was no difference between right & left eyes across systems for CVNs ($F = 0.05$, $p > 0.81$) and CVDs ($F = .51$, $p > .47$), the average of the two eyes was used for each subject. In CVNs there was a significant difference between systems ($F = 2304$, $p < .001$). Post hoc comparisons showed that Konan R and G cone CS was higher than CCT and NCI scores (Tukey-HSD). However, B cone CS was higher for the CCT compared to Konan and NCI. CVDs also showed a difference between systems ($F = 592$, $p < .001$) with higher protan and deutan Konan scores but no difference for the normal cone CS scores. The CCT again showed higher B cone scores vs Konan and NCI (Tukey-HSD). All three tests showed 100% sensitivity for detection and identification of CVD and type. In CVNs all tests showed 100% specificity for confirming normal R and G cone CS, but Konan showed 96% specificity in CVNs and 92% in CVDs for B cone CS. **DISCUSSION:** All systems showed 100% sensitivity for detection and identification of type of CVD and high specificity for confirming CVN. The Konan system yielded higher values for R & G cone CS, attributable to its finer gradation in contrast steps & PSI method of achieving a threshold. However, the CCT with extended contrast range yielded higher B cone scores most likely due to the larger character size used on the CCT to render its target near the peak of the B cone CS function. Future comparisons to anomaloscope & occupational measures of color vision are forthcoming.

Learning Objectives

1. The participant will be able to comprehend how contrast sensitivity is assessed using computerized color contrast sensitivity tests.
2. The participant will be able to comprehend the sensitivity and specificity of computerized color contrast sensitivity tests.
3. The participant will be able to learn why different tests yield higher scores and how different scores compare across tests.

[336] PILOT INTERVIEW REPORTS OF SPATIAL DISORIENTATION EXPERIENCES AND MITIGATION

Torin Clark[1], Tristan Endsley[2], Jordan Dixon[1]
[1]*University of Colorado Boulder, Boulder, CO, USA;* [2]*The Charles Stark Draper Laboratory, Cambridge, MA, USA*

(Original Research)

INTRODUCTION: Spatial disorientation (SD) in aviation, an incorrect perception of one's orientation, position or motion relative to a reference frame, remains a leading cause of Class A mishaps and fatalities. To understand SD during operational flight, several survey investigations have been undertaken. However, to intervene during an SD event, it is important to better understand the temporal dynamics of SD events and the impact of SD training, which are likely better assessed using methods of interviewing pilots rather than a static survey. **METHODS:** We developed and performed interviews of pilots, informed by initially administering the WP61 SD survey postal questionnaire. Interviews were aimed at gathering targeted responses regarding impacts of SD training on pilot capacity for recognition and recovery, as well as how SD develops and is experienced in-flight. A semi-structured interview format enabled gathering rich data not feasibly captured in static surveys. Thirteen pilots (age 35-76) with an average of 7333 ± 5613 (SD) flight hours were interviewed. **RESULTS:** The results of the survey show SD remains rife, aligning with past reports. Of the top 10 most reported SD experiences, 6-8 are shared with the most recent surveys conducted by Pennings et al. (2020) and Lewkowicz et al. (2020) indicating a representative sample of the population in this extended study. Over 1000 statements were provided through the interviews bringing new insight to SD research surrounding training, temporal dynamics and countermeasures. Findings indicate nearly unanimous reports of a staged SD temporal response upon recognition of SD: a habitual reaction to move attention to instruments, an analytical investigation of the aircraft state, followed by an intuitive execution of a response if deemed appropriate. **DISCUSSION:** The interview data revealed the complex interactions and personal differences in SD experiences, and established its utility as a tool for deepening the field's understanding of SD. The analytical phase, estimated to take seconds to tens of seconds, is an opportunity for active interventions. Further, since the recognition and recovery phase is typically preceded by a phase of unrecognized SD estimated to last up to 15 seconds (with good cross-check habits), safety may be improved with early detection systems. Analysis of rich interview reports can uncover otherwise uncaptured aspects of SD that could be crucial in building a holistic defense.

Learning Objectives

1. The audience will learn how currently adopted spatial disorientation training impacts a pilot's ability to recognize, perceive and recover from spatial disorientation events, in addition to recommendations for future training enhancements.
2. The audience will learn how spatial disorientation events evolve temporally, and understand how this information facilitates novel spatial disorientation detection and countermeasure approaches.
3. The audience will learn the existing barriers, from the pilot's perspective, of integration, acceptability and use of a spatial disorientation detection and intervention system in the cockpit.

[337] THE HISTORY OF USAF AIRCREW VISION STANDARDS: BACK TO THE FUTURE? - PART IV

Douglas Ivan[1], Adrien Ivan[2], Thomas Tredici[3]
[1]*ADI Consultants, San Antonio, TX, USA;* [2]*Vernon College, Wichita Falls, TX, USA;* [3]*University of Texas Health Sciences Center, San Antonio, TX, USA*

(Education - Tutorial / Review)

INTRODUCTION: The fourth installment in this series tracing the historical origins of USAF aircrew vision standards will build on the aeromedical lessons learned during World Wars I and II. **TOPIC**: The United States (US) and its Allies encountered a number of aeromedical and visual challenges during the war as the operational capabilities of military aircraft expanded rapidly and physiological stressors intensified. In addition, the US struggled with the overwhelming number of individuals being processed for war, making the concept of mass medical screenings a significant challenge given what became obvious disconnects between military vision requirements and existing clinical testing capabilities. At the request of the Army and Navy, the US government created the *Army-Navy-National Research Council (NRC) Vision Committee* to address pre-eminent vision problems needing immediate resolution that emerged during the war, as well as for inevitable future military mobilizations, given emergent developments on the Korean Peninsula. Following creation of the *U.S. Air Force* (USAF) in 1947, the committee was renamed the *Armed Forces-NRC Vision Committee.* The committee became the epicenter for development and testing of military aircrew vision products, selection standards, and vision testing devices from 1944-1973. Among its most enduring accomplishments were: standardized visual acuity letters and testing charts, the *Armed Forces Vision Test Apparatus (AFVTA)* with its multiple vision function test slides, and standardized tri-service color vision (CV) testing, including development of a new pseudo-isochromatic plate (PIP) CV screening test and secondary test lanterns, such as the Navy's *Farnsworth Lantern* (FALANT) and *Color Threshold Test* (CTT). Additionally, during this period, the USAF developed a new military spectacle frame (HGU-4/p) and sunglass lenses that

eventually became the *Department of Defense* (DoD) standard for US aircrew spectacle eyewear. **APPLICATION**: This presentation will highlight the key historical developments from the end of WWII through 1980 that were instrumental in defining aeromedical vision and standards from that period, many of which are still used today.

Learning Objectives

1. The audience will learn about the origins of USAF aircrew vision standards and the history of aeromedical vision screening devices still used today.
2. The audience will learn about the role of the Armed Forces Vision Committee in developing military aircrew vision standards.

[338] A NEW STEREO TEST FOR MILITARY AIRCREW

Bonnie Posselt[1], Alex Van Atta[2], Marc Winterbottom[3], Steve Hadley[3]
[1]USAF/ RAF Center of Aviation Medicine, Dayton, OH, USA; [2]Hedgefog Inc., San Pedro, CA, USA; [3]USAF, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Newer Helmet Mounted Displays (HMD) can display information and imagery binocularly in stereoscopic 3D. Properly implemented, this added feature can reduce reaction times, improve search and situational awareness, becoming a critical part of the aircraft system. Interpretation of stereo depth requires the user to have adequate stereo ability as measured by their stereo acuity. Despite advances in optical technology placing previously unconsidered stresses on the human visual system, military vision standards have not been reviewed or revised. The current stereopsis vision standard for UK military aircrew is 120 arcsec as measured by the TNO booklet test. The TNO test is able to measure stereo acuities no better than 60 arcsec and in coarse bins thereafter. Furthermore, correct responses can be memorized with the added potential for examiner bias. An alternative stereo test is proposed, a digital random dot stereogram (dRDS), capable of accurately measuring to threshold with the potential to predict operational performance, such as using stereo 3D HMDs. **METHODS:** A dRDS, similar to the TNO test, was developed using a stereoscopic 3D computer monitor to display the dynamic dots viewed at 1m with active shutter glasses. A pilot study was conducted using 10 participants, who completed the TNO test, viewed at 40cm, and dRDS twice on separate occasions to examine test-retest reliability. **RESULTS:** Median stereo acuity as measured with dRDS was 41 arcsec (range 25-279), and for the TNO 60 arcsec (range 60-240). 80% of subjects obtained a lower (better) score using the dRDS, with significantly lower median scores (Mann-Whitney U=81, p=0.017). The test-retest correlation for the dRDS test was r=0.94, p<.001 (Pearson's). The two tests demonstrated weak correlation, which was not significant (Spearman's r = 0.472, p = 0.168). **DISCUSSION:** With a large floor effect at 60 arcsec, the TNO test was unable to characterize any finer degree of stereo acuity. The dRDS had good test re-test reliability, was simple to perform, and could be considered to replace the TNO test to more accurately measure stereo acuity. This may be increasingly important for military aviators for whom stereoscopic displays and HMD are becoming more prevalent and critical.

Learning Objectives

1. The audience will learn how stereoscopic 3D HMDs can be used in the military aviation environment.
2. The audience will learn about stereo acuity test selection standards for military aircrew.
3. The audience will learn about different test methods to measure stereo acuity.

Thursday, 09/02/2021 ***10:00 AM***
Plaza A/B

[S-63]: PANEL: SPACE SURGERY: PAST, PRESENT AND FUTURE

Chair: Tovy Kamine

Panel Overview: *With the renewed focus on exploration class missions to the Moon by 2024 and beyond, there has been renewed interest in the ability to care for surgical and traumatic disease in both cislunar and interplanetary space. While there has been intermittent research on these disease processes in this population a central group to advocate for research and innovation in procedural medicine in space was lacking. Over the past year a group of individuals dedicated to the advancement and study of procedural medicine in space has formed the Space Surgery Association. The panel will review the history and current capabilities for surgery in microgravity and discuss future surgical and procedural requirements and capabilities on a lunar base. Specifically, after an overview of the Space Surgery Association, the Panel will discuss the history of surgery and procedures in microgravity and austere environments. Following this, the Panel will address development of a system for surgery and procedural medicine in a lunar base. Anesthesia and resuscitation considerations in microgravity will be considered and the utility of prophylactic surgery prior to spaceflight will be discussed.*

[339] SURGERY IN REMOTE ENVIRONMENTS: AN HISTORICAL PERSPECTIVE

Dana Levin[1], Siddharth Rajput[2], Tovy Kamine[3]
[1]Columbia University Medical Center, New York, NY, USA; [2]Royal Australian College of Surgeons, Sydney, Australia; [3]Baystate Medical Center, Boston, MA, USA

(Education - Program / Process Review)

BACKGROUND: Humans are explorers. Our oldest stories are about travelling into the unknown, as are our present dreams, but wherever we go injuries and illness follow. Traditionally, remote medicine has focused on rendering care using minimal, improvised, or carefully curated equipment to fit the limited carrying capacity of remote expeditions. However, most expeditions have occurred within reach of full surgical suites should the need arise. In the past, when expeditions have travelled beyond the reach of tertiary medical care, surgeons have been part of the trip. As we consider such expeditions again, to the far reaches of the solar system, it is worth reconsidering the need for surgical capability. **OVERVIEW:** This presentation reviews expeditions and experiments in surgical capability as it has evolved from the suture kits of thousands of years ago to the modern surgical theatre and zero G surgical experiments. While most modern surgery requires a large team, a vast array of tools, and substantial power, there have been several cases in recent memory of emergency surgery occurring under more austere conditions with far smaller kits.
DISCUSSION: As space agencies consider sending crews on exploration class missions to The Moon, Mars, and beyond the space medicine community needs to consider the risks and needs of humans on such long duration, distant missions. Space medical planners routinely prepare for medical conditions that deteriorate rapidly and need intensive support. However, while conditions requiring surgery often meet this need, invasive surgical capabilities are not included in present operations due to mass, volume, power, and training constraints. Instead, space medicine experts rely on the availability of rapid evacuation to bring patients to surgeons should the need arise. When evacuation is not rapid or not available surgeons must be brought to patients on site or the crew must accept the risk of rapid and often fatal deterioration from what are typically survivable conditions. This presentation discusses historical cases of surgery in remote environments, experiments, and developments in space flight surgery. It is meant to illustrate where we are today and how much work still remains to bring surgical capability to exploration class missions.

Learning Objectives

1. Understand a brief overview of the history of surgical interventions in austere and remote environments.
2. Understand the current state of surgery for space based procedures.

[340] DEVELOPMENT OF SYSTEMS FOR SURGICAL INTERVENTION ON THE MOON

Danyal Fer[1], George Pantalos[2], Peter Lee[3]
[1]University of California San Francisco East Bay, Oakland, CA, USA; [2]University of Louisville, Louisville, KY, USA; [3]Brown University, Providence, RI, USA

(Education - Program / Process Review)

BACKGROUND: Establishing a manned lunar base that involves extended tours on the lunar surface will require a reimagining of how

medical care will be provided on these missions. In particular, the non-zero risk of the need for surgical intervention on lunar missions warrants considering systems to address the surgical issues that may arise. Additionally, the 3 day travel period dictates the prospect of emergent return to Earth is significantly reduced, if not eliminated. The lunar theater can be broken into four primary scenarios that should be considered; lunar orbit, lunar lander, lunar station (without dedicated healthcare) and a lunar colony with dedicated healthcare facilities. Here we will discuss personnel considerations, controlling the surgical environment, providing the tools for surgical intervention, and augmenting the health care provider's (HCP) capabilities through telemedicine, AI and robotics. **OVERVIEW:** As we move from lunar lander-based missions to a lunar colony, the risk of needing surgical intervention increases but presumed payload dedicated to medical capability increases as well. Here we discuss a proposal of personnel selection and training when supporting permanent colonies. Practical considerations for facilitating surgery must be addressed as well. Considerable work has been done on maintaining containment of the surgical field while facilitating instrument use and irrigation. Additionally, developments in 3D printing provide opportunity for generating surgical tools for specific procedures limiting the payload dedicated to specific tools to facilitate surgery and augmenting periodic resupply missions. To address HCP skill, developments in artificial intelligence may provide real-time procedural guidance in concert with ground-based HCPs through telemedicine. Finally advances in robotics can support automation of high complexity surgical tasks. The role that each of these capabilities will fill will be vary based upon the venue, however variations of each capability will likely find a place in each theater. **DISCUSSION:** Personnel selection, training, equipment, AI and robotics will all have a part to contribute to ensuring the capability to perform surgery during lunar missions. There continues to be gaps in capability that must be filled in order to make a surgical capability a reality and these solutions have direct applicability for surgical care where resources may be limited in military and rural venues.

Learning Objectives

1. The audience will understand the critical considerations in determining the skill set of astronauts needed to support a surgical capability on a Moon Colony.
2. The audience will understand the current solutions being tested to control the surgical field and provide tools for surgery.
3. The audience will understand the current state of the art in robotics and artificial intelligence in the context of surgical assistance and guidance.

[341] PERIOPERATIVE AND ANESTHETIC CARE AND RESUSCITATION IN THE SPACE ENVIRONMENT

Arthur Formanek[1], Rowena Christiansen[2]
[1]Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA; [2]The University of Melbourne, Melbourne, Australia

(Education - Program / Process Review)

BACKGROUND: Once exploration beyond Low Earth Orbit becomes a reality, surgery in space will become an inevitable necessity. Terrestrial perioperative medicine relies on established protocols, highly trained staff, and infrastructure to ensure safe care. In addition, critical care medicine will be needed for long duration spaceflight and settlements. **OVERVIEW:** Elements of perioperative care in space will include resuscitation, critical care, and cardiopulmonary support. Necessary equipment for patient care and monitoring would have to be easily transportable or 3D printed. Current knowledge of IV pharmacology, invasive lines, and drainage device management is based on assumption of 1*G* physiology. Intubation presents a unique problem due to considerations for positioning and cranial fluid shift, and an LMA or natural airway at first poses an attractive option. However, microgravity has unknown effects on lung mechanics and gastric contents, making aspiration a very real risk, with pneumonitis or ARDS being potentially grave consequences. Intra-operatively, inhaled anesthetics present a risk for environmental contamination. Regional anesthesia is untested in microgravity and is reliant on skilled providers. Effects of neuraxial anesthesia baricity in microgravity are currently unknown. IV anesthesia (with or without airway control) still requires ready supply of hypnotics, analgesics, skilled providers, and reliable equipment for cardiopulmonary monitoring and support. Adequate volume resuscitation is essential to perioperative and critical care. Challenges currently exist in adequately de-airing IV lines and bags, as current commercially available air-traps capable of handling blood or rapid transfusion do not work in a microgravity environment. Indicators of volume status are prone to pitfalls even in resource rich terrestrial environments with highly trained and proficient providers. Critical care medicine is reliant on real-time assessment of physiology, pathology, and timely interpretation of laboratory values. Delay could prove fatal or make accurate perioperative management impossible. Cardiopulmonary resuscitation has been simulated in microgravity but poses its own unique challenges. **DISCUSSION:** For a realistic prospect of surgery being performed in microgravity, anesthesia and critical care must be readily available. Many obstacles remain before surgery or critical care in space would be a survivable event, and further research is needed.

Learning Objectives

1. Attendees will understand the nature of the challenges associated with perioperative care in the space environment.
2. Attendees will gain an understanding of a variety of anesthetic options suitable for long-duration spaceflight.
3. Attendees will understand the challenges of resuscitation and critical care in the space environment.

[342] PROPHYLACTIC SURGERY FOR DEEP SPACE MISSIONS: HOW POST-OPERATIVE CARE AND COMPLICATIONS CAN INFORM OUR CHOICES

Danielle Carroll[1], Rowena Christiansen[2], Peter Lee[3]
[1]University of Colorado Boulder, Boulder, CO, USA; [2]University of Melbourne, Melbourne, Australia; [3]Brown University and Southcoast Health, Providence, RI, USA

(Education - Program / Process Review)

BACKGROUND: With missions to the Moon and Mars on the near horizon, we must critically re-evaluate medical and surgical capabilities onboard exploratory spacecraft. Mission duration in excess of 3 years for planned Martian missions lends itself to revision not just of inflight treatment planning, but also of pre-flight optimization strategies. Post-operative care and complications in space may share some commonality with terrestrial austere environments such as war and disaster zones. In debating the utility of prophylactic surgery, these considerations represent a "two-edged sword". **OVERVIEW:** The chance of a surgical event among a 4-member crew on a 3-year Mars mission may approach 18%, rendering surgical planning a critical piece in overall medical readiness. Though we have made considerable advancements in medical and surgical capabilities for the spaceflight environment, will technical readiness alone be sufficient to ensure effective treatment of surgical disease? In this presentation, we discuss the current state of knowledge regarding post-operative care in space and parallels from other austere environments; we also explore how the perceived benefits of prophylactic surgery in negating future risk may transfer this risk into the present and add the enduring possibility of post-operative complications. We will conclude with a discussion of risk mitigation strategies and the need for future research. **DISCUSSION:** In hospitals, post-operative care is well-resourced and staffed by well-trained, diverse health professionals. Long-duration spaceflight will disrupt this paradigm. Emergent surgical disease cannot be avoided, but is prophylactic surgery an effective minimization strategy? Newer research suggests that prophylaxis is not entirely benign, and this may contribute to mission risk. One study by an Integrated Medical Model Team[1] (and others) suggests appendectomy carries lifelong risks related to both intra-abdominal adhesions and serious chronic disease. Without prophylaxis, mission risk must be mitigated in other ways. Strategies such as careful astronaut selection and assessment of individual risk profiles, dietary supplementation, and well-researched diagnostic and non-surgical treatment algorithms will all play a part. Further research is needed on post-operative care in austere environments, the possible immuno-protective function of the appendix, and ethical concerns around prophylactic surgery.

[1] IMM Service Request S-20160407-35.

Learning Objectives

1. Understand the nature of the challenges associated with post-operative care in the space environment.
2. Gain an understanding of both sides of the debate about the utility of prophylactic surgery for long-duration spaceflight.
3. Understand the diversity of risk-mitigation strategies to reduce the need for inflight surgery.

Thursday, 09/02/2021 ***10:00 AM***
Plaza D/E

[S-64]: PANEL: ASAMS PANEL: AEROMEDICAL RISK ANALYSIS

Sponsored by American Society of Aerospace Medicine Specialists

Chair: Daniel VanSyoc

Panel Overview: INTRODUCTION: *This is the annual ASAMS sponsored panel that reviews pertinent medical topics with an aeromedical spin and discussion of aeromedical concerns. We will present six topics discussing the current aeromedical risk management.* Topic: *The AsMA panel on aeromedical updates, sponsored by the American Society of Aerospace Medicine Specialists (ASAMS), has been presented annually since 2008. In that time, there have been a total of 89 presentations on 76 topics (several presented more than once). Each has represented a synopsis of the condition, the aeromedical impact, the appropriate management of the condition, and the way forward to accomplish a waiver.*

[343] TRAUMA- AND STRESSOR-RELATED DISORDERS IN USAF AVIATORS - PART 1, ADJUSTMENT DISORDERS

Terry Correll[1]
[1]*USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*

(Education - Tutorial / Review)

INTRODUCTION: Trauma- and stressor-related disorders include adjustment disorders, acute stress disorder, and posttraumatic disorder. These disorders are disqualifying for all flying classes in the U.S. Air Force. Therefore, they have a significant impact on individual and mission readiness. **TOPIC:** Part 1 of this presentation will focus on adjustment disorders. Extended "down" times are common in aviators with adjustment disorders. It is very common for aviators with adjustment disorders to be prescribed a long-term antidepressant, receive no psychotherapy, and not even to be evaluated/treated by mental health. This presentation discusses the treatments for adjustment disorders along with their potential waiverability following treatment and stabilization of the aviator. When managed well, many adjustment disorders never require DNIF periods, and even when they do, their length can be minimized. **APPLICATION:** Excellent evaluation and management (including potentially healthy lifestyle interventions, psychotherapy, and medication) can not only minimize and even avoid DNIF periods, but can enhance resilience to avoid recurrence of similar adjustment disorder episodes. This presentation will simplify the flight surgeon's job by elucidating these concepts and describe effective management strategies for trauma- and stressor-related disorders. **RESOURCES:** 1. Dickey, M, Heacock, KF, Speakman, R. Adjustment Disorder (Aug 20). In: Air Force waiver guide. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2020: 1-4. 2. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*, 5th edition. Arlington (VA): American Psychiatric Association; 2013: 265-290.

Learning Objectives

1. Demonstrate how extensive combat exposure, repeated deployments, and life stressors predispose USAF aviators and special forces to developing adjustment disorders.
2. To understand adjustment disorders and how they can be appropriately diagnosed and managed in the aerospace environment.
3. Examine the impact of allowing maintenance psychotropic antidepressants, psychotherapy, and performance of duty with adjustment disorders.

[344] TRAUMA- AND STRESSOR-RELATED DISORDERS IN USAF AVIATORS – WAIVER CONSIDERATIONS

Ryan Peirson[1]
[1]*USAFSAM, Wright-Patterson AFB, OH, USA*

(Education - Tutorial / Review)

INTRODUCTION: Trauma- and stressor-related disorders include adjustment disorders, acute stress disorder, and posttraumatic disorder (PTSD). These disorders are disqualifying for all classes of flying in the U.S. Air Force. Depending on the severity and duration of the presentations, they may or may not require a waiver. **TOPIC:** Part 2 of this presentation will focus on post-traumatic stress disorder (PTSD) in U.S. Air Force (USAF) aviators and battlefield airmen. Both groups are uniquely positioned to experience significant trauma via extensive combat exposure, especially over the last few decades with ongoing conflicts throughout the world and recurring deployments. When PTSD is suspected or diagnosed in Airmen, the USAF mandates evaluation, treatment, and thorough study of every impacted individual. Treatment plans are required to potentially include psychotherapy, healthy lifestyle interventions, and psychotropic medication(s), or other appropriate somatic therapies. If the service member can continue performing duties while getting treatment, the USAF supports this approach. When necessary, the service member can be taken out of their primary USAF duties to allow full treatment and resolution of symptoms to occur. **APPLICATION:** PTSD is a prevalent condition among military members and is potentially waiver-eligible in USAF aircrew. Residual symptoms after treatment may remain and not impair the member from performing assigned duties. Excellent evaluation and management (including potentially healthy lifestyle interventions, psychotherapy, and medication) can minimize DNIF periods, and can enhance resilience to avoid recurrence. This presentation will highlight these concepts and is primarily relevant to USAF flight surgeons but it also has utility for other military services and civilian flight medicine. **RESOURCES:** 1. Wood J, Heaton J, and Van Syoc D. Post-Traumatic Stress Disorder (PTSD) (June 2017). In: Air Force waiver guide. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2019. 2. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*, 5th edition. Arlington (VA): American Psychiatric Association; 2013: 265-290.

Learning Objectives

1. Participants will understand when a waiver is not required for disqualifying PTSD.
2. Participants will be able to describe common residual symptoms of posttraumatic stress disorder.

[345] ASAMS AEROMEDICAL RISK ANALYSIS - AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE

Charles Mathers[1]
[1]*FAA, Oklahoma City, OK, USA*

(Education - Tutorial / Review)

INTRODUCTION: Autosomal dominant polycystic kidney disease (ADPKD) is an inherited condition, which can lead to a decline in kidney function and hypertension. Aeromedically significant presenting symptoms can include hypertension, hematuria, proteinuria, renal insufficiency, flank pain due to renal hemorrhage, nephrolithiasis, or urinary tract infection. ADPKD can also present with significant extra-renal manifestations, such as cerebral aneurysm, hepatic and pancreatic cysts, cardiac valve disease, colonic diverticula, and abdominal wall and inguinal hernia. **TOPIC:** This presentation will provide an overview of ADPKD and discuss its aeromedical significance, with a specific focus on screening for the presence of cerebral aneurysm. **APPLICATION:** Aeromedical practitioners will gain insight regarding the potential aeromedical risks associated with ADPKD.

Learning Objectives

1. Understand the prevalence of cerebral aneurysm in pilots with autosomal dominant polycystic kidney disease.
2. Recognize aeromedically significant extra-renal manifestations associated with autosomal dominant polycystic kidney disease.

[346] CENTRAL SEROUS RETINOPATHY: MATCHING THERAPY WITH PATHOPHYSIOLOGY

Jonathan Ellis[1]
[1]*Aeromedical Consultation Service, USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*

(Education - Tutorial / Review)

Central serous retinopathy is one of the more common diagnoses seen by ophthalmology at the ACS. Recent studies have elucidated the

underlying causal pathophysiology for CSR, which now allows for targeted therapy. The new recommended treatment paradigm will be discussed to optimize outcomes and reduce DNIF times for aviators.

Learning Objectives

1. Understand the historic and now currently understood pathophysiology of central serous retinopathy.
2. Understand the currently available treatments for central serous retinopathy to include observation, medications, and laser therapies.
3. Understand the differences in DNIF time for aviators for the different available treatments (including observation) for central serous retinopathy.

[347] PAST, PRESENT AND FUTURE OF REFRACTIVE SURGERY IN THE US AIR FORCE

Michael Parsons[1]
[1]USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Education - Tutorial / Review)

INTRODUCTION: A brief history of the Refractive Surgery readiness program will be covered, with emphasis on its continued application today, and future operational and readiness implications. **TOPIC:** The USAF Refractive Surgery program was established to improve Readiness for all USAF Warfighters. Concurrently, it was tailored to meet the unique needs of USAF aircrew in order to ensure that these elite airmen were getting the latest technology, but in a manner that had been demonstrated to be safe and effective for each member. This presentation will discuss the history of the development of the program, unique challenges to having refractive surgery patients in this environment, standards to mitigate risk of visual degradation or deterioration postoperatively, and finally, opportunities/limitations for refractive surgery in aircrew in the future. **APPLICATION:** To best understand the role of the USAF Refractive Surgery program in order to maximize the pool of medically qualified aircrew able to meet mission demands.This presentation will address the purpose of a centrally monitored program for refractive surgery candidates in the aerospace environment, focusing on some of the unique challenges and concerns of refractive surgery specific to aircrew as compared to ground-based airmen. **RESOURCES:** 1. Reinstein, D JRS April 2010 Vol 26 issue 4 259-271. 2. The American Academy of Ophthalmology images collection. 3. Image and slide archives of Warren Hill, MD. (presented at ASCRS 2019 and shared with permission from author). 4. https: //www.edmundoptics.com/resources/application-notes/opticsintroduction-to-modulatation-transfer-function/. 5. http: //ocsurgical.com/crystalens/. 5. http: //www.eyeworld.org/images/New_Articles/2013/09/54_b.jpg

Learning Objectives

1. To best understand the role of the USAF Refractive Surgery program in order to maximize the pool of medically qualified aircrew able to meet mission demands.
2. To describe some of the unique challenges and concerns of refractive surgery specific to aircrew as compared to ground-based airmen.

[348] THE CHANGING ARENA OF MILITARY AEROMEDICAL STANDARDS: AN AEROMEDICAL UPDATE

Daniel Van Syoc[1]
[1]Retired, San Antonio, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: The forces leading to changes in aeromedical standards in the U.S. military are evolving which has led to changes in established standards and practices. **TOPIC:** The AsMA panel on aeromedical updates, sponsored by the American Society of Aerospace Medicine Specialists (ASAMS), has been presented annually since 2008. In that time, there have been a total of 89 presentations on 76 topics (several presented more than once). Each has represented a synopsis of the condition, the aeromedical impact, the appropriate management of the condition, and the way forward to accomplish a waiver. In the past few years, there has been external pressure to alter standards or to develop new standards. I will be presenting three sample aeromedical conditions that fall into that category: color vision, HIV, and gender dysphoria. Each of these three has been presented in past years as a part of this panel, and each of these conditions has either had a long-standing preexisting standard or no prior developed standard. **APPLICATION:** Aeromedical standards are not static and are subject to change based on evidence-based research, changes in approved therapies, and/or changes in direction from higher authorities. Flight surgeons need to be aware that every aeromedical standard is carefully reviewed on a regular basis and major changes can occur for a variety of reasons.

Learning Objectives

1. The audience will understand the political/institutional pressures to change or develop aeromedical standards.
2. The audience will be presented with three examples of changes and learn how they were developed.

Thursday, 09/02/2021 ***10:00 AM***
Plaza F

[S-65]: PANEL: SPACEFLIGHT OPERATIONS IN THE TIME OF COVID-19

Chair: William Valencia
Co-Chair: Serena Aunon-Chancellor

Panel Overview: *The COVID-19 global pandemic has challenged healthcare professionals around the globe in unprecedented ways. The field of aerospace medicine is no exception, and practitioners in the field have been tasked with ensuring the safety of the aerospace medicine community, from aviators to astronauts, during these troubling times. While spaceflight operations have continued during the pandemic, innovative methods for preventing infection, testing in the field and contingencies for infected crew members need to be developed. This panel will highlight some of these approaches carried out by space medicine practitioners, both from NASA as well as commercial space agencies. The first presentation will provide an introduction to COVID-19, with an emphasis on the rapidly developing landscape of testing and treatment that was seen in the early months of the pandemic. The second presentation will describe the medical operations during the COVID-19 pandemic at the Johnson Space Center Flight Medicine Clinic. This will be followed by a presentation that will similarly describe medical operations at SpaceX during the pandemic, at a time when the company launched its first crewed mission. The final two presentations will introduce potential screening and monitoring guidelines that could be used at NASA for crewmembers that have been infected by COVID-19 to ensure a safe return to duty. One will describe screening for the cardiopulmonary and hematologic systems, while the other will focus on neurologic and ophthalmologic considerations. Overall, this panel will provide an overview of the innovative response to a global pandemic from the space medicine community to continue spaceflight operations while ensuring the health and safety of crewmembers.*

[349] COVID-19 FROM 417 KM: A SUMMARY OF THE PATHOPHYSIOLOGY, DIAGNOSIS, TREATMENT OPTIONS, AND IMPLICATIONS FOR SPACEFLIGHT

Stephen Kunkel[1], Matthew Pecha[1], John Marshall[1], Ronak Shah[2], Serena Auñón-Chancellor[2]
[1]University of Texas Medical Branch, Galveston, TX, USA; [2]NASA Johnson Space Center Clinic, Houston, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: Since emerging in late 2019, the COVID-19 pandemic has caused 41 million infections and 1.1 million deaths worldwide as of October 2020, marking the most devastating pandemic of the 21st century. With no vaccine, few effective treatments, and no signs of improving, the SARS-CoV-2 infection and its sequelae must be accounted for in upcoming crewed missions. Here, we summarize SARS-CoV-2 pathophysiology, diagnosis, and treatment options. Companion submissions address organ system-specific consequences and propose guidelines to return astronauts to duty. **TOPIC:** COVID-19 infects people of all ages, with hospitalization and death correlating with age. Coexisting hypertension, hyperlipidemia, chronic kidney disease, diabetes, cardiovascular disease, and chronic inflammatory states portend severe infection and higher risk of death. The

virus interacts with the ACE-2 receptor, and transmission occurs via respiratory droplets with as few as 10 viral particles. Fecal-oral and ocular transmission are also suspected. While many patients are asymptomatic, symptoms can range from upper respiratory complaints to respiratory failure. Severe disease is characterized by an inflammatory response, cytokine and bradykinin storm, sepsis, and a procoagulant state. Infection is diagnosed via RT-PCR, and disease progression can be followed by CT (preferably HRCT). Dexamethasone is currently the only treatment option shown to improve survival. Efforts to study the virus and design an effective vaccine have been stymied by the paucity of effective animal models, as well as the virus's unique clinical manifestations and disease progression-even among members of its own genus such as SARS-CoV and MERS-CoV. Case-fatality rates for astronaut-aged individuals 20-49 years is 0.007%-0.035%. If an astronaut develops and survives COVID-19, significant effects across multiple organ systems are possible, as in the general population. **APPLICATION:** Owing to the breadth and severity of possible COVID-19 symptoms and sequelae, complications could jeopardize an astronaut's ability to fly or have severe ramifications in the flight environment. Correlating acute COVID-19 symptoms and long-term sequelae with the unique physiologic environment of space and astronaut fitness requirements will optimize astronaut assessment and monitoring to ensure their safe return to duty and prevent unforeseen mission complications.

Learning Objectives

1. The participant will learn about the pathophysiology, diagnosis, and treatment options for COVID-19.
2. The participant will be able to understand the importance of accounting for COVID-19 symptoms and sequelae in astronauts.

[350] IMPACT OF COVID-19 TO JSC MEDICAL OPERATIONS AND CONSIDERATIONS FOR DEVELOPMENT OF A CLINICAL PRACTICE GUIDELINE

Ronak Shah[1], Serena Auñón-Chancellor[1]
[1]*NASA Johnson Space Center Clinic, Houston, TX, USA*

(Education - Tutorial / Review)

INTRODUCTION: In order to protect and ensure successful spaceflight operations in low earth orbit, COVID-19 forced an immediate response from the National Aeronautics and Space Administration (NASA) Johnson Space Center (JSC) medical operations team to preserve crew training, critical personnel, aircraft operations, and mission control facilities. **TOPIC:** COVID-19 brought America to a standstill in the spring of 2020. The International Space Station (ISS), however, continued 24/7 operations and was dependent on a continuous influx of crew and cargo to maintain a presence in low earth orbit. The response team at NASA Johnson Space Center was a multi-disciplinary effort that warranted rapid consideration of multiple factors, including changes to launch and landing operations both domestic and international, health stabilization programs, potential spread within the center and preventive measures to limit that spread, aircraft operations, clinic procedures and testing capability, and continuous operations within the mission control center. More recently, the launch of DM-2 with our commercial partner proved to be even more challenging as the first launch from American soil in many years was now occurring in the midst of a global pandemic. **APPLICATION:** This particular talk will discuss the complexity of NASA Johnson Space Center's response at a local, national, and international level to ensure continuous and safe spaceflight training and mission operations.

Learning Objectives

1. Understand NASA Johnson Space Center's operational considerations related to the COVID-19 pandemic.
2. Understand NASA Johnson Space Center's responses to the COVID-19 pandemic endeavoring to ensure continued safe operations.

[351] SPACEX OPERATIONS DURING THE COVID-19 PANDEMIC

Eric Petersen[1], Anil Menon[2]
[1]*University of Arizona College of Medicine Phoenix, Phoenix, AZ, USA;* [2]*SpaceX, Hawthorne, CA, USA*

(Education - Tutorial / Review)

INTRODUCTION: The Covid-19 global pandemic forced rapid changes within SpaceX to continue operations through the Demo-2 mission that returned manned launch capabilities to the International Space Station from the United States, commercial satellite operations, and Starship development. **TOPIC:** The COVID-19 pandemic brought many challenges to commercial spaceflight operations in order to continue to meet deliverable milestones in both crewed and non-crewed missions. The formation of a multi-disciplinary COVID-19 response team allowed for rapid assessment of disease and workplace-based literature to craft and implement policies for site and mission-specific responses. This team allowed for large-scale decisions to be deployed, monitored, and altered as the pandemic progressed and priorities adjusted. Disease screening and workplace adaptations were critical to provide a safe environment for mission critical tasks, including astronaut training and the Health Stabilization Program for DM-2. Lessons learned from that response were adapted and applied to other missions including offshore recovery operations. Engineering, administrative, and PPE policies also allowed the design and manufacturing teams to continue to make rapid progress on commercial satellite contracts and Starship development while promoting the health and safety of each team. **APPLICATION:** This particular talk will discuss the complexity of SpaceX's response at a local, national, and international levels to ensure continuous and safe spaceflight training and mission operations.

Learning Objectives

1. The participant will understand how the crewed health stabilization program for DM-2 was adapted by a commercial provider to the COVID-19 pandemic.
2. The participant will learn how engineering, administrative, and PPE adjustments allowed for the continuation of satellite and Starship design and development.

[352] COVID-19: ASTRONAUT MONITORING AND RETURN TO DUTY: NEUROLOGIC, NEUROCOGNITIVE, OPHTHALMOLOGIC, AND DERMATOLOGIC CONSIDERATIONS

Genevieve Korst[1], John Marshall[1], William Valencia[1], Stephen Kunkel[1], Ronak Shah[2], Serena Aunon-Chancellor[2]
[1]*University of Texas Medical Branch, Galveston, TX, USA;* [2]*NASA Johnson Space Center Clinic, Houston, TX, USA*

(Education - Tutorial / Review)

INTRODUCTION: COVID-19 affects multiple organ systems and may have effects weeks, months, or years into the future. Crew members developing COVID-19 related neurologic, neurocognitive, ophthalmologic and dermatologic sequelae will require thorough testing and monitoring to ensure safe return to duty. **TOPIC:** Mild to moderate neurologic manifestations of COVID-19 include anosmia and ageusia, as well as more severe illnesses such as strokes, meningoencephalitis, inflammatory polyneuropathies and neurocognitive deficits. These illnesses may cause severe impairment of crew members, and deficits may be subtle in early stages, complicating diagnosis and monitoring. In the COVID-19 afflicted crew member, we recommend an initial neurology consultation. Further testing as clinically indicated may include head or plexus magnetic resonance imaging, electromyography, neurocognitive batteries, and Astronaut Strength, Conditioning and Rehabilitation group assessment. Ophthalmologically, conjunctivitis is most common but typically resolves without major consequence. A small percentage of patients with more severe disease may develop cotton wool spots and microhemorrhages. Evidence is conflicting regarding changes to the Retinal Nerve Fiber Layer (RNFL). No vision loss or visual disturbances have been attributed to COVID-19-associated microcirculation defects or RNFL changes. Given Spaceflight Associated Neuro-Ocular Syndrome (SANS) risks in astronauts and its overlap with COVID-19 ophthalmologic manifestations, we recommend monitoring via Ocular Coherence Tomography, fundoscopy and retinal photographs if COVID-19 is diagnosed. Associated dermatologic manifestations include pseudo-chilblain, vesicles, urticaria, maculopapular, livedo or necrosis with possible pruritis, burning or pain. Preexisting skin conditions may be exacerbated during infection. Full skin survey is recommended if COVID-19 is diagnosed. If a new skin lesion is found, it should be monitored for resolution. If an alternative etiology is suspected, laboratory testing and dermatology consultation may be considered. **APPLICATION:** Known and impending COVID-19 sequelae necessitate new clinical practice guidelines to return crew members to duty. These guidelines involve a comprehensive approach befitting the rigorous standards for crew member functional performance.

Learning Objectives
1. Understand major neurologic, neurocognitive, ophthalmologic, and dermatologic manifestations of COVID-19 and their impacts on astronaut function and fitness for duty.
2. Understand the need for and the bases of novel clinical practice guidelines for returning astronauts diagnosed with COVID-19 to duty.

[353] COVID-19: ASTRONAUT MONITORING AND RETURN TO DUTY: CARDIOPULMONARY AND HEMATOLOGIC CONSIDERATIONS

William Fernandez[1], Quinn Dufurrena[1], Michael Rhode[1], Matthew Pecha[1], Brian Rodriguez[1], Omar Leonards[2], Ronak Shah[2], Serena Auñón-Chancellor[2]
[1]University of Texas Medical Branch, Galveston, TX, USA; [2]LSU Health-Baton Rouge, Baton Rouge, LA, USA; [2]NASA-Johnson Space Center, Houston, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: COVID-19 affects organ systems with varying acute, sub-acute, and chronic manifestations. Understanding potential complications is essential for determining when astronaut crew members can return to ground, flight, and spaceflight operations. The diversity of chronic disease progression across cardiopulmonary and hematologic systems necessitates a rigorous, conservative testing regimen to ensure crew member health and readiness for return to duty. **TOPIC:** COVID-19 can result in chronic cardiopulmonary and hematologic manifestations. These may include myocarditis, heart failure, venous thromboembolism, pulmonary hypertension, pulmonary fibrosis, and a persistent inflammatory state. Given this disease diversity, a variety of screening tests may be required to ensure acceptable crew member health prior to returning to duty. To evaluate cardiopulmonary and hematologic health once a crewmember has subjectively returned to an asymptomatic, baseline level of health/function (minimum of two weeks post-COVID-19-recovery), the following tests are recommended: cardiac/inflammatory biomarkers, electrocardiogram (ECG), pulmonary function testing, echocardiogram (echo), duplex ultrasound imaging of all extremities, and possibly cardiac magnetic resonance imaging. If the above tests are reassuring, the crew member may then proceed to exercise treadmill testing with simultaneous VO2 max testing before returning to duty. If any of the above tests are abnormal, the crew member will not proceed to exercise testing and will instead resume post-COVID-19-recovery treatment until test results return to baseline. Additionally, if testing indicates a pulmonary disease pattern (e.g. certain ECG abnormalities, elevated right atrial pressure on echo) or if a deep vein thrombosis is found, the crew member could then progress to computed tomography with angiography and possible right heart catheterization if deemed necessary in consultation with cardiology experts. APPLICATION: The severity of COVID-19 and associated chronic sequelae require novel clinical practice guidelines to ensure the health and continued safety of the astronaut population on the ground, in atmospheric flight, and during spaceflight.

Learning Objectives
1. The audience will learn the most up-to-date chronic manifestations of Covid-19 involving the cardiopulmonary and hematologic systems, and why they are relevant to astronaut duties.
2. The audience will learn the recommended return-to-duty testing for astronauts whom have recovered from Covid-19.

Thursday, 09/02/2021 ***1:30 PM***
Governor's Square 14

[S-66]: SLIDE: WHAT'S NEW WITH HYPOXIA?

Chair: Nicholas Green
Co-Chair: Ross Pollock

[354] CEREBRAL AND PHYSIOLOGICAL RESPONSES TO SUBMAXIMAL EXERCISE IN PILOT TRAINEES IN VARIOUS NORMOBARIC/HYPOBARIC AND NORMOXIC/HYPOXIC CONDITIONS

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(Original Research)

INTRODUCTION: In hypoxic environment, cerebral blood flow regulation is vital to maintain adequate oxygen supply to the brain. The present study aimed to evaluate change in cerebral blood flow velocity (MCAv) and its influence on cerebral oxygen delivery (cDO_2) at rest vs. moderate-intensity exercise, in acute normobaric vs. hypobaric normoxic/hypoxic conditions. **METHODS:** Eighteen healthy pilot trainees (26±3 years old, 177±10 cm, and 70±11 kg) performed a 6-min moderate-intensity exercise (1 W/kg, at 80 rpm) on a cycle ergometer (eBike II basic, GE medical systems, Germany) in four randomized conditions (normobaric normoxia, NN; hypobaric hypoxia, HH and normobaric hypoxia, NH at 5000m; and hypobaric normoxia, HN). Inspired oxygen pressure (P_IO_2) was matched between normoxic (NN vs. HN, 141.2±0.8 vs. 141.5±1.5 mm Hg) and hypoxic (NH vs. HH, 75.7±0.4 vs. 74.3±1.0 mm Hg). Pulse oxygen saturation (SpO_2), heart rate (HR) and MCAv (transcranial Doppler, ST3, Spencer Technology, Seattle, WA) were measured at rest and during exercise as well as rating of perceived exertion (RPE). Repeated measures ANOVAs were performed to assess statistical significance. **RESULTS:** At rest, MCAv was higher in HH (48±7 cm/s) than in NN (43±6 cm/s, p=0.022) and HN (42±5 cm/s, p=0.003). HR was higher and SpO_2 lower in NH and HH than in HN and NN (i.e., hypoxic effect, p<0.001). During exercise, MCAv was higher in HH (57±6 cm/s, p=0.01) than in NN and HN (49±6 and 48±6 cm/s, respectively). Moreover, HH induced greater HR (131±17 bpm, p=0.002) and lower SpO_2 (69.2±5.7 %, p<0.001) than NH (119±15 bpm and 81.4±4.8 %). RPE was higher (p<0.001) in NH (11.3±2.2) and HH (11.8±2.3) compared to NN (8.1±1.3) and HN (9.1±1.3). There was no significant difference in cDO_2 between conditions either at rest or during exercise. No significant difference was reported between NN and HN. **DISCUSSION:** Hypoxemia in NH and HH induced an increase in MCAv to maintain cDO_2 (Brugniaux *et al*., 2007). The present results (i.e., lower SpO_2 and greater HR) confirm the more severe condition in HH than in NH (DiPasquale *et al*., 2015; Savourey *et al*., 2003). However, the effect of hypobaria seems negligible in normoxic conditions since there was no difference in MCAv, HR and SpO_2 between NN and HN. These findings are of clinical importance for pilots training in flight simulator (i.e. NH) to prepare for flights hypoxic events at real altitude in HH.

Learning Objectives
1. How is cerebral oxygen delivery (cDO2) modulated in hypoxic and hypobaric conditions during low-intensity cycling exercise.
2. Physiological responses to low-intensity cycling exercise in normobaric hypoxia, hypobaric hypoxia and hypobaric normoxia.

[355] DELAYED RECOVERY OF A NEURAL MARKER OF AUDITORY PROCESSING FOLLOWING ACUTE HYPOXIA

Daniel McHail[1], Kyle Pettijohn[1], Kara Blacker[1]
[1]Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Hypoxia impairs cognition broadly and remains a primary threat in aviation. Compounding this threat, recovery from hypoxic exposure is delayed, as hypoxia-induced deficits in reaction time (RT) may persist for over 2 hr post-exposure (Phillips et al., 2015). To help inform return to duty criteria for individuals following hypoxic exposure, it is necessary to better understand the neurophysiological response to hypoxia during both exposure and recovery. Recently, electroencephalography (EEG) experiments showed that the mismatch negativity (MMN) and P3a signal complex, an index of auditory processing integrity, is sensitive to hypoxia (Seech et al., 2020). In the current study, we track the MMN/P3a for 4 hr following an acute normobaric hypoxia exposure to characterize the time course of recovery. **METHODS:** In a within-subjects design, 20 participants were recruited for the study. In each session, the MMN/P3a was elicited via infrequent "oddball" tones delivered to earbuds interspaced with frequent "standard" tones while participants completed a computerized psychomotor vigilance task (PVT) for 10 min. During an initial baseline visit, participants completed 2 sessions while either breathing 21% or 100% O_2. During two separate recovery visits, participants completed a session with 6 time points: while breathing either 9.7% O_2 (i.e., hypoxia), breathing recovery gas immediately following and 20 min after the hypoxia exposure, and then while breathing normal room air 60, 120, 180, and 240 minutes post-exposure. Participants immediately recovered on either 21% or 100% O_2 (order counterbalanced) during the two recovery visits. **RESULTS:** PVT RT and MMN/P3a latency and amplitude were computed for each time

point. Compared to baseline levels, RT slowed during and immediately following hypoxia and gradually returned to baseline levels during the 4 hr recovery. Similarly, the amplitude of the MMN/P3a complex was reduced during hypoxia relative to baseline, continued to decrease up to 20 min post-exposure, and then gradually returned to baseline during the remainder of the 4 hr recovery session. **CONCLUSIONS:** These results agree with previous findings showing delayed recovery of RT following acute hypoxic exposure. Further, they demonstrate a similar time course for the recovery of neural activity underlying sensory processing. These findings will help inform return to duty criteria following a hypoxic exposure and/or hypoxia training.

Learning Objectives

1. The audience will learn about a novel method for detecting sensory processing impairment due to hypoxia.
2. The audience will learn about the time course of recovery from an exposure to hypoxia.

[356] EFFECT OF NOISE AND HYPOXIA ON RISK TAKING BEHAVIOR: A CAUSE FOR ONCERN IN AVIATORS?

Devdeep Ghosh[1]
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(Original Research)

INTRODUCTION: Cognitive performance issues in pilots are pervasive in nature and have important flight safety implications. Larger Implicit Association Test (IAT) effect increases pilot's risk-taking behavior that may lead to hazardous consequences in high risk situations. Deterioration of cognitive function due to hypoxia is a historically proven fact. The effect of noise on cognition is equivocal from detrimental to no effect, even improvement. Literature regarding the concurrent effect of these dual stressors on cognitive function are sparse. In this study, an effort has been made to assess the effect of white noise and simulated hypoxia of 14,000 ft altitude on human cognitive function independently as well as concurrently.

METHODS: Cognitive performance viz. implicit association was assessed in 30 healthy volunteers sequentially in four different conditions- at ground level (Baseline condition without any stressors), ground level with 85 db(A) noise, 14,000 ft simulated altitude and 14,000 ft simulated altitude with 85 dB (A) noise. Explosive decompression chamber was used for altitude simulation and white noise was generated through software. Cognitive performance was assessed with Psychology Experiment Building Language (PEBL) test battery. Data were analyzed using descriptive statistics, Repeated measure ANOVA and Post-hoc test. **RESULTS:** The study revealed significant decrement of implicit reaction time at 14,000 ft altitude, 85 dB(A) noise as well as concurrent altitude and noise ($p<0.05$). Implicit correctness had statistically insignificant reduction in three study conditions. Decreased SpO_2 due to altitude exposure as well as increased heart rate in both noise and altitude exposure were the normal physiological responses of the human body. **DISCUSSION:** Noise and hypoxia both individually and concurrently may influence pilot's risk taking behavior and hence jeopardize flight safety. Proper installation of noise attenuating mechanisms to keep the noise level well within psychological comfort zone as per European Standard or Mil Std 1417D is essential. Awareness of the aircrew community about the potential psychological side effects of noise and hypoxia beyond the psychological comfort zone needs to be ensured.

Learning Objectives

1. The audience will understand the importance of the effect of noise and hypoxia on pilot's risk-taking behavior.
2. The audience will understand the potential psychological side effects of noise and hypoxia beyond the psychological comfort zone.

[357] EXOGENOUS KETOSIS FOR IMPROVING HUMAN COGNITIVE PERFORMANCE DURING HYPOXIA

Olivia Jackson[1], Michelle Harper-Sciarni[1], Dawn Kernagis[1], Jeff Phillips[1]
[1]*The Institute for Human and Machine Cognition, Pensacola, FL, USA*

(Original Research)

INTRODUCTION: Studies have shown that during altitude-induced hypoxia, cognitive capacity degrades. In an operational setting, this can compromise performance. In an investigation into a potential solution for mitigating hypoxia effects on cognition, we observed that the impact hypoxia has on cognition differs by test type, suggesting that different cognitive processes are affected. Prior research has not identified these cognitive processes. Our findings begin to reveal these processes. **METHODS**: The study that led to the findings was a randomized, crossover study that investigated the effects of a metabolic intervention on cognitive performance during normobaric hypoxia exposure. Eleven healthy male military aviation students were recruited. Participants completed several occulometric-based cognitive tests, in addition to several tablet-based cognitive tests under normoxic and hypoxic conditions following consumption of an experimental and a placebo drink. Relevant here is the effect that hypoxia had on cognition under the placebo condition. **RESULTS**: Results indicated a significant hypoxia effect for only one of the tablet-based cognitive assessments (code substitution) and one among the occulometric tests (blink duration). Specifically, under the hypoxia condition participants performed significantly poorer on the code substitution task and had shorter blink durations compared to when under the normoxic condition. **DISCUSSION:** The findings in this study provide an understanding of the types of cognition affected by hypoxia. Knowing this may help identify operational tasks negatively impacted at higher altitudes. Finding a significant cognitive effect for the more complex assessment and not the simpler assessments suggests that simple tasks requiring lower level cognitive processes such as quick reaction time (e.g., target detection) may not be affected by hypoxia. On the other hand, more complex tasks requiring higher order cognitive processes such as working memory (e.g., receiving and executing a close air support mission) could be affected to a greater degree.

Learning Objectives

1. Gain a better understanding of the types of cognition affected by hypoxia.
2. Identifying operational tasks that could negatively impact operators at higher altitudes.

[358] EXPOSURE TO HYPOXIA DEGRADES AWARENESS OF ENVIRONMENT IN HELICOPTER CREWS

Yuval Steinman[1], Monique Frings-Dresen[2], Eric Groen[3]
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(Original Research)

INTRODUCTION: Helicopter cabins are not pressurized, and most helicopters are not equipped with oxygen systems. Therefore, hypoxia is a realistic hazard for helicopter pilots flying at altitude. The purpose of the present simulator study was to determine whether hypoxia affects awareness of environment (AoE) in helicopter pilots in an operationally relevant scenario. **METHOD:** Eight Apache helicopter crews, consisting of two pilots, participated in a counterbalanced, single blinded repeated measures study. The crews flew two operational flights in a flight simulator while breathing gas mixtures of 20.9% (equivalent to 0 ft. altitude) and 11.4% (equivalent to 15,000 ft altitude) oxygen. Each flight included five missions of about 15 min, during which environment items were introduced that the crews needed to be aware of and respond to. **RESULTS:** In the 15,000 ft. condition, the crews missed more than twice as many environment items than they did in the 0 ft. condition. In contrast, the crews' technical skills (TS) were not significantly affected by altitude. The majority of pilots did not notice being hypoxic, and did not recognize their hypoxia symptoms during the simulation flight at 15, 000 ft. **DISCUSSION:** We showed that hypoxia has a detrimental effect on a pilot's awareness of environment while pilot's technical skills were unaffected. Performing hypoxia training in a flight simulator can help pilots recognize in-flight hypoxia symptoms and their effects on performance.

Learning Objectives

1. The audience will learn about importance of hypoxia training in a flight simulator.
2. The audience will learn how exposure to hypoxia effects awareness of environment.

[359] HYPERVENTILATION AND HYPOXIA HANGOVER DURING NORMOBARIC HYPOXIA TRAINING IN A HAWK SIMULATOR

Nikke Varis[1], Antti Leinonen[2], Hannu Kokki[2], Tuomo Leino[3]
[1]*Faculty of Medicine and Health Technology, Tampere University, Tampere, Finland;* [2]*School of Medicine, University of Eastern Finland, Kuopio, Finland;* [3]*Aeromedical Centre, Centre for Military Medicine, Helsinki, Finland*

(Original Research)

INTRODUCTION: Oxygen emergency is a major threat to a high altitude aviator. There is variation between individuals' physiological response and tolerance to hypoxia. Based on clinical observation of normobaric hypoxia training in the Finnish Air Force, we assumed that pilots who hyperventilate, develop the most severe hypoxia symptoms. The aim of this study was to evaluate how normobaric hypoxia affects pilots' ventilation and flight performance in Hawk simulator during operational flight sortie. **METHODS:** Twelve volunteered fighter pilots from the Finnish Air Force participated in double blinded, placebo controlled, randomized study. The subjects performed three flights in a tactical Hawk simulator with full flight gear and mask on. In two of the flights hypoxia was induced using 8% or 6% oxygen and one flight was a control flight using normoxic, 21 % oxygen breathing air. Ventilation volume was measured before, during and after hypoxia. SpO_2, heart rate and ECG were monitored. Flights were conducted in randomized order with pilots and flight instructors both blinded to the gas mixture. Pilots performed tactical maneuvering at high altitude until they recognized symptoms of hypoxia. After that they performed hypoxia emergency procedures with 100 % oxygen and returned to base with GPS malfunction and waterline HUD mode during ILS approach. The flight performance was evaluated by two flight instructors on a scale of 1 to 5, with 1 being the worst and 5 being the best result. **RESULTS:** Ten minutes after hypoxia and emergency procedures, flight performance was significantly decreased from 4.5 (control flight) to 3.8 with 8% oxygen ($p=0.03$) and to 3.3 with 6% oxygen ($p=0.01$) during ILS approach. Ventilation volume increased during hypoxia from 12.9 L/min (control flight) to 18.5 L/min ($p<0.01$), and 20.9 L/min ($p<0.01$), respectively. No correlation was found between subjects' ventilation volume and flight performance. **DISCUSSION:** Even moderate normobaric hypoxia has a long-lasting effect on pilot's flight performance although hypoxia emergency procedures are executed without delay. This phenomenon is known as hypoxia hangover. Physiological response causes reflectory hyperventilation during normobaric hypoxia which leads to hypocapnia. Based on this study, it does not correlate with worsened hypoxia hangover.

Learning Objectives

1. Pilots' flight performance is substantially decreased even 10 minutes after a normobaric hypoxic incidence.
2. Hyperventilation during normobaric hypoxia pre se may not affect pilots flight performance.

Thursday, 09/02/2021 ***1:30 PM***
Governor's Square 15

[S-67]: PANEL: OPTIMIZING PERSONNEL SELECTION IN THE AVIATION ENVIRONMENT: TECHNIQUES, METHODS, AND CONSIDERATIONS

Chair: Tatana Olson

Panel Overview: *In the high stakes environment of military and civil aviation, an effective personnel selection program is critical to ensuring individuals possess the knowledge, skills, abilities, and other characteristics necessary for successful job performance. However, it is not always clear what factors to consider when designing and implementing a selection program. This panel includes five presentations discussing techniques, methodological considerations, and best practices for the assessment and selection of naval aviators, unmanned aircraft system (UAS) operators, and civilian air traffic controllers. The first presentation from the Naval Aerospace Medical Institute (NAMI) provides an overview of the Aviation Selection Test Battery (ASTB), the primary tool used to select naval aviation candidates for the Navy, Marine Corps, and Coast Guard. The second and third presentations discuss the purpose, design, and advantages of using computer adaptive testing and approaches for mitigating adverse impact within the context of pilot selection. The panel concludes with presentations on the development and validation of a selection test for UAS operators from the Naval Medical Research Unit-Dayton, and a discussion from the Federal Aviation Administration (FAA) of the unique features and challenges associated with the selection of air traffic controllers.*

[360] COMPUTER ADAPTIVE TEST DESIGN IN NAVAL AVIATION SELECTION TESTING

Henry Phillips[1]
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(Education - Program / Process Review)

BACKGROUND: Computer-adaptive testing (CAT) formats have existed for over 70 years and are used widely in high-stakes testing applications (Embretson & Reese, 2002). Advantages of CAT over static test design include individualized test construction, improved test security, shorter test duration, and improved score accuracy. Statistical assumptions underlying CAT ensure that scores on tests comprised of different items are still comparable. CAT design requires large amounts of data, and delivery requires management of a large item library or libraries. **OVERVIEW**: This presentation will describe the purpose, design, and advantages of the use of CAT on multiple-choice assessments included in the Aviation Selection Test Battery (ASTB), the tool used to select candidates for naval aviation training. **DISCUSSION**: Discussion will also include a short explanation of fundamental assumptions underlying classical test theory and item response theory, the 3 parameter logistic (3PL) model of response prediction, the expected a priori method of test score (theta) estimation, a short explanation of differential item functioning and differential test functioning estimation, and a brief discussion of model fit calculations.

Learning Objectives

1. Understand the general process by which test items are selected for inclusion in a computer-adaptive test.
2. Understand the advantages yielded by computer-adaptive testing over static form testing.

[361] PERSONNEL SELECTION FOR AIR TRAFFIC CONTROLLERS: A SPECIALIZED APPROACH

Kelley Krokos[1], David Hamill[2]
[1]*North Carolina State University, Raleigh, NC, USA;* [2]*University of Baltimore, Baltimore, MD, USA*

(Education - Program / Process Review)

BACKGROUND: Each day, thousands of aviation professionals manage the National Airspace System (NAS) to ensure that aircraft navigate their cargo and passengers to their destinations safely and efficiently. Among these professionals are more than 14,000 air traffic controllers. Given that it can take years of training to achieve certified professional controller (CPC) status, and given the safety critical nature of the controller job, the FAA devotes significant resources to its controller selection program. An FAA panelist will describe the program's history and some of its unique features. **OVERVIEW:** The FAA's controller selection program consists of numerous steps in a multiple hurdle approach. Applicants begin their journey by submitting their application, followed by minimum qualification screening. Next, applicants must pass a pre-employment selection test battery and—after receiving a conditional offer of employment—must pass medical and psychological examinations prior to reporting for basic training. In support of the development and validation of these steps, the FAA routinely conducts job analyses to ensure that selection procedures accurately reflect job requirements and replaces its selection procedures and instruments as needed. Experienced job analysts, technical subject matter experts, managers, and labor representatives contribute. Legal requirements and professional standards guide every decision. **DISCUSSION:** The FAA's selection program requires specialized approaches. Aviation is a high-risk industry that is closely tied into the nation's security and its economy; it is closely scrutinized. We must respect the public trust that has been placed in us. The controller job is a single occupational series, but it is performed in three different facility types. Differences and similarities by facility type must be considered. The FAA is the only non-military employer; a

significant portion of our controller applicant pool has no air traffic control knowledge or skill. Consequently, our selection procedures must be based primarily on abilities and other non-technical worker characteristics. The NAS is constantly evolving; the controller job must be evaluated on an ongoing basis to determine whether it has also changed and modifications made accordingly. The FAA panelist will highlight some of these special features.

Learning Objectives

1. Identify two situational characteristics that influence how a personnel selection system can and should be designed and implemented.
2. Describe how the multiple hurdle approach to personnel selection is different than the compensatory approach.

[362] DEVELOPMENT AND VALIDATION OF SELECTION FOR UNMANNED AERIAL SYSTEMS (UAS) PERSONNEL (SUPER)

Tatana Olson[1]
[1]*Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA*

(Education - Program / Process Review)

BACKGROUND: In 2013, the Office of Naval Research funded a program titled UAS Interface, Selection, and Training Technologies (UASISTT), one of the goals of which was development of a selection battery for UAS Operators of Group 3, 4, and 5 platforms. This battery was developed by Georgia Tech with support from the Naval Medical Research Unit – Dayton (NAMRU-D), Naval Aerospace Medical Institute (NAMI), Naval Air Systems Command (NAVAIR), Air Force Research Laboratory (AFRL), and Air Force Personnel Center (AFPC) over a five year period, delivered in 2018. **OVERVIEW:** The battery was originally comprised of 15 subtests based on a mission-task analysis, and criterion-validated against performance on a UAS simulation designed for this purpose among a sample of Georgia Tech students. Construct and additional criterion-related validation was conducted using additional samples at Ft. Huachuca (Enlisted N = 38), NAS Pensacola (Officers N = 237), Naval Special Warfare Coronado (Enlisted N = 28), Springfield Air National Guard (N =4), and Randolph Air Force Base (Officers N = 219). Although field training performance and attrition data were limited, preliminary validation data were collected in a laboratory setting using a realistic UAS simulator. **DISCUSSION:** A reduced version of the battery was delivered using a secure web-based test delivery platform called APEX, and consists of seven subtests, including: Paragraph Completion, Spatial Orientation, Following Directions, Memory for Landmarks, Dial Reading, Necessary Facts/Word Problem Solving, and Traffic Navigation. Additional data collection is planned to establish platform-specific criterion-related validity evidence and recommended cut scores for operators of the MQ-25 Stingray, MQ-4 Triton, and MQ-8 Firescout. Validation work to date has not incorporated any Navy UAS training data.

Learning Objectives

1. The participant will understand why an Unmanned Aerial System Operator selection battery is needed.
2. The participant will learn which aptitudes are assessed by the Selection for Unmanned Aerial Systems (UAS) Personnel (SUPer) instrument and why they matter.

[363] MITIGATING ADVERSE IMPACT IN SELECTION TESTING BY INCORPORATING NEW CONSTRUCT ASSESSMENTS IN THE PERFORMANCE-BASED MEASURES (PBM)

Brennan Cox[1]
[1]*Auburn University, Dayton, OH, USA*

(Education - Program / Process Review)

BACKGROUND: The Uniform Guidelines on Employee Selection define adverse impact as a condition in which the selection ratio for a protected group making up 2% or more of the applicant population is less than 80% of the selection ratio of the majority group. The existence of adverse impact in itself is not evidence of unfairness, but does require demonstration of criterion-related validity evidence for selection tools used in the private sector. **OVERVIEW:** The US Navy carefully monitors the levels of adverse impact present in its selection tools. This presentation will discuss the degree of adverse impact observed in selection ratios yielded for different groups by scores on the Aviation Selection Test Battery (ASTB), the tool used to select candidates for naval aviation training. **DISCUSSION:** Discussion will address how the incorporation of a series of performance-based measures (PBM) in 2013 assessing audio information processing, psychomotor skills, divided attention, spatial ability, and response under stress changed the selection ratio differences between majority and minority applicants in some groups, and reasons for those observed changes. Discussion will conclude with a consideration of alternatives to optimized Ordinary Least Squares (OLS) regression weighting schemes that can yield similar multiple R estimates for the prediction of training outcomes but less adverse impact after cross-validation.

Learning Objectives

1. Understand the process by which adverse impact estimates are calculated.
2. Understand the implications of the existence of adverse impact on a selection instrument.

[364] OPTIMIZING PERSONNEL SELECTION IN THE AVIATION ENVIRONMENT - TECHNIQUES, METHODS, AND CONSIDERATIONS

Ken King[1]
[1]*Navy Medicine Operational Training Center (NMOTC), Pensacola, FL, USA*

(Education - Program / Process Review)

BACKGROUND: The Aviation Selection Test Battery (ASTB) is the selection instrument used to identify candidates eligible for Naval aviation training as student naval aviators and student naval flight officers in the Navy, Marine Corps, and Coast Guard. **OVERVIEW:** The ASTB is comprised of six sections, including math skills, reading comprehension, mechanical comprehension, aviation and nautical information, a forced-choice adaptive personality assessment, and a performance based measures (PBM) battery assessing audio information processing, psychomotor skills, divided attention, spatial ability, and response under stress. These sections yield score components designed to predict academic performance, primary phase flight performance, and training attrition. The ASTB score components exhibit uncorrected criterion-related validity coefficients for the prediction of continuous academic and flight training criterion variables between r = 0.30 and 0.52, and components of the ASTB exhibit biserial correlations with training completion as high as r_b = .23. **DISCUSSION:** Evidence of the incremental contributions of ASTB sections to multiple R will be reviewed. Finally, the presentation will outline the process by which utility estimates of $52M/FY in training cost avoidance yielded by the ASTB are calculated. Discussion will also include a summary of the secure web-based test delivery APEX system used to administer and manage the battery.

Learning Objectives

1) Understand the process by which cost avoidance estimates for use of the Aviation Selection Test Battery are derived.
2) Understand the degree of predictive validity yielded by the Aviation Selection Test Battery for the prediction of naval aviation training outcomes.

Thursday, 09/02/2021 ***1:30 PM***
Plaza A/B

[S-68]: PANEL: PAST, PRESENT, & FUTURE OF NASA'S BIOMEDICAL FLIGHT CONTROLLERS

Chair: Jamie Moore

Panel Overview: *The Biomedical Engineer Flight Controllers (call sign: BME) support the Mission Control Center (MCC) operations at NASA Johnson Space Center (JSC). Together with the Flight Surgeons, BMEs serve as the Medical Operations representatives to the Flight Director and the rest of the Flight Control Team in MCC. The primary responsibility of the BME position is to ensure that all medical requirements are implemented appropriately for in-flight crewmembers. In doing so, the BME supports the Flight Surgeon and the rest of the NASA medical community in ensuring medical hardware operability, medical monitoring activity scheduling, medical data downlink*

and distribution, among other duties. The BMEs have a long history of supporting astronaut health during spaceflight, starting with the inception of the Space Shuttle Program, continuing support and adding an expansion of scope throughout the International Space Station (ISS) Program, where BME support was extended to NASA's International Partners (IPs), and currently planning to continue forward towards NASA's future lunar and exploration programs. The BME team has continued to evolved through the years, by incorporating new technologies in the MCC environment, taking on new and expanding console responsibilities, and furthering collaboration between teams. Each phase of BME flight control and the evolution of the role will be discussed if the following five areas: (1) Shuttle-era BME Flight Control; (2) Early ISS-era BME Flight Control; (3) Current ISS BME Flight Control; (4) IP BME Flight Control; and (5) Future of BME Flight Control. The service that the BMEs provide is critical to the continued success of protecting astronaut health during spaceflight, and the BME position's evolution through the years has allowed for more advanced medical operations support, with lessons learned that would carry forward to future space programs.

[365] SPACE SHUTTLE BME FLIGHT CONTROL

Robert Janney[1]
[1]*KBR, Houston, TX, USA*

(Education - Program / Process Review)

BACKGROUND: The Biomedical Engineer Flight Controllers (call-sign: BME) have a extensive history of providing flight control support in the Mission Control Center (MCC) at Johnson Space Center (JSC) for crewed missions. For the Space Shuttle Program, the BME position was developed and implemented as a real-time support position for the Flight Surgeon (call sign: SURGEON). The primary responsibility of the Shuttle BME flight controller was to offload many of the non-medical requirements of the SURGEON Flight Control Room (FCR) position, allowing for enhanced focus on the medical aspects of the mission. **OVERVIEW:** This briefing will discuss the roles and responsibilities of the Shuttle BME flight controller, starting in the early part of the Space Shuttle Program; followed by the evolution of the position from the days of analog flight control through the digital transformation of Mission Control and into longer duration missions, concluding with joint missions with the ISS flight control team and the close out of the Space Shuttle Program. **DISCUSSION:** To understand the evolution of the BME flight control position in MCC through multiple spaceflight programs, it is important to establish a baseline reflecting how and why the position was established. This briefing will set the stage for the follow-on presentations, tracing the growth of the BME flight controller position from a one-person backroom support arrangement to a critical FCR discipline team with substantial responsibilities directly reporting to the Flight Director.

Learning Objectives

1. Understand the roles and responsibilities of the Biomedical Flight Controllers that supported the Space Shuttle Program.
2. Understand how and why the Biomedical Flight Controller position evolved throughout the years of the Space Shuttle Program.

[366] EARLY ISS BME FLIGHT CONTROL

Ted Duchesne[1]
[1]*KBR, Houston, TX, USA*

(Education - Program / Process Review)

BACKGROUND: The Biomedical Engineer Flight Controllers (call sign: BME) support International Space Station (ISS) Mission Control Center (MCC) operations at NASA Johnson Space Center (JSC). Together with the Flight Surgeons, ISS BMEs serve as the Medical Operations representatives to the Flight Director and the rest of the Flight Control Team in ISS MCC. The ISS BME shares two primary responsibilities, the first is to ensure the on-orbit crew properly implements the medical requirements. The second is to support and respond to on-orbit issues with the Crew Health Care System (CHeCS) Hardware on the ISS. **OVERVIEW:** To look at the initial concept of operations for ISS BME console support. In the previous panel presentation, the BME support of Shuttle missions was discussed. This panel will break down the primary differences between the Shuttle BME and the ISS BME, focusing on the broad scope of hardware supported by the ISS BME, the depth of medical requirements that needed to be implemented, and the difference in on-orbit duration of the crews. The panel will highlight how the initial plans of console support were developed. The initial support concept of operations had the ISS BME in charge of almost all aspects of hardware support and implementation of requirements. Eventually this support evolved as the on console and in office, workload was better understood. **DISCUSSION:** Understanding the initial ISS BME flight control support and how initial lessons learned were quickly implemented to create a better workload balance shows that one must be able to adapt their plans to reality. This panel will show that even the best-laid plans must be able to adapt to how the mission actually runs. The lessons learned and how they were implemented continue to have an effect on the planning of future BME flight control in support of NASA programs currently in development, including Orion, Artemis, Gateway, and further exploration. By ensuring NASA's medical requirements are implemented operationally, the BMEs play a vital role in ensuring in-flight astronaut health, thereby supporting the future of human spaceflight.

Learning Objectives

1. Understand how the initial support operations for the ISS BME developed from the Shuttle BME era.
2. Understand how initial lessons learned from early ISS BME flight control experience were quickly implemented to develop a better workload balance both on console and in the office.

[367] CURRENT ISS BME FLIGHT CONTROL

Jamie Moore[1]
[1]*KBR, Houston, TX, USA*

(Education - Program / Process Review)

BACKGROUND: The Biomedical Engineer Flight Controllers (call-sign: BME) support International Space Station (ISS) Mission Control Center (MCC) operations at NASA Johnson Space Center (JSC). Together with the Flight Surgeons, ISS BMEs serve as the Medical Operations representatives to the Flight Director and the rest of the Flight Control Team in ISS MCC. The primary responsibility of the ISS BME position is to ensure that all medical requirements are implemented appropriately for in-flight crewmembers. In doing so, the ISS BME supports the ISS Flight Surgeon and the rest of the NASA medical community in ensuring medical hardware operability, medical monitoring activity scheduling, medical data downlink and distribution, among other duties. **OVERVIEW:** To look at the current posturing of ISS BME console support requires a comparison against past console support. In the previous panel presentation, the genesis of ISS BME support and 3-crew ISS operations were discussed. A turning point for the ISS BMEs began when the ISS transitioned from 3-crew to 6-crew operations. Since the ISS BME's duties revolved around the crewmembers, more crew equated to more work, and therefore the ISS BME team sought out efficiencies wherever possible. Also, as hardware and software technologies advanced, the ISS BMEs were dealing with an increased complement of medical devices and many upgrades to existing devices to better meet the medical needs of the crew and/or to test out new technologies for future space exploration programs. **DISCUSSION:** Understanding current ISS BME flight control support provides a basis for planning out efficient and effective future BME flight control in support of NASA programs currently in development, including Orion, Artemis, Gateway, and further exploration. By ensuring NASA's medical requirements are implemented operationally, the BMEs play a vital role in ensuring in-flight astronaut health, thereby supporting the future of human spaceflight.

Learning Objectives

1. Understand how the current ISS BME flight controllers have adapted to increasing console demands due to transition to 6-person ISS crew.
2. Understand how current ISS BME flight controllers provide specialized support for the medical hardware/software technologies on the ISS.

[368] INTERNATIONAL PARTNER (IP) BME FLIGHT CONTROL

Frits de Jong[1]
[1]*ESA, Cologne, Germany*

(Education - Program / Process Review)

BACKGROUND: The International Partner (IP) Biomedical Flight Controllers (call sign: BME) support medical operations for their

segments of the International Space Station (ISS) and for crewmembers representing their agencies, which includes the European Space Agency (ESA), Japanese Aerospace Exploration Agency (JAXA), and Canadian Space Agency (CSA). The IP BMEs work in close coordination with the BMEs that support NASA Mission Control Center (MCC) operations at Johnson Space Center (JSC). The coordination between the IP BMEs, the NASA BMEs, and the Flight Surgeons ensures that all medical requirements and issues are properly executed and addressed when an IP crewmember is onboard. An efficient collaboration between the NASA team and the different IP medical teams is crucial to ensure IP crewmember and overall mission success. **OVERVIEW:** The IP BME represents the entire IP medical team when they are on console at their respective Mission Control Center, and in their interactions with the NASA BME. The duties of an IP BME differ depending on if an IP crewmember is onboard or not. The IP BME team's support of an IP crewmember's mission includes pre-flight, in-flight, and post-flight support of the IP Space Medicine team and the crewmember. When an IP crewmember is not on orbit, the IP BME team's support scales back while maintaining operational awareness and preparation for the next IP crewmember. Console support varies from agency to agency. This pitch will focus on the IP BME support provided by ESA over a period of 15 years, how ESA's support concept developed over the years and how ESA dealt with operational budget restrictions. In addition, this pitch will provide some high-level insight on the way JAXA and CSA have implemented their BME responsibilities. **DISCUSSION:** It is likely that IP crewmembers will continue to be a part of NASA's future space programs. Understanding IP BME flight control support and how the cooperation between the IP and NASA BME teams have improved and developed will be useful in planning out efficient and effective BME flight control in support of the space programs currently in development, including Orion, Artemis, Gateway, and further exploration. Through the years, the IP BMEs and NASA BMEs have developed into a cohesive team who play a vital role in ensuring in-flight health and well-being for all astronauts from all IPs, thereby supporting a truly collaborative and international effort in human spaceflight.

Learning Objectives

1. Understand how the collaboration between IP BME flight controllers and NASA BME flight controllers contributes to the successful continuation of keeping all astronauts healthy during spaceflight.
2. Understand that different IPs have very different concepts in providing real time medical operations support to their ISS crew member.

[369] FUTURE OF BME FLIGHT CONTROL (ORION, GATEWAY, LUNAR)

Chris Van Velson[1]
[1]*KBR, Houston, TX, USA*

(Education - Program / Process Review)

BACKGROUND: The Biomedical Engineer Flight Controllers (call-sign: BME) have a vast history of providing flight controller support in the Mission Control Center (MCC) for crewed missions from Shuttle to ISS, and now plans for Exploration. BME responsibilities have evolved over the past 3 decades and will continue to evolve for Exploration (Orion, Gateway, Lunar), the future of Medical Operations support. **OVERVIEW:** The Exploration missions will bring new challenges and some challenges not experienced since the Apollo program. BMEs will need to adapt while still continuing to maintain a strong, trusted relationship with the Flight Surgeons in order to provide optimal medical operations for the astronauts. **DISCUSSION:** Having astronauts travel in the Orion capsule, dock to Gateway, travel to the lunar surface, and perform EVAs on the lunar surface will be both exciting and challenging. The BME will continue to play a vital role in ensuring in-flight astronaut health for Exploration missions, the future of human spaceflight.

Learning Objectives

1. Understand the Exploration Design Reference Missions and how differ from other current and previous Programs.
2. Understand how the Exploration Design Reference Missions will drive changes in the BME Flight Controller support.

Thursday, 09/02/2021 ***1:30 PM***
Plaza D/E

[S-69]: SLIDE: CARDIAC AND DIABETIC RISKS - NEW APPROACHES

Chair: Robert Orford
Co-Chair: John Barson

[370] THE FEASIBILITY OF DNA TESTS IN CORONARY ARTERY DISEASE RISK PREDICTION

Denis Bron[1]
[1]*Aeromedicalcenter Swiss Airforce, Duebendorf, Switzerland*

(Original Research)

INTRODUCTION: Family history is a risk factor for coronary artery disease (CAD). Recent studies have identified several genetic variants associated with coronary artery disease. Some of these genetic variants are and some are not associated with classical cardiovascular risk factors and the mechanism of such associations is unclear in the medical assessment in aviation. Preventive measurements in aviation is very important. The aim of the study was to analyses the feasibility of DNA tests in CAD risk prediction algorithms. **METHODS:** Over the last 4 years, we have reviewed more than 5000 routine aeromedical examinations. About half of the patients showed elevated cholesterol levels, around 1% of these showed AGLA Risk Score 7.5 % or more. Pilots with high AGLA Risk Score and therefore even higher risk for asymptomatic CAD, were introduced to our program for further evaluation of the existence of possible plaques and/or atherosclerosis including offering coronary CT. In case of a strong positive family history for CAD and a potential benefit due to genetic testing's, a specific genetic assessment has been offered. **RESULTS:** Over the last 4 years in three cases a genetic atherosclerosis assessment has been done. Special local genetic counseling circumstances needed to be addressed, but in our cases, the genetic assessment had a direct impact of preventive measurements such as in medication and control rhythm. **CONCLUSION:** The genetic assessment is a valid a supportive element in the prevention of atherosclerosis. Special education of treating AME's are necessary. The results could have a direct therapeutic effect in the prevention of atherosclerosis. Further studies are needed.

Learning Objectives

1. The participant will learn about the necessity of a special education in genetic assessment as a treating AME of Pilots with increased CAD risk.
2. The audience will understand the relation between classic cardiovascular risk factors and the associated genetic variants.
3. The audience will understand the benefit in optimiying the medical assessment in aviation medicine.

[371] HELP, I'M DIVING, BUT I CAN'T BREATHE! A CASE OF IMMERSION PULMONARY EDEMA PRESENTING AS ACUTE CORONARY SYNDROME?

Kristi Ray[1], Bob Sanders[2]
[1]*Louisiana State University, New Orleans, LA, USA;* [2]*NASA Johnson Space Center, Neutral Buoyancy Lab, Houston, TX, USA*

(Education - Case Study)

INTRODUCTION: Immersion pulmonary edema (IPE) is a life-threatening illness seen in both civilian and military swimmers and SCUBA divers. A case will be presented of a SCUBA diver who presented with signs and symptoms of IPE but was incorrectly diagnosed with acute coronary syndrome (ACS). **BACKGROUND:** IPE is being diagnosed more frequently and is even implicated in the death of divers as seen in the literature. It is not taught to physicians or divers; and this knowledge gap can lead to misdiagnosis, subjecting patients to increased risks and healthcare costs. Efforts to close this knowledge gap and improve

awareness of IPE are essential to improving outcomes. **CASE PRESENTATION**: A 62-year-old male on day 3 of a diving vacation, dove to 65 feet of salt water (fsw). After 20 minutes, he felt short of breath. Skipping the safety stop, he surfaced, gasping for air. In the ED, the patient was cyanotic when oxygen was removed and had rales bilaterally. Chest x-ray showed lung congestion and initial troponin was negative. The patient, however, was flown to Florida for cardiac catheterization which showed severe 3-vessel chronic coronary artery disease with extensive collaterals. He was taken to the OR for a 5-vessel coronary artery bypass graft (CABG). On post-operative day 3 he developed atrial fibrillation, was chemically cardioverted, and discharged on an antiarrhythmic and blood thinner. Total cost of care was $494,000.
DISCUSSION: IPE can have a classic history and physical when physicians ask the right questions. Even when it does, it is often misdiagnosed due to inadequate knowledge in the medical community. While ACS is a more debilitating process than IPE overall, misdiagnosis can be very costly and subject patients to risky therapies. Even when the respiratory aspects were noted, this patient was still tracked into a coronary pathway, air lifted to the U.S., underwent catheterization, and completed a six-month rehabilitation routine. Since this occurs in both civilian and military swimmers and divers, it is important for clinicians to be trained in the diagnosis and management of IPE.
Learning Objectives
1. The audience will be able to recognize the signs and symptoms of IPE, as well as appropriate treatment of IPE
2. The audience will learn about SCUBA diving related illnesses and what questions to ask patients for evaluation

[372] HYPOXIC PULMONARY VASOCONSTRICTION AND CONGENITAL HEART DISEASE

Matthew Cooper[1]
[1]3M Health Care, Lake Elmo, MN, USA

(Education - Tutorial / Review)

BACKGROUND: Improved surgical outcomes following the correction of complex congenital heart disease have resulted in long-term survival and near normal life expectancy. This has impacted the population as a whole and the pool of pilot candidates and pilots. **OVERVIEW:** A particular subset of these individuals has single ventricle or so-called 1½ ventricle physiology in which all or a component of pulmonary blood flow, respectively, is passive. Such "Fontan" pulmonary blood flow is determined in part by pulmonary vascular resistance. Some reactivity of the pulmonary bed is anticipated in response to the relative hypoxia at higher altitudes, even during pressurized commercial flight. This suggests that evaluation of oxygen saturation at rest and with exercise are important, and that it may be appropriate to consider testing the pulmonary response to altitude induced hypoxia to determine whether a specific requirement for supplemental oxygen is required based on physiology. **DISCUSSION:** The character and incidence of anatomic substrates corrected to passive pulmonary blood flow will be reviewed, as will theoretical vs. real implications for pilot evaluation and performance. The latter may include consideration of the special issuance class of medical that satisfies an individual's flying aspirations.
Learning Objectives
1. Develop an understanding of the modern era of adults with remediated congenital heart disease and considerations for ongoing care and potential interventions.
2. Consider implications of reconstructed single ventricle physiology for the performance and safety of pilots – abnormal physiology in an abnormal environment.

[373] RISK MANAGEMENT OF INSULIN TREATED DIABETICS IN CANADA

Rani Tolton[1], Edward Brook[2]
[1]Transport Canada, Vancouver, British Columbia, Canada; [2]Transport Canada, Ottawa, Ontario, Canada

(Education - Program / Process Review)

BACKGROUND: Diabetes mellitus (DM) is increasing throughout the world. In 2015 The Organization for Economic Cooperation and Development (OECD) countries had a prevalence of DM of 7% (93 million) of all adults. In Canada in 2018, 7.1% of the population aged 12 and older (2.24 million people) reported being diagnosed with DM. Five to 10% of people with diabetes in Canada have Insulin Dependent Diabetes Mellitus (IDDM). With the aging pilot and air traffic controller population, the number of aircrew treated with insulin is increasing and this trend is expected to continue. **OVERVIEW:** Many aviation authorities would assess applicants with Insulin Treated Diabetes Mellitus (ITDM) to be unfit with the major issue being the risk of hypoglycemia. Since 1992 Transport Canada has allowed selected ITDM pilots/controllers to safely fly and control aircraft. A risk assessment framework can help guide and identify low risk ITDM applicants. Included in the assessment is the positive attitude of the applicants towards monitoring their health status including glucose levels while flying/controlling. A comprehensive assessment assists in mitigating any adverse effects to flight safety. **DISCUSSION:** This presentation will describe the ITDM risk assessment process, including key factors that must be considered to ensure flight safety. It will also describe how technology is assisting pilots/controllers in preventing hypoglycemia. Updated data on ITDM applicants will also be presented including information on Canada's recent decision to allow *ab initio* ITDM applicants to progress to Class I medical certificates.
Learning Objectives
1. The audience will learn the risk assessment process for selection and monitoring used to allow applicants with insulin treated diabetes mellitus to safely fly or control aircraft in Canada.
2. The audience will learn the factors that are taken into consideration when applying the ITDM risk assessment framework

[374] THE BRITISH, IRISH AND AUSTRIAN JOINT PROTOCOL FOR THE CERTIFICATION OF PILOTS WITH INSULIN-TREATED DIABETES: RESULTS SO FAR

Ewan Hutchison[1], Gillian Garden[2], Julia Hine[2], Tom Gaffney[3], Veronika Hofmann[4], Stuart Mitchell[1], Gerdt Koehler[4], Graham Roberts[5], David Russell-Jones[2]
[1]United Kingdom Civil Aviation Authority, Gatwick Airport, United Kingdom; [2]University of Surrey, Guildford, United Kingdom; [3]Irish Aviation Authority, Dublin, Ireland; [4]Austrocontrol, Vienna, Austria; [5]CRF-C University College Cork, Cork, Ireland

(Original Research)

INTRODUCTION: The UK Civil Aviation Authority (CAA), Irish Aviation Authority (IAA) and Austrocontrol are issuing EU Class 1 and 2 medical certificates to applicants with insulin treated diabetes mellitus. Pilots in the protocol are subjected to regular oversight, including review of each blood glucose measurement made pre-flight and in-flight. Data from blood glucose measurements has been reviewed to evaluate the performance and safety of the protocol. The protocol includes a traffic-light system for determining whether and what further action is required following measurement of blood glucose. **METHODS:** Clinical details, pre-flight and in-flight blood glucose monitoring values and information from flight log books were correlated against the traffic light system of "Green" (5-15mmol/l), "Amber" (low 4-5 and high 15-20mmol/l), and "Red" (low <4 or high >20mmol/l) ranges. **RESULTS:** 49 pilots (24 class 1, 18 class 2), median age 44, (84% type 1, 16% type 2) were studied. The average HbA1c pre-certification was 55.0mmol/mol and following certification (average 5 years) 55.1mmol/mol. 38,621 pre-flight and in-flight blood glucose monitoring values have been recorded. Overall 37,729 (97.69%) of blood glucose readings were within the 'green' range. 550 (1.42%) in the low 'amber' range, 288 (0.75%) in the high 'amber' range. 48 (0.12%) readings were in the low 'red' range (34 pre-flight; 14 in-flight) and 6 (0.02%) in the high 'red' range (4 pre-flight; 2 in-flight). Appropriate action was taken by pilots for all out-of-range measurements. There have been no pilot incapacitations due to low or high blood glucose and no deterioration in individuals' diabetes control. **DISCUSSION:** The Diabetes protocol that enables the UK CAA, IAA and Austrocontrol to issue medical certificates to pilots with insulin treated diabetes continues to operate with no reported safety events or adverse health effects.

Learning Objectives
1. The audience will learn about the protocol used by the UK CAA, Irish Aviation Authority and Austrocontrol for aeromedical certification of insulin treated diabetic pilots.
2. The audience will learn about the findings of an observational study of pilots with insulin treated diabetes who were granted medical certification to fly commercial and non-commercial aircraft.

[375] FACTORS AFFECTING INSULIN TREATED DIABETIC PATIENTS IN HIGH ALTITUDES

Mustafa Alaziz[1], Samir Talib[2], Nasam Alfraji[3]
[1]Wright State University, Dayton, OH, USA; [2]Raritan Bay Medical Center, Perth Amboy, NJ, USA; [3]Jersey Shore University Medical Center, Neptune, NJ, USA

(Education - Program / Process Review)

BACKGROUND: Exposure to high altitude represents a challenging situation in which body metabolism can be significantly changed because of changes in atmospheric pressure, temperature, oxygen pressure, and oxyhemoglobin saturation. Insulin-treated diabetic patients (ITDP) can be affected by high altitudes in different ways. For instance, increasing altitude leads to changes in oxygen transport, lipid metabolism, and muscle atrophy, which might increase the risk of insulin-related complications. **OVERVIEW:** Several factors affect diabetic patients in high altitudes, including terrain elevation, time spent at altitude, and energy expenditure. There is limited data on the impact of terrain elevation on ITDP. The normal barometric pressure at sea level is 760 mmHg and drops to half at 18,000 ft; the effect of hypoxia is more apparent at altitudes > 15,000 ft. From a diabetes perspective, the higher the terrain elevation is from sea level, the larger the drop is in barometric pressure and oxygen saturation, which might impact normal metabolism. Changes in the glycemic curve in response to high altitudes have been noted throughout the stay. Studies showed that initial exposure (1–9 days) to high altitude results in a hyperglycemic state because of the hormonal counter-regulatory mechanism. Comparatively, long-term exposure (≥10 days) improves insulin sensitivity and may result in hypoglycemia. Literature shows that energy expenditure could be increased in high altitudes. However, the changes in total energy expenditure in high altitudes depends on the type of physical activity, whether nonintentional or strenuous. **DISCUSSION**: Although the adjustment of insulin dosage might be needed to avoid diabetes-related complications in ITDP traveling to high altitudes, the relationship between the altitude and insulin needed in ITDP cannot be established without considering environmental factors, individual characteristics, insulin type, and glycemic profile. Pre-ascent preparation and close glucose monitoring, either by frequent glucose monitoring or a continuous glucose monitoring device, are key to adjusting insulin dosage and maintaining optimal glycemic control to ensure safety in ITDP traveling to high altitudes.

Learning Objectives
1. The audience will learn about the factors affecting glucose level in insulin-treated diabetic patients exposed to high altitudes.
2. The audience will learn about the approach to minimize the effect of high altitudes on glucose levels in diabetic patients.
3. The participant will identify the gaps in maintaining the safety of insulin-treated diabetic patients exposed to high altitudes.

Thursday, 09/02/2021 ***1:30 PM***
Plaza D/E

[S-70]: PANEL: INNOVATIONS IN AEROSPACE MEDICINE EDUCATION

Chair: Quinn Dufurrena
Co-Chair: Dana Levin

Panel Overview: *The field of aerospace medicine continues to grow rapidly, and with exciting changes such as the expansion of the commercial space industry, there is an ever-increasing need for effective education. As this growth in aerospace medicine is occurring, the landscape of medical education, and education in general is changing. Advances in technology and media have ushered in an era of high-fidelity simulation accessible to the general population and self-directed learning in the form of podcasts, online videos and tutorials created by experts in a given field. Likewise, interdisciplinary collaboration has become increasingly recognized as essential in order to develop solutions to the problems that arise in complex systems and processes seen in aerospace medicine. Fortunately, Aerospace Medicine has no shortage of innovators in every aspect of the field, including education. This panel aims to highlight some of the creative methods of education and outreach being pioneered by them. The panel will start with the Exploration Medicine Podcast, an online community taking advantage of the unprecedented reach and customizability of internet-based education. This will be followed by a presentation on an innovative, online Aerospace Medicine Seminar Series developed by the University of Texas Medical Branch to provide an introduction to the field. The third presentation will describe the efforts of NASA's Exploration Medicine Capability Element to involve students and residents in the complex interdisciplinary work advancing medical capabilities in space. The final presentation will discuss the development of a unique long-form simulation course at the University of Colorado that teaches the application of engineering approaches to the challenges of space medicine. Included presentations in the panel exemplify ways in which educators are developing innovative programs to broaden the experience base of members of the aerospace medicine community in order to address the complex and multi-faceted challenges that the field encounters.*

[376] CREATION OF A DIGITAL COMMUNITY FOR INFORMAL, ON-DEMAND EDUCATION IN AEROSPACE AND EXPLORATION MEDICINE

Sultana Peffley[1], Quinn Duferrena[2], Jeremy Sieker[3], Dana Levin[4]
[1]University of Miami/Jackson Health System, Miami, FL, USA; [2]University of Texas Medical Branch, galveston, TX, USA; [3]University of California, San Diego, San Diego, CA, USA; [4]Columbia University Medical Center, New York, NY, USA

(Education - Program / Process Review)

BACKGROUND: Aerospace and exploration medicine are fascinating topics. However, the complexity of the fields, interdisciplinary nature, and the relatively small number of experts leave few options for either formal or informal education. Additionally, modern students seek flexible, on demand educational products where involvement can be titrated to their level of interest. **OVERVIEW:** To address the broad range of preprofessional, post professional, and amateur interest in aerospace and exploration medicine education, we created Explorationmedicine.com. It is as an online community centered around short podcast episodes, online discussion forums, and downloadable educational products. The community takes advantage of the unprecedented accessibility and customizability of internet based education to supplement formal training, provide an informal information source, and introduce aerospace and exploration medicine for unfamiliar with the field. **DISCUSSION** The episodes and website explorationmedicine.com are routinely accessed by 100s of people each month from more than a dozen countries, on 6 continents. Since it started in 2017, it has served to stimulate discussion, increase awareness of the aerospace and exploration medicine, and has had more than 15 individuals contribute content, ranging from students to residents to professionals practicing aerospace and exploration medicine around the world.

Learning Objectives
1. The participant will be able to understand the importance of asynchronous, self directed learning in aerospace medicine.
2. Understand the importance of social media outreach in aerospace medicine education

[377] UNIVERSITY OF TEXAS MEDICAL BRANCH AEROSPACE MEDICINE SEMINAR SERIES

Amy Kreykes[1]
[1]University of Texas Medical Branch, Galveston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Most medical students will never be exposed to or receive training in Aerospace Medicine. Aerospace Medicine is a small field

with only four residencies (Civilian – University of Texas Medical Branch (UTMB; Armed Forces – Air Force, Navy, and Army) and one fellowship (Civilian – Mayo Clinic) available for trainees in the United States. Students with an interest must seek out resources on their own. Often finding resources is challenging and open access educational tools are rare. UTMB created a free online Aerospace Medicine Seminar Series to provide a readily accessible resource for students interested in pursuing Aerospace Medicine. **OVERVIEW:** The field of Aerospace Medicine is growing. Commercial air travel, military operations, continued Low Earth Orbit and exploration operations by the National Aeronautics and Space Administration (NASA), as well as the emergence of commercial space-flight necessitate the ongoing training of Aerospace Medicine specialists. Moreover, the FAA Extension, Safety, and Security Act of 2016 introduced BasicMed, a program in which select civilian pilots can be certified as medically safe to fly by providers with no formal training in aviation medicine. Despite this, medical students in the United States receive no training or exposure to the field of Aerospace Medicine unless, perhaps, they are co-located at an institution that provides Aerospace Medicine Residency training. Opportunities for exposure and training do exist but are by application only and have traditionally involved travel for approximately a month for an away rotation, limiting participation. As a leader in the field, UTMB is helping to fill this educational gap by providing an open access learning resource for medical students interested in Aerospace Medicine. UTMB designed and validated a series of six seminars introducing Aerospace Medicine training and career opportunities as well as key topics in the discipline. The series is available online at https: // www.utmb.edu/pmph/aerospace-medicine/aerospace-seminar-series. **DISCUSSION:** Open access educational resources in Aerospace Medicine are rare. UTMB is leading the way with their Aerospace Medicine Seminar series, which is available online to interested students across the globe at no cost, whether military or civilian.

Learning Objectives

1. The participant will be aware of an open access educational Aerospace Medicine Resource – The University of Texas Medical Branch Aerospace Seminar Series.
2. The participant will be aware of the content of the lectures in the UTMB Aerospace Medicine Seminar Series.

[378] INTEGRATING MEDICAL TRAINEES WITH INTERDISCIPLINARY RESEARCH AND DESIGN TEAMS FOR EXPLORATION MEDICAL CARE

Dana Levin[1], Benjamin Easter[1], Melinda Hailey[2], Kris Lehnhardt[1]
[1]NASA Johnson Space Center, Houston, TX, USA; [2]KBR, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: NASA's Exploration Medical Capability Element (ExMC) has four main goals. These are to determine the medical conditions likely to occur on long duration space missions, define the associated risk, determine the medical system to reduce the risk, and work within the spacecraft design and crew constraints to build the optimum medical system for overall mission risk. These goals require integrating the subject matter and clinical expertise of physicians, pharmacy workers, and nurses with the technical knowledge of engineers, software designers, mission planners, statisticians, and others. This entails substantial translation between technical languages and defines new processes to address the hybrid workflow and unanswered questions of The Element. **OVERVIEW:** Traditional medical education is not sufficient to prepare physicians to work in this environment so The Element has established a trainee rotation. The rotation pairs students with a mentor and assigns them interdisciplinary projects combining medicine with subject areas like engineering, pharmacology, statistics, radiation physics, and human factors design. Student lead projects have included tracing conditions to capabilities within a systems engineering model, performing systematic reviews, designing processes and protocols for identifying medical conditions requiring risk mitigation, performing volumetric assessments of procedures, designing medical workstations, and building a database of spaceflight environmental effects on medications. Trainees receive an orientation email, and a sign-out from previous trainees or from their mentor. This also includes a schedule of meetings to attend, and resources pertinent to the trainees' project. Students work with their mentor and other members of the project team to complete their portion of the project and develop a presentation of their work for relevant stakeholders. Since ExMC resources and personnel are located all over the United States the schedule and location of the rotation are flexible. **DISCUSSION:** Students are often able to work remotely and take advantage of their home institution resources while learning about space medicine and advancing NASA's goals. This work exposes the students to the unique challenges of cross-discipline research and development, enhances ExMC productivity/ preparedness for internal deadlines, and helps ensure adequate training for the next generation of space medicine workers.

Learning Objectives

1. Understand the cross disciplinary challenges of developing exploration medical systems
2. Understand how trainee rotations have been adapted to address the cross-disciplinary challenges of developing exploration medical systems

[379] ENGINEERING AND MEDICAL COLLABORATION FOR EDUCATION IN HUMAN SPACEFLIGHT: THE UNIVERSITY OF COLORADO MEDICINE IN SPACE AND SURFACE ENVIRONMENTS COURSE

Benjamin Easter[1], Allison Anderson[1], Dana Levin[2], James Kurrle[3], Arian Anderson[1], Richard Cole[4], Jay Lemery[1]
[1]University of Colorado, Denver, CO, USA; [2]Columbia University, New York, NY, USA; [3]University of Notre Dame, Sydney, Sydney, Australia; [4]University of Texas Medical Branch, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: Advancing human spaceflight requires sophisticated, interdisciplinary collaboration among healthcare practitioners, human health and performance experts, and the engineers who design the systems and devices used for medical care delivery. Maintaining astronaut health and safety in extreme, exploration environments necessitates unique training, preparation, technology, and advanced medical care. To address these challenges, the University of Colorado Departments of Aerospace Engineering and Emergency Medicine pioneered a course for undergraduate and graduate students called Medicine in Space and Surface Environments (MiSSE). The course begins with traditional didactics, but concludes with a weeklong immersive field simulation conducted at an analogue Martian Habitat in the remote desert environment. This allows participants to learn the challenges conceptually and then experience them first-hand when providing medical care in simulation. **OVERVIEW:** MiSSE focuses on several primary objectives. First, participants receive didactic education on aerospace and extreme environmental medicine (e.g. dysbarisms and toxicology), and learn basic hands-on skills, such as primary assessment, Wilderness First Aid, and CPR. Second, students then apply this conceptual knowledge to an operational environment with simulated EVAs. During each EVA, a medical scenario arises that they must address using the didactic training as well as operational skills, such as effective radio communications, task prioritization, group dynamics, and situational awareness. Third, students apply engineering solutions to address the challenges of remote, operational medicine. They identify a conceptual need, assume the role of an engineering design team, and work to design devices under mass, power, and volume constraints. This helps them to better understand the unique requirements that human physiology and medicine pose for their systems. Past projects have included a rocket delivery system with an environmentally-controlled payload for medical supplies and a wireless physiological monitoring interface for EVA field teams. **DISCUSSION:** Tackling the challenges of spaceflight to maximize human health and performance requires significant input and collaboration between engineers and physicians. The MiSSE has successfully brought these fields and associated experts together, and is helping to train the next-generation of experts to think and work in multidisciplinary fashion.

Learning Objectives

1. The participant will be able to describe the benefits of medicine-engineering collaboration for medical system and device design.
2. The participant will be able to describe the benefits of a medicine-engineering partnership for advancing human spaceflight.

Thursday, 09/02/2021 ***1:30 PM***
Governor's Square 12

[S-71]: POSTER: SPACE MEDICINE

Chair: Tovy Kamine

[380] FOCUSED ULTRASOUND EXAMINATION TRAINING FOR LDSM CREWMEMBERS - UNLOCKING THE DIAGNOSTIC POTENTIAL OF ULTRASOUND

Syed Ahmed[1], Adam Sirek[1]
[1]Schulich School of Medicine and Dentistry, London, Ontario, Canada

(Education - Program / Process Review)

BACKGROUND: Ultrasonography has a broad range of medical applications during space flight. As possibly the sole method of medical imaging to be available during Long-Distance Space Missions (LDSMs), future LDSM crewmembers must be adept at capturing and interpreting ultrasound (US) images autonomously. Currently, International Space Station (ISS) crewmembers are given minimal ultrasound training prior to launch. The capability of ISS crewmembers to conduct US examinations is augmented through the use of remote guidance from experts on Earth. Increased communication delays during LDSMs will require crewmembers to be able to capture and interpret US images autonomously. **OVERVIEW:** Studies examining US teaching programs in remote and rural areas have successfully shown that training in focused US examinations can be done quickly and effectively. Furthermore, participants of these training programs have captured US images of high quality and have interpreted US images with a high degree of diagnostic sensitivity and specificity. LDSM missions can benefit from training crewmembers in focused US examinations prior to launch. **DISCUSSION:** 1. Crewmembers adept at performing and interpreting focused US examinations will broaden the utility of US during LDSMs. In an emergency situation, trained crewmembers could use US in order to inform mission decisions as well as use imaging to guide treatment. 2. Various aspects of crewmember health can be monitored using specific focused US examinations. This information can be relayed to Earth and used for the study of the effects of long-distance space travel on human health. Innovate US training and practice methodologies may be developed secondary to adapting training curricula for non-physician LDSM crewmembers. Novel training techniques developed for space flight may open doors for increased US use in military and civilian spheres. 3. Many barriers to autonomous US use are shared by both space flight and remote/rural Earth environments. US is becoming increasingly economically accessible which has translated to an increase in its use in remote/rural areas. The availability of skilled operators lags behind this trend. Studies have demonstrated the effectiveness of training non-physician military and civilian personnel in various focused US examinations. Adoption of focused US training programs is a means to unlock the diagnostic potential of the imaging modality within human space flight, civilian and military spheres.

Learning Objectives

1. The audience will learn about the value of ultrasound use for long-distance space missions including its role in: monitoring crewmember health; diagnosing medical impairments; and assisting in mission and treatment decisions.
2. The audience will learn about recent studies reporting the effectiveness of short focused ultrasound examination training programs in remote and rural areas and their relevance to training future crewmembers of long-distance space-flight missions.
3. The audience will learn about barriers to autonomous ultrasound use shared by both space flight and remote / rural Earth environments and how training future long-distance space mission crewmembers in focused ultrasound examinations may help overcome some of these barriers.

[381] AEROSPACE MEDICINE AND ANESTHESIOLOGY ON THE BRINK OF COMMERCIAL SPACEFLIGHT

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(Education - Program / Process Review)

BACKGROUND: Dramatic cost reduction and commercial access to space will transition the space faring population from few career astronauts to a larger and more diverse group of paying customers. The traditional role of the flight surgeon is likewise expanding from managing spaceflight hazards associated with normal physiology in carefully selected professionals to caring for lay citizens, with an emphasis on their underlying medical conditions, pre-flight medical optimization, in-flight surveillance and management of emergencies, and post-flight recovery. This paradigm shift will require novel, multidisciplinary approaches to medical management of civilian astronauts. Analogous to aerospace medicine, anesthesiology strives to provide optimal care during a pre-planned period of acute stress by specifically addressing (1) preoperative risk assessment and mitigation; (2) medical optimization and pre-habilitation; (3) intraoperative monitoring and critical care; (4) postoperative recovery. We propose that, as aerospace medicine broadens its population, the perioperative armamentarium may prove invaluable to in-flight patient care. **EXPERIMENTAL MODELLING:** This research group is investigating ways to apply evidence from large studies of perioperative interventions to populations of pilots. Our approach will be demonstrated by selecting two contrasting medical complications with contrasting prevalence/morbidity that are relevant to both perioperative and aerospace medicine: (1) postoperative nausea and vomiting (PONV), and (2) acute respiratory distress. In a hypothetical case of a commercial orbital flight of a 57 year-old male with history controlled hypertension, chronic obstructive pulmonary disease, status post total hip arthroplasty 5 years ago complicated PONV and deep venous thrombosis, we will explore how the lessons-learned from the perioperative management can be utilized in this aerospace medicine scenario. **DISCUSSION:** By introducing the key principles utilized by perioperative medicine to the aerospace audience and highlighting the key areas of overlap, we seek to facilitate exchange of information between the specialties that may serve as a platform for advancement in both fields, particularly as it relates to care of spaceflight participants with comorbidities. We believe that such an interdisciplinary collaboration may drive progress essential for the success of safe commercial spaceflight.

Learning Objectives

1. Summarize the paradigm shift in human spaceflight and space medicine from professional career astronauts to a diverse group of paying private citizens.
2. Appreciate the principal analogies and differences between the fields of anesthesiology and aerospace medicine.
3. Understand how the tools and approaches used by anesthesiologists may be applied to aerospace medicine while taking care of civilian astronauts with comorbidities.

[382] USE OF PODCASTS TO FACILITATE EDUCATION IN AVIATION AND AEROSPACE MEDICINE

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(Education - Program / Process Review)

BACKGROUND: The first podcast was developed in 2004 and since then the field of podcasting has ballooned; with over 1.5million podcasts available as of late 2020. Similarly, the field of Aviation and Aerospace medicine has also expanded, with specialist training programmes in the field developing in the US, UK and Australia. In addition, over 4.3 billion passengers travelled by air in 2018 and commercial spaceflight was established as a realistic venture by companies such as SpaceX and Virgin Galactic. However, Aerospace medicine remains a niche specialty which

few outside the field are aware of, despite it being bigger than ever before. We therefore produced a podcast to educate listeners about the physiological, clinical and human factor challenges of aerospace and the growing opportunities available in the field. **OVERVIEW:** We created the Aerospace Medicine podcast with the goal of bringing inspiring stories from experts in the field which might appeal to a vast and varied audience whilst allowing stimulating conversation on which to hinge teaching on topics such as space medicine, human factors and developing research. Within two months the podcast has achieved 459 listens and 19 5-star reviews on Apple podcasts, demonstrating its reach and worth. **DISCUSSION:** The feedback so far shows there is a huge potential for Aviation and Aerospace medicine knowledge to be disseminated and new discoveries to be shared through the medium of podcasting in a high yield fashion. The ability of internet focused methods such as podcasts to reach a wide audience within a short period of time is remarkable, and the reviews received show this a useful and worthwhile method of outreach. We encourage more active methods of engaging young STEM students and professionals using new mediums such as podcasting to further the field for the next generation.

Learning Objectives

1. The audience will be able to understand the benefit of podcasts in outreach for aerospace medicine.
2. The audience will be able to understand the benefits of podcasts in education in aerospace medicine.

[383] CARDIOPULMONARY RESUSCITATION IN HYPOGRAVITY SIMULATION: DO INFLUENTIAL FACTORS EXIST?

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(Original Research)

INTRODUCTION: Limited research exists into extra-terrestrial CPR despite the drive for interplanetary travel. This study investigated whether the terrestrial CPR method can provide quality external chest compressions (ECCs) in line with the 2015 UK resuscitation guidelines during ground-based hypogravity simulation. It also explored whether gender, weight and fatigue influence CPR quality. **METHODS:** Twenty-one subjects performed continuous ECCs for 5 min during ground-based hypogravity simulations of Mars (0.38 Gz) and the Moon (0.16 Gz), with Earth's gravity (1 Gz) as the control. Subjects were unloaded using a body suspension device (BSD). ECC depth and rate, heart rate (HR), ventilation (VE), oxygen uptake (VO2) and Borg scores were measured. **RESULTS:** ECC depth was lower in 0.38Gz (42.9±9 mm) and 0.16Gz (40.8±9 mm) compared to 1Gz and did not meet current resuscitation guidelines. ECC rate was adequate in all gravity conditions. There were no differences in ECC depth and rate when comparing gender or weight. ECC depth trend showed a decrease by min 5 in 0.38 Gz and by min 2 in 0.16 Gz. Increases in HR, VE and VO2 were observed from CPR min 1 to min 5. **DISCUSSION:** The terrestrial method of CPR provides a consistent ECC rate but does not provide adequate ECC depths in simulated hypogravities. The results suggest that a mixed-gender space crew of varying bodyweights may not influence ECC quality. Extraterrestrial-specific CPR guidelines are warranted. With a move to increasing ECC rate, permitting lower ECC depths and substituting rescuers after 1 min in lunar gravity and 4 min in Martian gravity.

Learning Objectives

1. The audience will learn about the use and efficacy of the terrestrial method of CPR in simulated hypogravity environments.
2. The audience will learn about the influential factors to providing quality CPR in simulated hypogravity environments.

[384] IMMERSIVE EXTENDED REALITY USE IN MEDICAL EDUCATION WITH IMPLICATIONS FOR REMOTE AND SPACE MEDICINE TRAINING

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(Original Research)

INTRODUCTION: Medical education continually adapts and evolves as evidence-based practice expands our knowledge. Ease of access and reduced cost of novel technology has revolutionized delivery of medical education. Next-generation immersive head-mounted virtual, augmented and mixed reality devices have been explored as novel avenues for medical learning. This immersive extended reality (iXR) technology may play an invaluable role in improving delivery and quality of medical education, terrestrially and for exploration class missions. **METHODS:** An extensive state-of-the-art literature review was conducted for using MeSH terms specific to iXR technology related to medical education. Relevant manuscripts were accessed from database searches and filtered based on pre-specified inclusion and exclusion criteria. Extraction of data and thematic qualitative analysis was conducted in relation to medical education and relevance to exploration class missions. **RESULTS:** From a total of 4005 search results, 35 final papers met inclusion criteria for this study. Current applications of virtual, augmented and mixed reality technology in medical education were explored, and themes from each modality of iXR technology were conferred. **DISCUSSION:** Themes determined from the results were applied to a discussion regarding the application of iXR technology in three distinct areas of medical education: early medical education, remote and rural medical training, and space medicine. Relative strengths and weaknesses of each modality of iXR were explored and applied to the unique factors impacting medical education delivery in these three domains. This review concludes by considering the future application and innovation of immersive extended reality technology in medical education.

Learning Objectives

1. Considering the future application and innovation of immersive extended reality technology in medical education
2. Exploring the relative strengths and weaknesses of each modality of iXR and their application to medical education in multiple domains.

[385] USING COMPUTER VISION TO MEASURE CREW BEHAVIORAL SKILLS DURING SIMULATED MEDICAL EVENTS IN SPACE

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(Original Research)

INTRODUCTION: The success of long-duration exploration missions will depend on behavioral skills of astronaut crewmembers, including teamwork, leadership, communication, and situational awareness. In a prior study, we developed and validated the Spaceflight Resource Management (SFRM-MED) tool to measure behavioral skills of astronaut crewmembers. This tool can be used to track behavioral skills of astronauts-in-training. While tools such as this currently represent the gold standard for behavioral skill measurement, inter-rater reliability can be variable, and recruiting observers is costly. Thus, there is a need to develop reliable, cost-effective, objective tools to measure behavioral skills. In a prior study we demonstrated the feasibility of computer vision software to capture position/motion data. Here we investigate the feasibility of using this data to help predict behavioral skills measured by human raters. **METHODS:** We captured six video clips of participants responding to medical events in our spacecraft simulator using a GoPro Hero 5 camera. OpenPose v1.3.0, an open-source, deep learning-enabled computer vision program, was used to track motion and position of participants. This data was used to calculate team proximity and total motion for each clip. Additionally, each of the six video clips were viewed by independent observers and team behavioral skills were rated on the SFRM-MED interactive online platform. **RESULTS:** Behavioral skill ratings showed substantial variability between teams. Team motion and proximity were plotted in a visual analytics dashboard, revealing significant dynamicity both during clips and between clips. Positional heat maps were created, providing a visual representation of participant interaction with the spacecraft simulator over time. **DISCUSSION:** In this study we demonstrated that it is possible to measure both behavioral skills and position/motion of astronaut-like participants responding to medical events in a spacecraft simulator. Both behavioral skill ratings and motion/position measurements demonstrated substantial variability. Our future work will investigate developing a machine-learning platform to predict behavioral skills from objective motion/position data.

Learning Objectives
1. Understand how computer vision offers an objective way to measure behavioral skills.
2. Understand how behavioral skills can be informed by motion and position data.

[386] UTILIZING THE INTELLIGENCE CYCLE TO DEVELOP FUTURE SPACEFLIGHT MEDICAL KITS

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(Original Research)

INTRODUCTION: Medical resource allocation for spaceflight missions has historically been entirely driven by subject-matter expert (SME) opinion. With the coming increase in the types and lengths of missions, there is a clear need for a more structured method to determine the contents of future kits. We propose using methods from the intelligence community to develop a process to create these medical kits. **METHODS:** The intelligence cycle methodology of tasking, collection, analysis, production, and dissemination were applied towards kit development. Known, presumed, unknown, unknowable (KPUU) framework was also used. Data from historical medical events (HME), SME opinion, and a Probabilistic Risk Assessment (PRA) were compared. **RESULTS:** Medical event categories ranked by SMEs did not match those listed in HME sources. Using similar categories, we arranged contents of the PRA model kit by what they would primarily be used to treat. While there were minor similarities, all three datasets revealed different categorical priorities for kit development. **DISCUSSION:** Certain medical events can be anticipated based on HME. SME opinion is important but may differ based on variations in training and experience. PRA models are useful in generating recommendations based on HME and SME input, but cannot be used alone. For this reason, we recommend the use of multiple inputs into PRA, with final decisions guided by SMEs. This work demonstrates that PRA models can augment the SME decision process, and intelligence methodology can be applied to the development of more robust spaceflight medical kits.

Learning Objectives
1. Become familiar with the intelligence cycle methodology of tasking, collection, analysis, production, and dissemination.
2. Learn about a novel method for medical kit development utilizing techniques from the intelligence gathering community.

[387] EXERCISE INDUCED CHANGES IN ARTERIAL AND INTRA-CRANIAL PRESSURE

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(Original Research)

INTRODUCTION: Exercise is the primary countermeasure during long-duration spaceflight. While benefits are apparent, exercise induced increases in blood pressure have been suggested to elevate intracranial pressure (ICP) and aggravate neuro- and ocular changes associated with long-term spaceflight. We tested the hypothesis that moderate aerobic exercise does not increase ICP and the well described post-exercise arterial hypotension is reflected in a concomitant decrease in ICP thereby maintaining cerebral perfusion pressure (CPP). **METHODS:** Following 15 min of supine rest 16 volunteers (8 female) completed 30 min of upright seated aerobic ergonomic bicycle exercise at 70% hear rate reserve by Karvonen formula (targeted HR=70%*(HRmax-HRrest)+HRrest) followed by 1 hour supine rest. In 13 subjects ICP was estimated non-invasively (CCFP, Marchbanks Systems, UK). In 3 subjects parenchymal ICP was directly measured through a frontal burr hole (Neurovent-P, Raumedic). In all, continuous cardiovascular profile was recorded (Nexfin). **RESULTS:** Invasive and non-invasive ICP changes were closely correlated (R2=0.90, P<0.001) and thus combined. Compared to supine baseline, post-exercise resting ICP was 53±19% lower (P<0.0001) and gradually returned to baseline values 30 min after exercise (P=0.098). This trend was correlated to MAP (R2=0.81, P=0.006), which initially decreased (from 83.9±2.4 to 76.6±2.9 mmHg) and returned to supine resting level approximately 30 min after exercise. Underlying vasodilation of exercised muscles and reduced venous return were reflected by lower total peripheral resistance and stroke volume which also correlated to the drop in ICP (R2=0.90, P=0.001 and R2=0.68, P=0.022, respectively). Heart rate was increased during and post-exercise (P<0.05). CPP was well maintained throughout the supine recovery phase (P=0.1). In 3 subjects, ICP was directly recorded during exercise, which did not increase ICP (seated rest baseline: -4±4 mmHg, average of 30 min aerobic exercise: -5±3.5 mmHg). **DISCUSSION:** Post-exercise arterial hypotension was mirrored in ICP thus maintaining CPP. Moderate aerobic exercise does not significantly elevate ICP. Moreover, post exercise vasodilation and hypotension trends to reduce ICP, which may be speculated to be beneficial. Our data is limited by the small N which was insufficient to reveal gender or age differences.

Learning Objectives
1. The audience will learn about the effects of exercise on blood pressure and pressure inside the brain.
2. Objective one will be explained in the context of aerobic exercise in space which is the number one countermeasure currently employed.

[388] SPACE MOTION SICKNESS TREATMENT

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(Original Research)

INTRODUCTION: Space motion sickness, a form of motion sickness experienced by astronauts in microgravity, is the most common clinical condition experienced during the first three days of spaceflight and can have a significant impact on well-being, performance, and mission planning. Despite awareness of space motion sickness (SMS) since 1961, the medical and scientific communities have not been able to fully understand the physiologic mechanisms at play that cause SMS or the best treatment for it. The use of terrestrial based methods to test efficacy of different pharmacologic SMS treatments have led to problems in translational success with inflight astronaut SMS treatment. To date, no clinical practice guideline has been established for treatment of space motion sickness for NASA flight surgeons and the treatments used currently are derived from anecdotal reports or previous success. **METHODS:** A literature review was conducted to determine the best pharmacologic treatment for space motion sickness. The databases of PubMed and InfoHawk, the Journal of Aviation, Space, and Environmental Medicine, the Journal of Aerospace Medicine and Human Performance, and the NASA library were used. These following search terms were used: Space Motion Sickness, SMS, and Motion Sickness. The results were weighted, giving priority to in-flight microgravity studies then parabolic flights followed by other terrestrial based methods. **RESULTS:** Results showed that the best published treatment for SMS in crewmembers has been promethazine IM 25 mg, which is currently the most relied upon drug for SMS treatment in space. Prophylaxis has had variable success and should be up to the discretion of the crewmember and flight surgeon based on the crewmembers previous experiences with motion sickness and space motion sickness. Non-pharmacologic strategies were not superior to pharmacologic agents. **DISCUSSION:** The studies comparing pharmacologic outcomes for SMS drugs are few and far between secondary to crewmembers medical privacy and lack of applicable terrestrial analog data. SMS drugs should be tested on crewmembers prior to flight to test for adverse effects and reactions and possibly for efficacy given the wide individual variability to SMS drugs. Future research on this subject should incorporate data from the longitudinal study of astronaut health to acquire recent data on the specific SMS medications used in crewmembers and their effect.

Learning Objectives
1. Review the literature to gain knowledge about the incidence of space motion sickness, theories for its causes, symptoms, and countermeasures.
2. Identify gaps in knowledge in the literature and understand limitations and applicability of terrestrial studies.
3. Research the literature for the most effective countermeasure with a pharmacologic focus.

[389] NONMELANOMA SKIN CANCER IN THE UNITED STATES GENERAL POPULATION: A SYSTEMATIC REVIEW AND COMPARISON TO THE UNITED STATES ASTRONAUT CORPS

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(Original Research)

INTRODUCTION: Among U.S. astronauts, the most common type of cancer is non-melanoma skin cancer (NMSC). Because NMSC is not reported to most cancer registries, it is unknown if the rate of NMSC in U.S. astronauts significantly differs from the general population. The purpose of this on-going project is to review published data on the incidence, prevalence, and mortality of NMSC among the general U.S. population in order to develop an appropriate population reference for the U.S. Astronaut Corps. **METHODS:** A systematic review following PRISMA guidelines was conducted to understand the incidence, prevalence, mortality, and changes over time of NMSC in the U.S. adult general population. A total of 2,029 titles and abstracts were screened independently by two reviewers. A full-text evaluation was then conducted on 117 articles by a single reviewer, of which 19 met the final criteria for inclusion and for further data extraction. **RESULTS:** The incidence of NMSC in the U.S. general population surpasses the incidence of all other cancers combined and is growing at an exponential rate. Older, white, non-Hispanic males had the highest rates of NMSC. Female incidence of nonmelanoma skin cancer is increasing, especially in the younger ages. The prognosis of NMSC is generally excellent with overall low mortality rates. **DISCUSSION**: The increases in incidence in NMSC among the general population may represent a true increase in disease, a change in diagnosis patterns, or simply greater physician awareness and reporting. Pending completion of this systematic review, the data will compared to the NSMC data extracted on the U.S. astronaut population. Limitations to this comparison include the small number of subjects in the U.S. astronaut corps and inherent differences in risk between the general population and the astronaut population. Based on the outcomes, recommendations for countermeasures and surveillance will be developed to ensure the safety of astronauts as they prepare for deep space human exploration.

Learning Objectives

1. The audience will be able to become familiar with the systematic review process using PRISMA guidelines.
2. The audience will learn about the incidence, prevalence and mortality rates of nonmelanoma skin cancer in the United States general population and how this compares to the United States Astronaut Corps data.

[390] SYSTEMATIC ANALYSIS OF COUNTERMEASURE EFFICACY TO COMBAT MICROGRAVITATIONAL FLUID SHIFT

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(Original Research)

INTRODUCTION: Long-term exposure to microgravity during spaceflight results in a cephalic fluid shift, causing systemic negative effects. Numerous countermeasures have been researched to mitigate these symptoms, with limited replication or scrutiny. This paper analyses the quality of evidence supporting each intervention, identifies which countermeasures have proven efficacy, and highlights which lack supporting evidence. **METHODS:** Database searches identified 58 primary countermeasure studies from spaceflights and ground analogues. Inclusion criteria: complete publications, original findings, available in English. From these studies, 11 countermeasures were identified: *Lower-Body Negative Pressure (LBNP), Endurance Training, Resistance Training, LBNP and Mixed Exercise*, *3 Dietary Supplements (Vitamin K, Furosemide, and Fludrocortisone), Thigh Cuffs, Electrical Stimulation, Centrifuges,* and *Centrifuges with Exercise.* Studies had an average of 18.36 participants with 2-12 studies per countermeasure. Countermeasures were analysed for number of supporting studies, quality of research (statistical significance $p < 0.05$, study size, duration) and number of symptoms mitigated across 14 fields identified in the evidence: *Autonomics, Balance, Bone Mineral Density, Cardiac Function, Exercise Capacity, Fluid Hormones, Visible Fluid Shift, Headaches, Intracranial Pressure, Muscle Size, Muscle Strength, Plasma Volume, Orthostatic Tolerance,* and *General Wellness*. **RESULTS:** LBNP and mixed exercise displayed the broadest efficacy (improvement in 6 fields) with 8 pieces of supporting research. Centrifuge with exercise was also effective in 6 fields but had only 4 sources with significant data and has proven difficult to implement in-flight. Supplements, electrical stimulation, and resistance training have limited proven effect (<1 symptom mitigated). No countermeasure was studied for effect across all 14 fields (avg. 5/med. 6) signifying gaps in an average of 9 fields per countermeasure. 34% of papers omitted key methods data, and 21% had no statistical significance reported. **DISCUSSION:** Further research should define standardised parameters by which to measure fluid shift and countermeasure efficacy, as well as address the current gaps in supporting evidence. Countermeasure research should address contemporary spaceflight demands such as differences in countermeasure efficacy between males and females, and the viability of countermeasures for longer-duration flights.

Learning Objectives

1. The audience will be able to understand the benefits and cautions associated with the range of available countermeasures to mitigate fluid shift in human spaceflight.
2. The audience will be able to use the identified gaps in the current body of evidence supporting countermeasures to guide future fluid shift research, with focus on meeting contemporary spaceflight needs such as gender equality and long-duration microgravity exposure.

[391] EFFECTS OF SIMULATED GALACTIC COSMIC RAYS ON CARDIOVASCULAR FUNCTION AND STRUCTURE IN MULTIPLE MOUSE MODELS

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(Original Research)

INTRODUCTION: In 2030, NASA plans to send astronauts on deep space missions including to Mars. Crewed missions will take at least 6-8 months. In comparison to low-earth orbit levels, much less is known about the potential adverse effects of deep space travel given astronauts will be exposed to ionizing radiation from galactic cosmic rays (GCR) and solar particle events. **METHOD**: We focused on the long-term effects of GCR on cardiovascular function and structure. We used two different mouse models: male Balb/C and female CD-1 mice. To simulate GCR, the mice were exposed to six beams of high-energy ions: Protons (1000 MeV) – 0.175 Gy, Silicon ions (600 MeV/n) – 0.005 Gy, Helium ions (250 MeV/n) – 0.09 Gy, Oxygen ions (350 MeV/n) – 0.03 Gy, Iron ions (600 MeV/n) – 0.005 Gy, Protons (250 MeV) – 0.195 Gy at the NASA Space Radiation Laboratory at BNL. This was a single day exposure with a total dosage of 0.5 Gy, roughly the dose of radiation an astronaut would be exposed to inside a space craft during a deep space mission to Mars. For each of the two mouse models there was a control or sham group of mice transported to BNL but not exposed to any simulated GCR. Mice were assessed at 15 weeks and 5-6 months after exposure. The effects of simulated GCR on parameters of cardiac function such as stroke volume, ejection fraction, diastolic and systolic volumes and diameters, were measured with high-resolution echocardiography. Cardiac tissue was obtained and indicators of immune cell infiltration (mast cell tryptase, CD2, CD4, and CD45) and fibrosis (total collagen deposition, collagen 3A, and a-smooth muscle cell actin) were assessed with Western blots and histology. Cardiac microvascular density was assessed with fluorescent lectin staining and calculating number of capillaries per area. **RESULTS**: Across all analyses, we found no significant differences between the sham and GCR exposed male and female mice in cardiac function or structure. These results suggest that the two mouse models tested are resistant to long-term effects of GCR on the heart. Additional time points after exposure are undergoing investigation. **DISCUSSION**: Future studies with a larger sample size may provide more conclusive answers on long-term health risks of GCR exposure. While practical limitations precluded us from studying male and female mice from the same strain, it may prove useful in future studies to use the same strain in order to make a direct comparison between the two sexes.

Learning Objectives
1. With my presentation, I will be able to explain the ongoing efforts of my lab's research into the space radiation and how it impacts the cardiovascular physiology and function.
2. The audience will learn about the process in which my lab's research is providing data for future deep space missions to gain a better understanding and safety risk specific to space radiation effects to the bodies of astronauts, in the case of this study in regards to hearts.

[392] A ROBOTIC SYSTEM FOR ULTRASOUND GUIDED PERIPHERAL VASCULAR LOCALIZATION FOR HUMAN SPACEFLIGHT

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(Original Research)

INTRODUCTION: A crucial step in the diagnosis or treatment of any patient is access to the blood in their veins. For patients that have veins which are hard to identify at the skin surface, clinicians use an ultrasound to identify and track veins for catheter placement. Autonomous robotic vein localization (detection and tracking) using ultrasound guidance could provide a more accurate and reliable process for patients that does not require advanced training for the clinician. **METHODS:** The efficacy of the fully integrated system for 3D localized volumes of peripheral vasculature was performed with force limits for future safety in human use. A novel ultrasound calibration procedure, specific for finding small tubular structure, is presented. A vein localization pipeline that consists of vessel detection and tracking is proposed to find the vein positions in real-time. **RESULTS:** Precision tests were performed with both predesignated areas and autonomously selected in an arm phantom. The average variance of the autonomously collected ultrasound images (to construct 3D volumes) between repeated tests was shown to be around 0.3 mm, similar to the theoretical spatial resolution a clinical ultrasound system. **DISCUSSION:** An autonomous RGBD and 2D ultrasound guided robotic arm collected 3D localized volumes of peripheral vasculature for potential application in human spaceflight. This compact design, with available commercial components, lends itself to platform utility throughout the human body. This fully integrated system demonstrates the capability of autonomous collection of peripheral vasculature imaging and 3D location in a body-centric reference frame with built in safety measures for future human testing.

Learning Objectives
1. Understand the utility of autonomous robotic ultrasound capture in remote environments such as space.
2. Learn about the system requirements of a fully integrated and automated system for the procedure of ultrasound capture on a future patient in space.

[393] FIRST VOID URINARY CALCIUM FOR TRACKING BONE LOSS AND KIDNEY STONE RISK IN SPACE

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(Original Research)

INTRODUCTION: Microgravity exposure in space increases bone loss and kidney stone formation risk. Slowing bone loss and preventing kidney stones are critical for successful spaceflight. Yet, no simple inflight methods exist for assessing bone loss and kidney stone formation risk in space. While 24-hour urinary calcium excretion is a well-established and reliable marker of bone loss in bed rest studies, measuring this in space requires both urine volume and urine calcium (Uca) concentration determinations. We studied the probability that a first morning void (FMV) would capture the highest Uca concentration in a day, and so could be a practical approach for assessing the risk of bone loss and kidney stone formation in prolonged spaceflight. **METHODS:** Ethics approval was obtained from the Dartmouth College Committee for the Protection of Human Subjects. 3 male and 3 female subjects collected 24-hour urine samples weekly for 8 weeks. Uca concentration was analyzed using a calcein-based system for a total of 377 voids collected. Uca concentrations were ranked among all samples from each person and a Mann Whitney U Test was conducted to compare Uca concentrations between all FMV and non-FMV (nFMV). The probability that a FMV would capture the highest Uca concentration in a day was also assessed. **RESULTS:** Among 377 voids collected, 46 were FMV and 331 were nFMV. Amongst all samples, the Uca concentration for FMV was significantly higher than nFMV ($p<0.0001$). Out of the 46 FMVs, 24 were highest in Uca concentration for the corresponding 24-hour collection period. Therefore, the probability that any given FMV would capture the highest Uca concentration in a day is 52.2%. The probability increases to 77.1%, and 89.1% when two or three FMVs are collected, respectively. **DISCUSSION:** Acquiring 2-3 repeated FMVs provides a high likelihood of capturing the highest Uca in a day. Our previous work shows that FMV concentration correlates well with overall 24-hour Uca excretion. This suggests first morning void Uca concentration could potentially be tracked to assess inflight risk of bone loss and kidney stone formation in space. This measurement could be done with simple hand-held equipment. The capability to measure bone loss and potential for kidney stone formation would enable an assessment of these risks while in space and may provide ability for real-time implementation of countermeasure programs to prevent bone and renal complications in prolonged spaceflight.

Learning Objectives
1. To understand the importance of and challenges with assessing bone loss and kidney stone formation risk in space.
2. To learn about how tracking first morning void urinary calcium concentration may serve as a practical approach for assessing the risk of bone loss and kidney stone formation in space.

[394] STRUCTURAL CHANGES IN BRAIN MRI INDUCED BY HEAD-DOWN TILT BED REST

José Gonçalo Teixeira Alves[1], Edson Oliveira[2], Pedro Morgado[1]
[1]*School of Medicine - University of Minho, Braga, Portugal;* [2]*Lisbon Medical School, Lisboa, Portugal*

(Original Research)

INTRODUCTION: MRI studies performed in astronauts have shown changes in brain anatomy pre and post-flight. Several studies are taking place to better understand the clinical implication of such discoveries. Head Down Tilt Bed Rest at a 6-degree angle (HDT) is a high-fidelity research model when trying to replicate the upward shift and isolate the actions of microgravity on the human brain's structure. The aim of this review is to systematically summarize and meta-analyse the combined data on the changes in brain structure observed in MRI induced by exposure to HDT. Likewise, we also aim with this review to create a foundation for future studies involving Brain MRI and HDBT to be built upon, in order to better understand and explain the changes the human brain goes through when exposed to microgravity. **METHODS**: We performed a comprehensive computer literature search on EMBASE, MEDLINE, Web of Science, CENTRAL and Google Scholar in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guidelines. We selected papers that mentioned experimental studies on healthy human individuals being submitted to HDT longer than 48 hours and that were submitted to structural Brain MRIs at the beginning of the intervention and after HDT exposure. We extracted the data referring to mean volumetry of gray and white matter, as well as detailed structural analysis of the whole brain. **RESULTS:** One hundred and twenty-four papers were identified. Five papers were identified as eligible for systematic review, with three articles being considered eligible for the meta-analysis. Gray Matter volumetry is reported to have decreased in areas responsible for lower limb movement (mostly posterior parietal and frontal areas), with an overall increase in brain volume due to the upward shift of fluids. No specific white matter changes were found. **CONCLUSIONS**: Several structural changes were identified as part of HDT exposure. However, due to the lack of a standardized process to study and report these changes, our review can't provide definite conclusions on the beahviour of the human brain in HDT and, consequently, in microgravity. Further experimental studies with adequate statistical power, study protocols, as well as a higher sample size are needed to better evaluate these anatomical changes and their clinical implications in spaceflight.

Learning Objectives
1. Understand the current evidence on HDT research involving structural brain changes observable using MRI.
2. Learn how future research on the topic should be conducted and reported in order to valuably add to the evidence base.
3. Learn about the current norm on ground-based human research analogs, possible limitations and ways those could be overcome.

[395] PREPAREDNESS FOR SURGICAL EMERGENCIES DURING EXPLORATION CLASS MISSIONS

Nina Purvis[1]
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(Original Research)

INTRODUCTION: Crewed missions to Mars are planned for the 2040s. Risks include distance and the extreme environment faced. Planning and self-sufficiency are key to success. Stabilisation, transport, and robust telemedicine capabilities are not a feasible model for surgical emergencies. Astronauts will have experienced significant physiological deconditioning. Considerations of the environment in which such a surgery may take place, statistical probability of surgical emergencies, the deconditioned status of the prospective patient, crew training, and technologies and equipment to utilise need to be outlined. **METHODS**: A systematic literature review and thematic analysis pertaining to surgery during long-duration spaceflight and on Mars. Databases: PubMed, NASA online archives, ESA online archives, cross-checking of reference lists. Search terms (1960-2020, papers in English): *Surgery *AND Spaceflight, *AND Mars, *AND analogue mission; Robotic Surgery *AND Spaceflight, *AND Mars, *AND analogue mission; Autonomous Robotic Surgery *AND Spaceflight, *AND Mars, *AND analogue mission; 3D Printing Surgical Instruments *AND Spaceflight, *AND Mars, *AND analogue mission*. **RESULTS:** 237 abstracts screened resulting in 46 papers to be appraised using PRISMA 2009 and CASP 2018 guidelines. **DISCUSSION:** Rat dissection and tail repair were carried out by crew during Neurolab STS-90, 3D printed surgical instruments have been tested during Mars analogue missions, robotic surgery has been tested during NEEMO missions and surgical techniques such as laparoscopic surgery have been tested during parabolic flight on animal models. Surgical enclosures of various design exist creating a sterile and adaptable surgical environment. Perioperative care has also been considered. Most studies do not consider partial gravity of 0.38*g*, most evidence is in 0*g* or analogues. Anticipated surgical emergencies include trauma, appendicitis, cholecystitis, and dental and urological emergencies. Preventative prophylactic surgery is considered. Utilising technologies such as 3D printing instruments and robotics could allow for preparedness for complex surgeries. There is a significant mass, power, volume and training constraint for Mars missions. Ultimately, prevention is better than surgery - crew selection, preventative medicine, exercise and protective countermeasures will help alleviate a surgical emergency but do not prevent the possibility entirely.

Learning Objectives
1. To understand the limitations of the spaceflight environment in carrying out surgical procedures such as micro/partial gravity, infection risk, limited medical tools, and delay in communications guidance.
2. To learn about potential solutions to these limitations, such as training in surgical skills for crew, 3D printed surgical instruments, and surgical enclosures for micro/partial gravity.
3. To be able to summarize the current state of the literature pertaining to this topic and state knowledge gaps.

Thursday, 09/02/2021 ***3:30 PM***
Governor's Square 14

[S-72]: PANEL: RESEARCH AND PRACTICAL CONSIDERATIONS ON THE USE OF EXTENDED REALITY IN NAVAL AVIATION

Chair: Brennan Cox

Panel Overview: *Extended reality (XR) is an overarching term used to describe all forms of virtual reality (VR), augmented reality (AR), and mixed reality (MR). As the name implies, XR effectively extends reality by blending real world and computer-generated experiences, most readily through the use of wearable or related immersive devices. These tools hold great promise for reshaping how we plan, execute, and understand the nature of complex tasks; as such, they are already being employed across aerospace, military, and medical environments for training, logistics, situation awareness, and human performance enhancement, among other applications. Potential users, however, are encouraged to proceed with caution based on the known limitations of these technologies and the emerging challenges resulting from their rapid innovation. This panel includes six presentations on research and practical considerations on the use of XR in naval aviation. The first presentation provides context for the session with an overview of fleet needs and requirements. The second presentation reviews existing technologies and technological gaps. The third, fourth, and fifth presentations discuss existing lines of research on VR, AR, and MR in support of naval aviation. Lastly, the panel concludes with a discussion on XR implementation challenges and mitigation strategies.*

[396] EXTENDED REALITY IN NAVAL AVIATION: FLEET REQUIREMENTS AND TECHNOLOGY GAPS

Chris Foster[1]
[1]*University of Houston, Houston, TX, USA*

(Education - Program / Process Review)

BACKGROUND: Extended Reality (XR) is an umbrella term that includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). These technologies offer the potential to revolutionize how Naval Aviators are trained by delivering more immersive and cost effective training solutions. Naval Aviation is investigating the potential use of this technology to revolutionize the manner in which aviators are trained. **OVERVIEW:** Naval Aviation is continuously looking at ways to improve training and readiness. Current challenges include the need to manage / reduce training costs, the need to improve and maintain proficiency, the need to match trainer fidelity to fidelity required for targeted KSAs, and the need to address training throughput challenges. Current XR technology offers a potential approach to address many of these challenges. Unfortunately, the private sector represents the largest customer base for XR technology and its requirements differ from those of Naval Aviation. Thus, while XR technology is quite promising there are a number of technological gaps that need to be addressed for the technology to fully address Naval Aviation's needs. This talk will focus on Naval Aviation's requirements as related to XR technology, highlight its benefits, and discuss current technology gaps. XR has four distinct advantages over legacy technologies. First, the costs of XR hardware is lower than traditional simulator based training system. Second, XR has a smaller footprint. Third, when combined with other technologies, such as Artificial Intelligence (AI), XR can reduce the need for human instruction. Lastly, XR can provide evidence-based instructional methods for training, such as adaptive training. **DISCUSSION:** The U.S. Navy has leveraged these advantages to create their Naval Aviation Training Next program. This program is investigating the use of current generation XR technologies to enhance aviation training and encouraging innovation to better address training requirements. Areas where additional innovation is essential include the need to reduce headset size, harden headsets for military use, and improve the mobility and processing power of XR systems. Lessons learned from this work have the potential to support numerous other applications to include military medicine. Cross service coordination is key to ensuring military requirements are addressed as XR technologies continue to evolve.

Learning Objectives
1. The audience will learn about Naval Aviation's training requirements and how Extended Reality (XR) technology can help to address these requirements.
2. The audience will learn about the current gaps in Extended Reality (XR) technology that must be addressed if XR is to be fully utilized in Naval Aviation.

[397] IS VIRTUAL REALITY A SILVER BULLET FOR AVIATION TRAINING? AN EMPIRICAL STUDY OF THE STRENGTHS AND WEAKNESSES AT THE UNITED STATES AIR FORCE ACADEMY

Todd Seech[1], Matthew Funke[2], Chad Tossell[1]
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(Original Research)

INTRODUCTION: From healthcare to construction to retail and beyond, the excitement is palpable and likely has many professionals asking "What can't virtual reality do?" Likewise, the defense industry has become enamored with the promise of Virtual Reality (VR) and has applied it to one of its most pressing issues: the rapid training of new pilots to offset recruitment and retention deficits. This effort has manifested in the form of programs like Pilot Training Next, which has replaced a portion of the live flight time seen in traditional flight training with VR sorties. These programs are the offspring of decades of diligent human factors research and development to improve ergonomics, increase safety, and provide targeted training. Given these benefits, the U.S. military is leveraging these technologies to provide immersive experiences for young aircrew to develop requisite knowledge and skills. Still, as these program concepts become realities, the scientific community should keep a meticulous eye towards empirically understanding the strengths and weaknesses of VR in aviation training. **METHODS:** The current study attempts to do just that by taking a measured first look at a developing VR flight training program. Thirty-six cadets at the U.S. Air Force Academy (USAFA) completed the Powered Flight Program that provided 32 metrics of airmanship performance (e.g., ground operations, pattern work, communications). Prior to this program, 20 cadets completed the VR-based USAFA Airmanship Next Program and 16 cadets had no VR training. **RESULTS:** A series of independent t-tests with small sample corrections to effect sizes were completed to compare their performance in a variety of graded events in powered flight. Even with the small sample size, effect sizes suggested that VR training enhanced a number of important knowledge and skill domains. Somewhat surprisingly, several domains practiced in the VR-based training negatively transferred to live flight such that the control group significantly outperformed the VR-trained group. **DISCUSSION:** While conclusions based on these data are tentative and study limitations (e.g., non-random assignment) should be heeded, this study provides insights into the design of aviation training given the imminent deployment of VR-based systems. Given VR is not a silver bullet to solve all pilot training shortfalls, this study also may give pause to those who hold virtual reality in general as a digital panacea.

Learning Objectives

1. Describe emerging trends in the military's use of virtual reality training.
2. Identify specific airmanship skills that can be positively transferred from virtual reality flight training.
3. Understand current limitations of virtual reality flight training.

[398] EXPLORING AUGMENTED REALITY EFFORTS IN NAVAL AVIATION

Aditya Prasad[1]
[1]*University of Southern California, Los Angeles, CA, USA*

(Education - Program / Process Review)

BACKGROUND: Augmented Reality (AR) is a subset of several discrete but highly interrelated technologies, collectively known as extended reality (XR), that merge real and computer-generated worlds to create enhanced perceptual experiences. AR specifically refers to technology that enhances individuals' interactions with real-world objects and environments by overlaying them with computer-generated information. The overlaid information is typically visual in nature—but may span other sensory modalities—occurs in real-time, and is delivered by means of Heads-up displays (HUDs), Head-mounted displays (HMDs), or Handheld devices (e.g., smartphones). **OVERVIEW**: Though some of the earliest AR systems ever developed were focused on improving human performance (e.g., Rosenberg, 1992), the rate of technological innovation allowing for increasingly sophisticated AR capabilities has far outpaced research efforts attempting to characterize and evaluate these systems with regard to augmenting human performance. In addition, the cost and complexity of AR technologies has continued to drop and ease-of-access has improved considerably due to the computational and imaging capabilities of modern smartphones. These features make AR highly appealing, yet key questions remain unanswered regarding the benefits and limitations of this technology, creating significant risk for early adopters in terms of cost, performance, and fulfillment of program goals. **DISCUSSION**: Discussion will frame the key concerns for AR technology in naval aviation by addressing existing lines of research, highlighting gaps, and identifying crucial future directions to be investigated. Emphasis will be placed on the importance of considering not just end-products or devices that deliver AR capabilities, but also the underlying infrastructure as well as the individuals who will operate, maintain, and support these technologies.

Learning Objectives

1. Be able to distinguish between Augmented Reality and other forms of Extended Reality.
2. Be able to describe the current state of Augmented Reality research in naval aviation and the key questions yet to be answered.

[399] MIXED REALITY RESEARCH LINES OF EFFORT

Alexandra Kaplan[1], Brennan Cox[2]
[1]*University of Central Florida, Orlando, FL, USA;* [2]*Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA*

(Education - Program / Process Review)

BACKGROUND: Mixed reality (MR) is a classification of eXtended reality (XR) that blends aspects of the real and digital world within a single display to provide users a highly interactive, hyper-immersive experience. With MR, users don a headset that presents digital objects and simulations within the same visual landscape of what they would normally see. Advanced sensor technologies allow the user to interact freely with this content using natural gestures and motions, and the digital objects respond as through real. The ability to interact with real and digital content concurrently, with realistic responses and in real time, helps to distinguish MR from augmented or virtual reality alone. **OVERVIEW:** Use of MR to enhance human performance is no longer the stuff of science fiction. However, the rapid technological innovations allowing for MR have outpaced research efforts to evaluate its true potential. In the best case scenario, use of immature or unproven technologies result in acceptable losses in cost and schedule; but, under worse case conditions, formal programs that do not undergo careful test and evaluation may produce lasting, hidden, and even catastrophic consequences. Questions remain as to whether the prospective benefits of MR outweigh the costs and challenges of employing these technologies in complex environments, such as the aviation and medical domains. **DISCUSSION:** Discussion will address existing research lines of effort on MR in support of naval aviation activities using a total system approach toward evaluation. The total system, in this sense, includes not only the technology or device for delivering MR, but also the people who operate and maintain the system, as well as the underlying support structure. Theoretical applications of MR will be evaluated against pragmatic considerations, with questions on fidelity, skill acquisition, transfer of training, and cost effectiveness addressed. The discussion will conclude by highlighting research gaps and future directions.

Learning Objectives

1. Explain the capability features that distinguish Mixed Reality from other forms of eXtended Reality.
2. Describe the current state of the research and remaining gaps regarding the use of Mixed Reality in naval aviation.

[400] RESEARCH AND PRACTICAL CONSIDERATIONS ON THE USE OF EXTENDED REALITY IN NAVAL AVIATION

Michael Natali[1]
[1]*CNATRA, Corpus Christi, TX, USA*

(Education - Program / Process Review)

BACKGROUND: As the virtual world continues to expand into the real world, it raises significant challenges when trying to optimize integration and benefits especially in work or training settings where it is often seen as a "silver bullet" fix to skill deficiencies. When examining whether to utilize or integrate extended reality (XR) technology, there are several factors to consider. **OVERVIEW:** Naval Aviation has recently begun adoption of XR technology to improve training at a fraction of the cost of traditional simulators. Four of the primary challenges to

successfully adopting XR technologies are: Testing & Evaluation: XR technology is ever growing and improving so identifying the appropriate model, version, and type of XR equipment is challenging. It is imperative to understand the limitations of the system and objectives of training to ensure alignment between the two. Often, disconnects between the two are unclear until the devices are used extensively. Integration: with the multitudes of versions of XR technology and companies, seamless integration is a critical aspect to address. Often, different companies do not integrate together or additional work needs to be done for different systems to work together – this can be as simple as having the right software for a Head Mounted Display or as complex as working multiple programs into an immersive training event. Buy-in: critical for XR to be beneficial in training is for the end-user to believe in the system – both as a usable training tool and as a reliable device. The end-user needs to be part of the process to build support and help lead adoption of XR into training. Sustainment: when integrating XR devices, their maintenance and sustainment needs to be considered. Who is responsible for maintenance, troubleshooting, or replacing devices? Additionally, technology is advancing so quickly the acquisition process is not suited for upgrading XR-type systems and new avenues need to be identified. **DISCUSSION:** The lessons learned from Naval Aviation's integration of XR technologies can inform Aerospace Medicine as we look to assist the effort as well as work XR into our own training and skill development. These systems cannot just be added to existing processes and expected to fix issues. A phrase coined by the Air Force that the Navy has adopted as we integrate is: "New technology plus old system equals more expensive old system; but new technology plus new system equals more efficient system."

Learning Objectives

1. The participant will be able to explain the challenges that arise when attempting to integrate XR systems into training.
2. The participant will be able to describe potential methods for achieving successful integration of XR systems into training.

Thursday, 09/02/2021 ***3:30 PM***
Plaza A/B

[S-73]: SLIDE: MEDICAL CARE IN SPACE - MODELS, ANALOGS, AND PREDICTIVE ANALYSIS

Chair: Stephen Vanderark
Co-Chair: Rochelle Velho

[401] DEVELOPING A NEW MEDICAL CONDITION LIST FOR EXPLORATION SPACEFLIGHT

Amy Kreykes[1], Rahul Suresh[2]
[1]University of Texas Medical Branch, ExMC NASA Johnson Space Center, Galveston, TX, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: For the last decade, the National Aeronautics and Space Administration (NASA) has utilized a probabilistic risk analysis tool called the Integrated Medical Model (IMM), which contains 100 medical conditions, to conduct medical trade-space analyses and risk assessments for International Space Station (ISS) operations. Planning for future missions to the Moon and Mars will require updated tools and evidence that consider the unique features of exploration missions. To address this need, the Exploration Medical Capability (ExMC) Element of the NASA Human Research Program is developing an advanced trade-space analysis tool suite, IMPACT. As a part of this effort, ExMC has produced the IMPACT version 1 Condition List (ICL 1.0) which expands the scope and definition of medical conditions. **OVERVIEW:** A list of conditions with potential to occur during exploration spaceflight was identified from the IMM condition list, NASA astronaut and terrestrial analog epidemiologic data, and subject matter expert (SME) input. This master list included a total of 443 candidate conditions. The ICL 1.0 list was constrained to 120 of these conditions to accommodate schedule and resource requirements. The master list was reviewed by the ExMC Clinical and Science Team—a multi-disciplinary group of physicians, nurses, and an epidemiologist—to determine conditions for inclusion. All conditions from the IMM condition list that have occurred in spaceflight were included on ICL 1.0. The remaining conditions were reviewed sequentially in order of level of concurrence between sources. With input from SMEs in areas related to exploration, conditions were divided or combined to refine their scope for optimal incidence data collection and resource-tracing later in the process. The ExMC team then refined condition severity definitions by consensus. Conditions felt to be less likely to occur or of lower relative consequence, but still relevant for exploration spaceflight, were archived for inclusion in a future iteration of the ICL. **DISCUSSION:** The ICL 1.0 reflects a list of more broadly scoped and refined conditions relevant to exploration design reference missions that will serve as the basis of the medical evidence supporting the IMPACT trade space analysis tool suite. Additionally, in anticipation of efforts to maintain the relevance of this list and further expansion of its scope, candidate conditions for inclusion in future versions of the ICL were identified.

Learning Objectives

1. Understand the reason for creating an updated medical condition list for IMPACT.
2. Understand the process behind the development of the IMPACT 1.0 Medical Condition List.

[402] SIMULATING MEDICAL OFFICER OCCUPIED TIME (MOOT) FOR SPACE MEDICAL SYSTEM DESIGN, A PILOT PROJECT

Preston Fedor[1], Dana Levin[2]
[1]U.S. Air Force Reserve, Portland, OR, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: Providing and receiving medical treatment takes time away from other duties. The time is expected to vary based on the provider's skill level, duration of the patient's illness, specific tasks performed, and the condition's severity. Since crew time is a limited resource, it is important to understand how MOOT will impact mission objectives. Historically, diagnostic/treatment time was estimated only for the patient by subject matter experts using a non-standard approach based on the condition as a whole. The present effort uses a Delphi approach among experts of varied training levels and based on estimates of specific medical tasks in order to more accurately assess downtime for both caregiver and patient with fewer errors. **METHODS:** A subset of medical system capabilities that are performed by a care provider was identified from NASA's Evidence Library project. These capabilities were organized into a survey which was administered to a minimum of 5 care providers at each of 6 training levels; Emergency Medical Technician – Basic, Paramedic/military medic, experienced ED/ICU nurse, Intern, Physician Assistant, Attending generalist physician skilled in procedures (e.g. emergency medicine or family medicine). These providers were asked to estimate how much time it would take to perform each capability within their scope of training. Additional information on the time required for specialized procedures was sought from specialists. **RESULTS:** The average time, and confidence intervals, required for providers of various training levels to perform medical diagnosis and treatment tasks were obtained. For each medical condition and each level of provider training, the time required for all diagnostic and treatment tasks were combined. This allowed an estimation of the total time required for treatment and diagnosis in both the acute and continuing care phases as a function of the training level of the treating provider. **DISCUSSION:** This pilot project represents one method to approximate the time required to treat medical conditions in space flight. These data can be used to inform exploration class medical system design requirements, estimate the impact to crew time from medical events, and estimate the effect provider training has on downtime for both patient and provider.

Learning Objectives

1. Understand the effect that medical operations have on crew time.
2. Understand how potential time savings of crew medical officer training may be modeled and accounted for in medical system planning.

[403] MODELING PROVIDER CREATIVITY IN MEDICAL SYSTEM DESIGN SIMULATING A MEDICAL MACGYVER

Brian Lonquich[1], Dana Levin[2], Lauren MC[3]
[1]Baylor College of Medicine, Houston, TX, USA; [2]NASA Johnson Space Center, Houston, TX, USA; [3]NASA Glenn Research Center, Cleveland, , USA

(Original Research)

INTRODUCTION: This presentation describes a method for modeling provider creativity during the requirements building and risk assessment phase of medical system design. Practicing medicine in isolated, confined, and extreme environments requires providers to use limited supplies in creative ways. This is necessary to handle unexpected medical events or make better use of limited storage capacity by leaving low-use, bulky equipment behind in favor of *in situ* or dual-use resources. This is a highly-valued skillset in remote environments, however, the ability to simulate this care creativity computationally is difficult. **METHODS:** A team of computational scientists, physicians, and remote medicine experts derived a strategy to address this by defining medical capabilities as groups of related medical resources and assigning resources within the capability as either primary or alternate. The capabilities are then defined as treatment clusters within Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT), a computational model that simulates space flight medical risk. **RESULTS:** By defining treatment in this way, the model can select alternate resources in a hierarchical fashion, governed by expert opinion, should the primary resource be unavailable or removed during trade-space optimization. In this way quantitative risk estimates as a result of care creativity can be measured, compared, and traded against. **DISCUSSION:** While imperfect, it is to our knowledge the first attempt to model improvisational care in medical system design, and to quantify its' impact on mission medical risk. This information can also be combined with provider training level to explore the effect of provider skill on medical risk reduction. The ultimate goal of this work is to optimize medical resource inclusion in mass and volume limited environments by exploring the effects of non-traditional, creative care.

Learning Objectives

1. Understand the challenges of modeling provider activities within a risk assessment tool.
2. Understand how the risk impact of provider creativity can be modeled.

[404] MODELING CHANGES IN INTRAOCULAR PRESSURE ASSOCIATED WITH THE PHYSIOLOGICAL RESPONSE TO CHANGES IN THE GRAVITATIONAL VECTOR

Richard Whittle[1], Lonnie Petersen[2], Justin Lee[2], Jeremy Sieker[2], Johan Petersen[2], Ana Diaz-Artiles[1]
[1]Texas A&M University, College Station, TX, USA; [2]University of California San Diego, San Diego, CA, USA

(Original Research)

INTRODUCTION: Spaceflight associated neuro-ocular syndrome (SANS) is one of NASA's "red" risks. Cephalad fluid shift associated with microgravity exposure is hypothesized to be a key risk factor in the development of SANS. We consider a modified version of a previously developed lumped-parameter model of the eye under the condition of different gravitational vectors. We explore how changes in the gravitational vector through a full 360° affect the steady state response of intraocular pressure (IOP), whilst considering two hypotheses. First that changes in the gravitational vector by head-down tilt (HDT) increases mean arterial pressure (MAP) at eye level to a greater extent than IOP thereby increasing ocular perfusion pressure (OPP). Second that IOP is significantly increased in prone versus in supine. **METHODS:** We validate simulation results by tilting 13 subjects on an inversion table from fully upright to -90° head down tilt (HDT, inverted) in both prone and supine configurations. IOP was measured using a noninvasive rebound technology (ICare Pro, Finland) while MAP was measured at heart level (N=6) (Omron, USA) or around a finger (N=7) (Nexfin, Netherlands) and then corrected to eye level. **RESULTS:** We find that IOP increased with tilt inversion and there was a significant increase in IOP when prone versus supine at 0° (dIOP = 3.4 mmHg, 95% CI 1.6 to 5.2 mmHg, $p < 0.0005$), 15° HDT (dIOP = 4.5 mmHg, 95% CI 2.7 to 6.3 mmHg, $p < 0.0005$), 30° HDT (dIOP = 5.2 mmHg, 95% CI 3.4 to 7.0 mmHg, $p < 0.0005$), 45° HDT (dIOP = 4.64 mmHg, 95% CI 2.8 to 6.4 mmHg, $p < 0.0005$), and 60° HDT (dIOP = 4.3 mmHg, 95% CI 2.5 to 6.1 mmHg, $p < 0.0005$). The same trends are seen in OPP. These results are matched well by our model simulations. We further compare with differences in prone vs. supine experiments found in published literature. **DISCUSSION:** This research achieves three separate aims. First, we continue to build dose response curves informing how IOP (and OPP) change with a changing gravity vector. Second, we show significant differences between IOP when prone and supine. These inform a deeper understanding of the relationship between IOP and SANS. Third, we validate our numerical ocular model with experimental data. This is the first step towards incorporating the eye model into our model of the systemic circulation, with the aim of modeling more complex gravitational and physiological changes such as centrifugation, the effect of exercise, and longer duration spaceflight.

Learning Objectives

1. The audience will learn about the use of computational modeling for studying changes in intraocular pressure due to changing the gravitational vector.
2. The audience will learn about the development of dose response curves for ocular variables, and how they increase understanding of the relationship between IOP and SANS.

[405] PREDICTIVE FEATURES FOR MISSION IMPACTING MEDICAL EVENTS IN A SIMULATED ASTRONAUT POPULATION DERIVED FROM A LARGE CLINICAL POPULATION

Connor Davis[1], Daniel Buckland[1]*[1]Duke University, Durham, NC, USA*

(Original Research)

INTRODUCTION: Current datasets available for training of machine learning of astronaut health events are too small with far too few relevant medical events for most common methods. This project uses a large clinical dataset of Emergency Department (ED) visits for training a model, and then validates the results on a subset of data simulating an astronaut population. **METHODS:** ED care leading to hospital admission can be a proxy for a mission impacting medical event. 778,276 visits over 2015 –2018 across 3 EDs were analyzed for predictive features leading to admission or discharge using a Light GBM classification model. 153,885 encounters from 2019 were used for validation. A subset from training (55,974) and validation (20,570) sets was defined to mimic an astronaut population: age 20 - 55, no hospital admissions in the year prior, no medical diagnoses, and no medical conditions. Performance was measured by AUROC and APC. The astronaut simulated subset was used to develop a separate classification model, then compared to wider model. **RESULTS:** Most common chief complaints associated with admission are abdominal pain, chest pain, motor vehicle crash, fall, gunshot wound. Most common comorbidities of these patients were motor vehicle collision, essential hypertension, unspecified sore throat, and cough. The model developed on all patients had an AUROC of 0.789 (95% CI: 0.782-0.796) and an APC of 0.105 (95% CI: 0.099 – 0.112) on the simulated astronaut validation subset. The simulated astronaut training subset had an AUROC of 0.814 (95% CI: 0.808-0.821) and an AUPRC of 0.158 (95% CI: 0.146-0.169) on the same validation subset. The most predictive features for both models overlap considerably, and the top 5 for both include age, hematocrit, white blood cell count, and platelet count. **DISCUSSION:** An astronaut equivalent model had similar predictive features for admission as a larger ED population. The most common comorbidities for these patients are hypertension, sore throat, and cough, or trauma-related items. Most were admitted for trauma-related or one-time issues. With this simulated astronaut dataset, we see that using a more general population of ED patients to train an adverse events model produces nearly comparable performance as one trained on a more specific subset with similar predictors. We should be able to develop a model on a larger clinical population that will perform as well on an independent cohort of astronauts.

Learning Objectives

1. The participant will learn about how to apply wider clinical population trends to a downselected astronaut population.
2. The audience will learn about machine learning methods as applied to predicting clinical events.

[406] FILLING THE VOID: THE ROLE OF THE MEDICAL PROVIDER IN ANALOG SPACE

Sheyna Gifford[1], Rochelle Velho[2], Marc O'Griofa[3], Marc Shepanek[4], Adrianos Golemis[5], Bonnie Posselt[6]
[1]Washington University St. Louis, St. Louis, MO, USA; [2]University Hospitals Birmingham, Birmingham, United Kingdom; [3]University of Limerick, Limerick, Ireland; [4]NASA, Washington, DC, USA; [5]European Space Agency, Cologne, Germany; [6]USAF/RAF Center of Aviation Medicine, Dayton, OH, USA

(Education - Program / Process Review)

BACKGROUND: Simulated space missions were introduced by government space agencies to support initial human spaceflight attempts during the Apollo era. Analog space, is a unique environment utilized for invaluable training, testing, and as a performance-optimization platform prior-to and during every subsequent phase of actual space exploration including Skylab, shuttle, and the International Space Station. It is vitally important appropriate medical risk assessments have been performed and the best medical care possible is aspired to. **OVERVIEW**: Simulated space missions have expanded into a spectrum of citizen science projects of varying scales and fidelities. These extra-governmental efforts provide further opportunities to examine human-space-flight-relevant clinical and technological issues. Where agency-run analogs have been essential to the past success of human spaceflight, citizen-scientist analogs may be able to confer similar benefits to future space habitation: if standards in data collection and human safety can be formulated and applied. Currently, rigorousness in terms of data collection and human safety in non-agency analogs varies widely, this may be due to lack of awareness, limited funding or inadequate situation specific medical preparation. The diversity of these simulated space environments creates a range of medical and data-relevant risks making any solutions even more challenging. **DISCUSSION:** We will discuss the opportunities provided by these potential analogs, and challenges for how they might support space mission research. Additional recommendations will be offered for optimizing medical conduct to these analog missions to enhance safety while maintaining fidelity, which will have the added effect of improving any data gathered.

Learning Objectives

1. The audience will learn about the range of medical analog platforms and ideal medical safety standards.
2. The audience will learn how to optimize medical care and safety to analog space missions.

Thursday, 09/02/2021 ***3:30 PM***
Plaza D/E

[S-74]: PANEL: UNUSUAL SITUATIONS IN CLINICAL AVIATION MEDICINE: HOW TO MANAGE?

Chair: Olivier Manen
Co-Chair: Jonathan Monin

Panel Overview: *The role of the aeromedical expert (AME) is to assess the risk for a medical event in one individual to jeopardize the flight safety and also the evolution of the aircrew's career, based on a medical report including anamnesis, physical exam and all investigations required when necessary. The final decision shall respect national or international norms such as the EASA regulations which allow more or less flexibility, depending on the status of the aircrew. Usually, there is a discussion about aeronautical fitness in case of a precise diagnosis, leading to the study of scientific data for one particular disease including the natural history, the possible complications and the risk of the treatment. Consequently, the AME may be at ease to back up the decision and to explain when temporary or permanent unfitness. However, is the situation so simple in the real life, particularly regarding the daily practice in Aeromedical Centres? Indeed, sometimes the diagnosis is possible but not definite, or a clear diagnosis is not associated with any argument for an aetiology. In other times, one pathology or syndrome is considered but is quite rare, and so the AME may neither have experience of it nor find a guide in the regulations like the EASA Acceptable Means of Compliance. There are also aircrews working in a very particular aviation speciality such as for civil fighter pilots flying with a Class 1 medical certificate only, and yet they are exposed to sustained +Gz accelerations. Pregnancy should also be considered as unusual situations in female aircrews if we refer to the low number of professional women who are able and decide every year to continue flying once they are aware of the diagnosis. Finally, the AME has to face, psychologically speaking, atypical applicants or confirmed pilots with some difficulties to manage despite the place of mental health in the European regulations. This panel will try to give key elements to the AME for the decision-making process in all these situations illustrated by different case reports.*

[407] HOW TO COPE WITH A DIAGNOSTIC DOUBT IN AEROMEDICAL EXPERTISE ?

Nicolas HUIBAN[1], Laetitia Corgie[1], François-Xavier Brocq[1], Jonathan Monin[2], Sebastien Bisconte[2], Olivier Manen[2], Marc Monteil[1]
[1]French Military Health Service, Toulon, France; [2]French Military Health Service, Clamart, France

(Education - Case Study)

INTRODUCTION: These case reports illustrate situations where the fitness decision issue is confronted with uncertain diagnoses.
BACKGROUND: Decision making in aviation medicine is most often part of a well-established framework in which epidemiological data allow to assess the risk of in-flight incapacitation through possible sequelae, complications and the recurrence risk. When clinical profile is less obvious, the challenge of expertise takes on a new dimension. **CASES PRESENTATION**: We will first present some doubtful EEGs in selection for military applicants before describing three case reports illustrating various situations. A case of poorly systematized deficient symptoms with evocative white matter lesions findings in an airline pilot will lead to discuss a demyelinated disorder or an isolated radiological syndrome. Then, we will describe the occurrence of lipothymic discomfort at the exercise height in a flight test experimenter, leading to document a hypoglycemia as well as a coronary disease without argument for paroxysmal arrhythmia or ischemia. We will last present a transient confusional episode in a young student helicopter pilot where no obvious etiology will consider a not typical transient global amnesia.
DISCUSSION: Aviation medicine typically relies on making a double prognosis related to the in-flight medical incapacitation risk and the safety challenge. A fitness decision will therefore require a healthy status not modified by flight circumstances, allowing to perform all on-board duties without challenging mission safety. With no clear diagnosis after a medical event, this approach gives rise to new questions: Is it more appropriate to use the most frequent, the most probable or the most risky diagnostic hypothesis regarding aeronautical prognosis? Should doubt benefit fitness with regard to operational issues? Do flight duties then become the main determinant for decision? If so, could operational limitations be justified and which ones? Should the situations with uncertain diagnosis be considered equally for initial applicants and confirmed pilots? These questions thus define specific challenges in aviation medicine. In the end, a case-by-case approach will often take shape in the light of all these considerations and will highlight both the importance of the training and the interest of the practice of AME (which we would like to illustrate here).

Learning Objectives

1. To be aware of the aeromedical decision-making issues in case of uncertain diagnosis.
2. To know how to evoke the relevant differential diagnoses suggested by a clinical situation

[408] RARE DISEASES : HOW TO MANAGE THE AERONAUTICAL FITNESS?

Sebastien Bisconte[1], Marie Marechal[1], Geatan Guiu[1], Jonathan Monin[1], Nicolas Huiban[1], Caroline Brescon[1], Jean Francois Oliviez[1], Anne Pia Hornez[1], Eric Perrier[1], Olivier Manen[1]
[1]French Military Health Service, Clamart, France

(Education - Case Study)

INTRODUCTION: This case report highlights the difficulties for the aeronautical expert to manage fitness to fly for a pilot who suffers from a rare genetic disease. **BACKGROUND:** Pseudoxanthoma elasticum

(PXE) is a genetic metabolic disease with autosomal recessive inheritance caused by mutations in the ABCC6 gene. The clinical prevalence of PXE has been estimated from 1 per 100,000 to 1 per 25,000. In the clinical description of PXE, there are dermatological signs (yellow papules on the nape and sides of the neck and in flexural areas), ophthalmological signs (angioïd streaks may trigger choroidal neovascularization and, ultimately, loss of central vision and blindness in late-stage disease) and cardiovascular lesions (peripheral artery disease, myocardial infarction, angina pectoris). There is no cure for PXE. **CASE PRESENTATION:** Routine screening during initial examination of a 19-yr-old helicopter pilot applicant revealed (an) angioïd streaks and loose and wrinkled aspect of the skin. He was referred to a national eye hospital where the diagnosis of PXE was confirmed. A detailed analysis of this case report will be presented, including the medical and aeronautical management, the risk assessment of in-flight incapacitation and the potential consequences of the exposure to specific aeronautical constraints. **DISCUSSION:** The authors will try to extract general guidelines for the aeronautical fitness management in case of a rare disease.

Learning Objectives

1. The participant will learn about diagnosis of PXE and its clinical manifestations.
2. The participant will learn about rare disease management by an aeronautical expert.
3. The participant will learn about aeronautical considerations of rare disease.

[409] UNUSUAL DUTIES AND FITNESS ASSESSMENT: WHEN REGULATIONS ARE OF NO HELP

Jonathan Monin[1], Gaëtan Guiu[1], Sébastien Bisconte[1], Anne-Pia Hornez[1], Nicolas Huiban[2], Eric Perrier[1], Olivier Manen[1]
[1]Percy Military Hospital Aeromedical Center, Paris, France; [2]AeMC, Toulon, France

(Education - Case Study)

INTRODUCTION: The aeromedical assessment is generally based on the disease of the aircrew member. According to the severity of the disease, the risk of worsening in relation to flights, and the risk of occurrence of inflight symptoms, the aeromedical expert can take a fit or unfit decision. But another criterion is very important to consider: the real duty of the crew. **BACKGROUND**: In this presentation, the authors will present some unusual duties which could be a problem for the aeromedical decision. Based on case reports of aircrews followed in our AeMC, we will first discuss the problem of the aerobatics fitness in civilian aviation, and then discuss some other unusual specialties. **CASES PRESENTATION AND DISCUSSION**: The European civilian regulations don't talk about aerobatics, which can be a problem for several professional pilots, but also for the private pilots who regularly practice aerobatics, sometimes as a competitive sport. We will first present a civilian professional pilot flying in Rafale as an instructor. The systematic EKG showed a 1st degree atrioventricular block, associated with supraventricular rhythm disturbances and a mild aortic valve disease. An evaluation including noninvasive then invasive cardiological tests, but also human centrifuge and inflight test was performed to allow a return to fly. During the follow-up, the valve heart disease and the rhythm disturbances worsened, which jeopardized his fitness to fly. We will then discuss a civilian fast jet team pilot who regularly performed cardiological investigations for the follow-up of premature ventricular beats. Six years after the onset of this arrhythmia, a Holter monitoring showed a non-sustained ventricular tachycardia which led to a diagnosis of arrythmogenic right ventricular cardiomyopathy. Other unusual duties will be discussed like nurses working in hypobaric chambers who regularly suffer from decompression sickness whereas no regulation exists about their fitness, also the flight engineers and attendants in zero G flights who are asked to get a private pilot medical certificate to fly. **CONCLUSION**: This presentation shows that, when there is a lack in the official regulations when unusual but specific duties, the aeromedical decision must be taken according to science and a good knowledge of the aeronautical constraints.

Learning Objectives

1. To understand how to take a fitness decision when the aircrew duty is not described in regulations.
2. To be able to discuss fitness in difficult cases without the help of regulations.

[410] IMPLICATION OF PREGNANCY FOR PILOTS AND CABIN CREW FITNESS TO FLY.

Dominique Luton[1], Olivier Manen[2], Carolines Cardines[3], Pierre André Leduc[3], Jean François Paris[3], Michel Kleirlein[3], Marie Christine Bouton[3], Vincent Feuillie[3]
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(Education - Case Study)

INTRODUCTION: Pregnancy is a non-pathological state which induce a particular vulnerability owing to profound physiological changes and specific jeopardizing conditions. The aeromedical expert will be confronted with standardized problems but also with unusual conditions necessitating sometimes multiple expertise. **BACKGROUND:** Medical issues in pregnancy implicates two beings : the mother and the fetus . For both the pilot and the cabin crew in flight duty is a physiological and potential emotional stress event that can interfere with the well being of the mother and the fetus. On the other hand some specific pregnancy risk can interfere suddenly and dramatically inducing a risk for the mother , the fetus and the flight security. The aim of the AME will have to deal with the wish of some pregnant staff to keep on flying with respect of the international rules and the ability to prevent at risk situation by either taking a decision of temporary grounding followed by a waiver or not. **CASE PRESENTATIONS:** One study and two type of cases will be presented. Our experience on a retrospective period of ten years will be presented giving the frequencies and the timing of flight for different crew categories mainly among our national airway company The main items to be check listed before flight authorization will be discussed , and the main contra indication due to specific health condition or environmental factors and kind of flight will be reminded. Specific recurrent conditions such as management of early pregnancy or post miscarriage period will be displayed. Aftereffect of serious obstetrical conditions such as placenta acreta will also be shown with the aim to help the AME to determine the best timing for flight duty authorization. Specific at risk infectious destination will also be discussed. **DISCUSSION:** The role of the AME for dealing with specific obstetrical condition need to have acurate knowledges and to have an available specialist network in order to take the best decision for the pregnant staff member but also for the flight security. As most of the obstetrical complications are difficult to anticipate one attitude could be to have a systematic grounding decision; but many staff individual wish to go on flying and therefore specific pragmatic rules have been established. One paradox is that early pregnancy which has a real risk of serious non predictable threatening complications is often not well considered in due time.

Learning Objectives

1. To be aware of the various pregnancy conditions which will indicate a decision of grounding or not.
2. To manage a pragmatic decision for a pregnant cabin crew wishing to fly that will preserve her own safety and the flight safety.

[411] ATYPICAL MEDICO-PSYCHOLOGICAL PRESENTATIONS IN AVIATION MEDICINE

Olivier Manen[1], Jonathan Monin[1], Gaëtan Guiu[1], Anne-Pia Hornez[1], Jean-François Oliviez[1], Caroline Brescon[1], Nicolas Huiban[2], Dominique Luton[3], Sébastien Bisconte[1], Eric Perrier[1]
[1]Percy Military Hospital - Aeromedical Center, Clamart (Paris), France; [2]Sainte Anne Military Hospital - Aeromedical Center, Toulon, France; [3]Bichat - Claude Bernard Hospital, Paris, France

(Education - Case Study)

INTRODUCTION: Aeromedical experts are regularly confronted with initial applicants or confirmed pilots with a borderline psychological presentation, but such an expertise is usually difficult to manage from the beginning to the final decision. **BACKGROUND:** The Germanwings tragedy has highlighted the importance of mental health in pilots and has recently led to a renewal of the European regulations with a serious change in the psychiatric and psychological part of the Acceptable Means of Compliance for civil pilots. However, despite the practical impact of this official guide, there are situations where the AME may not be at ease. **CASE PRESENTATIONS:** Two categories of case reports will be presented: Firstly, there are applicants or pilots who have presented either a medical episode or a professional, personal or family event which clearly questions about the mental health, and yet the individual is not convinced about that, he/she may be opposed to a specific evaluation, and the trust relationship between him/her and the AME may turn into suspicion and conflict. Examples will be developed as this applicant coming with a strange tattoo, or these pilots who have stopped their activity in relation to a stress-related / aviation-related disorder or protective measures decided by the aviation authority. Secondly, during their career several aircrews ask for a definitive unfitness and yet there is theoretically not enough medical or psychological argument to conclude in this way, including after a specific assessment. This situation is typically related to fatigue and demotivation, also to working conditions presented as unfavourable to continue flying, and sometimes to a conflict with the employer who may be described as responsible for the medical condition of the aircrew ("aerotoxic syndrome"). **DISCUSSION:** The role of AME is crucial for the screening of atypical medico-psychological situations but also later after the knowledge of interesting findings. The accessibility to a psychiatrist or clinical psychologist qualified in aviation medicine is not immediate. Consequently, AME are expected to determine particularly which individual shall require such an evaluation and shall continue flying while waiting for it. The decision is facilitated in the Aeromedical Centres by questioning about the feeling of the other members of the medical staff, a collegial thought if necessary, and a regular debriefing with colleagues about these cases to improve experience.

Learning Objectives

1. The audience will be aware of several various and difficult situations when the mental health is jeopardized in aircrews during the aeromedical expertise.
2. The audience will learn to determine which of the pilots with a mental health questioned shall require a specific psychological assessment and what immediate decision is the more appropriate.

Thursday, 09/02/2021 ***3:30 PM***
Plaza F

[S-75]: PANEL: CAREER OPTIONS AFTER RESIDENCY IN AEROSPACE MEDICINE

Chair: Kazuhito Shimada
Co-Chair: Terry Taddeo

Panel Overview: *Not all of beginner in Aerospace Medicine have a clear idea in selecting life after residency. Especially if you are a civilian, job openings are only a few per an institute each year. Still, as there are so many types of aerospace medicine jobs, if you look beyond popular institutes, there are abundant openings in the wide market. In this session, each panelist will share their actual professional life story: what happened after graduating from the medical school. We hope the information from this session help audiences to find more opportunities. Panelists with vast spectrum of specialties, space agency, aviation authority, academia, industry entities, are selected to give their view in aerospace medicine career development. One of the panelists will also provide foreign medical graduate view in addition. Panelists from today's session were all trained at the Aerospace Medicine Program at Wright State University. Unfortunately, this program at Weight State University no longer accepts any new resident. NASA used to fund the scholarship for two residents per year at the time of panelists' era. Many NASA scholarship graduates from Aerospace Medicine program led by late Dr. Mohler were selected to work at NASA, which was the result sponsor aimed for. Other than NASA, about dozen more graduates went to work at non-US space agencies. The largest group of aerospace physician resides in FAA. As you all know, FAA assists Aviation Medicine Examiners and keeps the system active. Within FAA, the clinical section is not the only section hires medical specialist. Many other aviation medical science sections also hire medical specialists. FAA's aerospace physicians group locates in Oklahoma, but many other branches exists in US, which means many more carrier opportunities. Please also note that FAA's operation as the federal authority is spreading to the commercial human space flight. In academic field, teaching positions in aerospace medicine is not a big entity, but their position is very fulfilling as they generate new colleagues of AsMA. There is always a chance of new institute establishing. Recent trend in the growing aviation industry is that traditional aviation business seeks not only clinical and occupational, but also other disciplines. Last of all, we would like to see more Foreign Medical Graduates trained internationally. Receiving aerospace medicine training in US is not easy, but there are some succeeded cases.*

[412] INTERNATIONAL VIEW OF U.S. RESIDENCY IN AEROSPACE MEDICINE

Kazuhito Shimada[1]
[1]*Tsukuba Koken, Tsukuba, Japan*

(Education - Tutorial / Review)

INTRODUCTION: Aerospace Medicine attracts not only those in the US, but also others in the world. When you look into the demography of our customers, US has ca. 600,000 pilots, in addition to cabin and ground personnel who are at roughly the same number. Extrapolating this to the world population of 7,000,000,000, we wonder why there are very few Residents in Aerospace Medicine outside US. Especially when customer number is growing with exploding population of drone operators, which we did not even included in our count here. **TOPIC:** How can the world educate necessary number of Aerospace Medicine personnel, specially Residents in Aerospace Medicine? We should look around the audience at AsMA to find hints. One of the keys is international activities. In many countries, the core role in Aerospace Medicine is assumed by Aviation Medical Examiners. FAA goes out of US and educate foreign AME's. Although only a small number of Foreign Medical Graduates are found among RAM programs, roles of those graduates are important in fulfilling the need of Aerospace Medicine leaders in countries outside US. In reality, every government authority is not familiar with why pilot medical certification is technically hard. Therefore, each government authorities need personnel who received formal education in Aerospace Medicine even more. **APPLICATION:** There are some obstacles to achieve mutual international collaboration. In USs' case, passing USMLE can be overcome by individual's effort, however, VISA requirement is tough with the additional financial burden. In the past, there were some cases that FMG RAM was denied access to medical facilities on a US base. However, now US bases are closed to all civilian foreigners. Therefore, abundant medical infrastructure for RAM education are unavailable to FMG. At present, it is not practical for an FMG to enter a RAM program and eventually become board-certified in Aerospace Medicine without governments support. US Air Force has a high need for RAM graduates, and they also provide "Advanced Aerospace Medicine for International Medical Officers", a 23-weeks course to foreign military physicians. It may not be easy to run such program by civilians, but considering the successful results from the past data, it is worth considering it. Education institutes should review AAMIMO program, and providing feedbacks for the future civilian program.

Learning Objectives

1. The audience will learn about roles, issues, and possible improvements of U.S. RAM programs, seen from an international standpoint.
2. The audience will learn about possible carrier options for Foreign Medical Graduates, after US RAM program.

[413] HUMAN ENGINEERING, SAFETY, AND AEROSPACE MEDICINE IN THE AEROSPACE INDUSTRY

Eduard Ricaurte[1]
[1]*The Boeing Company, Oklahoma City, OK, USA*

(Education - Tutorial / Review)

BACKGROUND: Aerospace medicine is the preventive medicine specialty that promotes the health and performance of crew members

and well-being of passengers traveling in aircrafts and space vehicles. Historically, the field of aerospace medicine has been essential in improving aviation safety by monitoring the aeromedical certification process of aerospace crewmembers, the medical standards and physical/mental fitness of aerospace flight applicants to obtain a medical certificate. However, a current challenging aspect of the aerospace environment is to minimize the health risk associated with air travel in the Covid-19 pandemic. In an effort to ensure the health and safety of the crewmembers and air travelers, research has been conducted and distributed to the public as part of the aerospace industry's data-driven scientific and engineering approach. As a result, new methods to achieve satisfactory levels of occupants' physical safety as well as new technologies and human engineering tools has been implemented to improve the three safety segments in the aerospace transportation: Functional, Operational, and Physical. **OVERVIEW AND DISCUSSION:** With current challenges in the aerospace industry, it is expected that more professionals with a combined experience in aerospace medicine, aeromedical research, human factors and system safety engineering are going to be needed. The role and contribution of aerospace medicine, human engineering, and system safety professionals in the complex environment of advanced design and technology, health and safety, quality and productivity improvement will be discussed during this presentation.

Learning Objectives

1. The participant will learn the increased role of human engineering professionals in the current aerospace industry.
2. The participant will learn the increased role of aerospace medicine professionals in the current aerospace industry.

[414] CAREER OPPORTUNITIES AT THE FAA CIVIL AEROSPACE MEDICAL INSTITUTE (CAMI)

Melchor Antunano[1]
[1]*FAA Civil Aerospace Medical Institute, Oklahoma City, OK, USA*

(Education - Program / Process Review)

The FAA Civil Aerospace Medical Institute (CAMI) is one of the premier civil aerospace medicine organizations in the world and it's mission is to promote civil aerospace safety through excellence in medical certification, research and education programs. CAMI's programs focus on the safety of pilots (air & space), flight attendants, air traffic controllers, passengers, and the entire human support system that embraces civil aerospace operations. The goals of our certification, research and education programs include: 1) The prevention of aerospace incidents and accidents due to human causes, 2) Making aerospace vehicles and all support systems safer for occupants (crews and passengers), 3) Optimizing human performance of safety-sensitive personnel in all aerospace operations, 4) Promoting the health and well-being of aerospace personnel and passengers, and 5) Preparing aerospace flight personnel and other occupants for post-accident survival. CAMI personnel are pioneering new technologies, procedures and scientific developments that will lead to new global safety standards as innovations are translated into operations. CAMI personnel address the medical and human factors implications of operational hazards in aerospace transportation including: adverse weather (storms, lightning, hail, icing, clear air turbulence, microbursts, etc.), runway incursions, ground incidents (taxiing, ramp operations, etc.), wildlife strikes, geological events (volcanic eruptions, tsunamis, etc.), wake turbulence, inflight traffic incidents, cockpit automation, laser strikes, inflight medical emergencies, operational fatigue in aviation (pilots, flight attendants, air traffic controllers, maintenance personnel, etc.),disruptive/unruly passengers, emergency evacuations (precautionary or real), aircraft maintenance, physiological incapacitation or impairment of pilots (hypoxia, inflight spatial disorientation, acceleration exposure, fatigue, medications and drugs, unreported medical conditions, etc.), primary training in technically-advanced aircraft, etc. The types of job opportunities available at CAMI include: aerospace physiologists, biochemists, engineers (biomedical, electrical, mechanical), epidemiologists, geneticists, information technology specialists (software and hardware), mathematicians, nurses, pharmacologists, physicians, physician assistants, psychologists (aerospace, organizational, industrial), radiobiologists, statisticians, and toxicologists.

Learning Objectives

1. The audience will learn about the types and scope of programs at the FAA Civil Aerospace Medical Institute.
2. The audience will learn about the types of careers available at the FAA Civil Aerospace Medical Institute.

[415] ACADEMIC CAREERS IN AEROSPACE MEDICINE

Edward Powers[1]
[1]*The University of Texas Medical Branch at Galveston, Galveston, TX, USA*

(Education - Program / Process Review)

BACKGROUND: Aerospace medicine is a small field of specialized medicine. Only five residency training programs exist in the US with very few graduates each year. Academic aerospace medicine has its own set of unique rewards and challenges distinct from focused clinical practice. Many factors contribute to the success or failure of a training program. OVERVIEW: One of the greatest challenges faced by academic programs is securing the funding for the program to pay for course tuition and salaries for the students. Contrary to most other residency training, the practice of aerospace medicine does not usually include patients who have Medicare or Medicaid. Therefore, these training programs are often dependent on military budgets, grant money or substantial contributions from the academic institution. Funding from these sources can be inconsistent from year to year. Another challenge is assuring that the program is in compliance with requirements determined by the accreditation organizations. In the case of an aerospace medicine residency program, the master's degree in public health is accredited by the Council on Education for Public Health (CEPH) and the residency program is accredited by the Accreditation Council for Graduate Medical Education (ACGME). There are often conflicts when scheduling all of the associated requirements for both entities into a two-year program. Ultimately, it is imperative for the program to meet requirements to assure eligibility for board certification by the American Board of Preventive Medicine (ABPM). Attracting qualified faculty for an academic program can be difficult as the number of board-certified specialists is few and providing a competitive salary requires support from the training institution. Also, supplying the type of training desired for future employers requires a broad network of connections and a good relationship with other professionals in the field. DISCUSSION: The benefits of a strong ASM Residency Program include providing a well-trained work force for the future. A broad range of training experience assures that graduates will be adaptable to the opportunities that become available. As commercial space activity increases, a higher demand for qualified aerospace medicine specialists will follow.

Learning Objectives

1. The participant will be able to identify the financial challenges of supporting an Aerospace Medicine Residency Program.
2. The participant will be able to identify the various organizations that are involved with accreditation of an Aerospace Medicine Residency Program.
3. The participant will be able to appreciate the difficulty in attracting qualified faculty to support an academic Aerospace Medicine education program.

[416] AEROSPACE MEDICINE CAREERS AT NASA

Terrance Taddeo[1]
[1]*NASA/Johnson Space Center, Houston, TX, USA*

(Education - Tutorial / Review)

INTRODUCTION: NASA's human spaceflight programs and mission operations require the substantial involvement of physicians with Aerospace Medicine expertise. These physicians, almost all of whom are graduates of Aerospace Medicine residency programs, encounter diverse challenges and opportunities in their practices. **TOPIC:** NASA currently operates the International Space Station and maintains a constant human presence in orbit. NASA physicians provide medical support before, during and after the orbital mission, and ensure that real time health and performance requirements are implemented. These physicians also participate in launch and recovery operations of crews from Kazakhstan, and plan for medical contingencies for all phases of the mission. NASA is

nearing the end of the development phase of the Orion, SpaceX and Boeing spacecraft. In work are the Gateway vehicle, lunar landers and planned lunar surface operations. NASA physicians have been intimately involved with the development of health and performance requirements for these vehicles, as well as requirements for pre-flight health stabilization, launch pad emergency escape, emergency medical services for launch, and recovery operations. Physicians at NASA support dive operations at the Neutral Buoyancy Laboratory and extravehicular excursions on-orbit, both of which involve prolonged suited activities and alternobaric environments. NASA physicians provide ongoing medical care of the astronaut corps as well as annual medical certification for flight assignability. They also provide medical certification for NASA's pilots and aircrews. A select few aerospace-trained physicians participate in NASA's human spaceflight programs as physician astronauts. **APPLICATION:** The nature of NASA's operations in air, space and under water provide unique and challenging opportunities for the practitioner of Aerospace Medicine.

Learning Objectives

1. The participant will learn about the career opportunities at NASA for a graduate of an Aerospace Medicine residency program.
2. The participant will learn about the breadth of operational activities where aerospace medicine expertise is required.

Friday, 09/03/2021 ***8:00 AM***
Governor's Square 14

[S-76]: WORKSHOP: MULTISPORT MEDICINE WORKSHOP

Chair: Cheryl Lowry
Co-Chair: Brian Pinkston

[417] *WORKSHOP OVERVIEW:* MULTISPORT MEDICINE WORKSHOP

Cheryl Lowry[1], Brian Pinkston[2]
[1]Kinetic Adventure Medical Education, Wichita Falls, TX, USA; [2]Kinetic Adventure Medical Education, Wichita Falls, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: Multi-sport adventure travel is becoming increasingly popular on every continent. Participants and the medical professionals supporting them benefit from understanding the risks inherent in a variety of sports and environments. This is intended to be an introductory, hands-on workshop focused on medically supporting and safely participating in a variety of sports in the wilderness. **TOPIC:** The need for medical professionals to understand and support remote expedition activities is rapidly expanding. NASA uses numerous wilderness sites to train astronaut candidates, astronauts, scientists and support staff. Military operations and mishap investigations frequently occur in remote areas, and the growing multisport adventure travel industry makes the wilderness accessible to a wide range of participants. Workshop attendees will gain foundational knowledge necessary for supporting operations in a wilderness environment as well as conduct pre-participation examinations. Lectures will describe common illnesses and injuries in the wilderness multisport environment, as well as treatment and prevention strategies. Additionally, this workshop will cover the psychology of extreme sports participants in order for pre-participation examiners to understand their motivations. The workshop will discuss wilderness hazards, the basics of wilderness survival, and the medical provider's role in supporting multi-sport expeditions and adventure travel. The workshop will provide familiarization with wilderness safety and life-saving equipment in the context of search and rescue operations. Expedition participant screening and support considerations will also be reviewed. Didactics will be reinforced by hands-on demonstrations and activities. Portions of this workshop will be conducted outdoors. **APPLICATION:** Competencies covered in this workshop will address the knowledge gap that exists among medical professionals regarding support of wilderness and extreme environment multi-sport activities. Didactics and hands-on sessions will be taught at a level applicable to a broad range of attendees including physicians, advanced practice providers, nurses, and anyone with an interest in medicine in austere environments.

Learning Objectives

1. Participants will be able to describe strategies to maintain safety and prevent injuries in a multisport environment.
2. Participants will be able to assess patients for fitness to participate in a variety of outdoor sports.