

## WEDNESDAY MAY 25, 2022

Wednesday, 05/25/2022  
Tuscany C,D,E

8:30 AM

### CHRISTIAN J. LAMBERTSEN MEMORIAL LECTURE

Robert Sanders, MD, DMT, FACEP, FUHM

“Undersea Medicine is Out of this World! -Hyperbaric Medical Support at NASA’s Neutral Buoyancy Lab”

Wednesday, 05/25/2022  
Tuscany C,D,E

10:30 AM

### [S-39]: PANEL: ENABLING PROGRESSIVELY EARTH INDEPENDENT MEDICAL OPERATIONS FOR HUMAN SPACE EXPLORATION

Chair: Kris Lehnhardt

Co-Chairs: Sharmi Watkins, Michael Barratt

**Panel Overview: BACKGROUND:** As NASA and its International Partners prepare to expand human space exploration beyond the International Space Station (ISS) to the Moon (and ultimately Mars) with the Artemis missions, the importance of evolving space medical operations in an Earth independent fashion becomes increasingly clear. Continuous human presence on the ISS for 20 years has demonstrated the successful development and execution of medical operations in low Earth orbit. However, this paradigm of medical operations is dependent upon continuous realtime communications, frequent resupply missions, and the availability of rapid evacuation options. As the distance and time away from Earth increase, all of these dependencies will no longer be available. In addition, future surface operations and dynamic flight events in deep space will incur medical risks beyond current ISS activities. As a result, the paradigm of space medicine operations will need to become more autonomous and less dependent upon mission support personnel on Earth. **DESCRIPTION:** To successfully shift the space medicine operational paradigm, all relevant crew health and performance stakeholders must work together towards this common goal. The first step involves a deep understanding of how medical operations are currently executed, which includes the training of astronauts as ISS Crew Medical Officers and the role of ground-based mission support personnel. The next step is an analysis of how this operations concept aligns with the realities of providing medical care in the spaceflight environment and identifying where the challenges of exploration spaceflight will exceed the parameters of this operations concept. Subsequently, it will be crucial to address two fundamental issues: how can astronauts be aided by technology solutions to make informed medical decisions in an autonomous fashion and what capabilities are needed on exploration missions to enable astronauts to perform complex medical tasks or procedures without real-time ground support? Finally, all of this information must be synthesized into a plan for developing Exploration Crew Medical Officers and vehicle systems that are capable of maintaining progressively Earth independent astronaut health. **DISCUSSION:** This panel will provide detailed examples of past, present, and future NASA efforts in each of these key areas, including research, technology development, and operations.

### [189] CREW MEDICAL OFFICER TRAINING AND ROLE OF GROUND SUPPORT FOR INTERNATIONAL SPACE STATION (ISS) OPERATIONS

Rachel Richardson<sup>1</sup>, Steven Piper<sup>2</sup>

<sup>1</sup>KBR, Houston, TX, United States; <sup>2</sup>NASA Johnson Space Center, Houston, TX, United States

(Education - Program/Process Review)

**BACKGROUND:** Insight into the current medical training regimen and operations concept will enable exploration medical system designers and mission planners to build a new concept of operations for missions where clinical decision-making shifts from a ground-based to a flight-based paradigm. **OVERVIEW:** Medical systems supporting exploration-class missions to the Moon and Mars will require greater inflight medical decision-making autonomy. An understanding of current ISS training regimens for Crew Medical Officers (CMOs) as well as the role of ground support personnel in medical operations is needed to identify the starting point from which exploration medical system design must evolve in order to achieve inflight medical autonomy. **DISCUSSION:** Pre-mission assignment, NASA astronauts do not complete any medical training, outside of standard first aid and cardiopulmonary resuscitation. However, physician astronauts may elect, with permission from their management, to maintain clinical skills through outside engagement with healthcare facilities but this is not mandatory and is difficult given their already demanding schedules. Upon ISS mission assignment, all astronauts begin an intensive training program in the two years leading up to launch, during which approximately 15 hours total is spent on CMO training. When compared to terrestrial training standards for other healthcare providers (paramedic, nurse, psychologist, physician), the CMO training regimen and duration is not equivalent to any one role or curriculum but is intended to enable the CMO to be an extension of the ground based interdisciplinary medical team. Due to the availability of near-real-time communications between Mission Control and the ISS, clinical decision support for inflight medical and behavioral events is provided by an interdisciplinary team of ground specialists. As a result, CMO training is focused only on familiarization and exposure to spaceflight-specific medical tasks, knowing that ground specialists will provide real-time guidance and troubleshooting in mission. For tasks needed in emergent events, experiential learning takes place on the ground, through the use of high-fidelity simulations. Inflight, computer-based training is provided to help maintain learned skills, in addition to live instruction for any needed just-in-time training.

#### Learning Objectives

1. The audience will be able to recognize where primary clinical decision making occurs for medical event management on ISS.
2. The participants will understand how ISS Crew Medical Officer training is framed to support the paradigm of limited in flight autonomy.

### [190] MEDICAL CARE IN SPACEFLIGHT: CHALLENGING TODAY AND ONLY GETTING HARDER

Serena Aunon-Chancellor<sup>1</sup>, Amy Kreykes<sup>2</sup>, Keith Brandt<sup>2</sup>, Benjamin Easter<sup>1</sup>

<sup>1</sup>NASA Johnson Space Center, Houston, TX, United States; <sup>2</sup>UTMB Medical Branch, Galveston, TX, United States

(Education - Program/Process Review)

**INTRODUCTION:** Medical care in spaceflight poses unique challenges. The International Space Station (ISS) is well equipped to provide medical care given its frequent resupply from visiting vehicles, large volume to accommodate medical resources, and proximity to Earth for evacuation. In contrast, exploration missions will have little to no resupply, small volume, and limited to no opportunity for evacuation in the event of a medical emergency. Exploration spaceflight will necessitate both more comprehensive and more autonomous medical care. **TOPIC:** The spaceflight environment poses unique challenges to medical care, many of which can be attributed to microgravity. These range from difficulty restraining supplies during a procedure to changed or absent hallmark terrestrial physical exam findings. Air-fluid levels do not form and bubbles do not rise, so even the simple act of drawing up a medication from a vial is difficult. Inflight care on ISS is a combination of autonomous care provided by the Crew Medical Officer (CMO) and guidance from flight surgeons through ground communication. In addition to urgent communications, ground-based care can occur through Private Medical Conferences (PMCs) and Private Psychologic Conferences (PPCs) that are scheduled at regular

intervals for all crewmembers. Diagnostic techniques on ISS include medical history taking, physical examination, and ultrasonography, all of which can be augmented through communication with the ground. However, these methods are largely reliant on near real-time and continuous communication. This telemedicine will be complicated by significant communication delays on exploration missions and will necessitate a shift in decision-making from ground to crew. The Crew Medical Officer (CMO) is responsible for helping to deliver medical care in flight. Nominally, any crewmember can be trained to serve as CMO as there is no requirement that a physician be present for ISS missions. However, physician-astronauts are likely to be the CMO for their crews, and although they receive similar training in the CMO role, they are expected to carry a higher degree of medical expertise as well as more autonomous diagnostic and treatment capability. **APPLICATION:** Although medical care in Low Earth Orbit is challenging, increasing distance from Earth on exploration missions will present new challenges, necessitating increased autonomy for the crew.

#### Learning Objectives

1. Become familiar with the unique challenges of providing medical care in spaceflight.
2. Provide a specific example of how the spaceflight environment makes medical care challenging.

### [191] AUGMENTING CREW AUTONOMOUS MEDICAL DECISION MAKING ON EXPLORATION MISSIONS USING CLINICAL DECISION SUPPORT

Brian Russell<sup>1</sup>, Sandeep Shetye<sup>2</sup>, Dana Levin<sup>3</sup>, Tianna Shaw<sup>2</sup>

<sup>1</sup>Auckland University of Technology, Auckland, New Zealand; <sup>2</sup>NASA, Moffett Field, CA, United States; <sup>3</sup>Columbia University Irving Medical Center, New York, NY, United States

#### (Original Research)

**INTRODUCTION:** Exploration spaceflight, with its distance from Earth and communication delays, will place new demands on crew autonomy. Crewmembers operating during such missions require a clinical decision support system (CDSS) that enhances autonomy by augmenting their knowledge, skills and abilities in different medical scenarios. **TOPIC:** We augment in-flight autonomous medical decision-making by describing use of ideal systems through a Concept of Operations (ConOps), outlining vehicle and human systems interfaces, and aligning technology and user interfaces with acuity and severity of conditions. The CDSS's role is to assist the crew in prevention, detection, diagnosis, and treatment of countless medical conditions that could arise in spaceflight, exacerbated by known decrements in sleep, cognition, nutrition, and exercise. While such demands exist today on the ISS, near real-time communications allow the burden on decision-making to remain on the ground. This will shift to the crew during exploration flights, and the CDSS is intended to support and optimize that process. The CDSS ConOps describes a vision for the system and outlines scenarios of how it might augment crew capability. The need for the CDSS to increase autonomy results in new practices and the inclusion of what is stereotypically non-clinical data from other human and vehicle domains. A CDSS will be an integrated system that interfaces with vehicle systems for information and context using advanced analytics. The system includes software, crew and resources, where the software is operating with a 'human in the loop'. The goal of an ideal aerospace CDS system is to include both core and advanced features incorporating work from collaborators and flexible for new technology in the future. A CDSS for autonomous crews needs to align the technology with context aware user interfaces addressing scenarios that cover acuity and severity of illness or injury. For example the assistance required for a non-medical crewmember responding to a heart attack will differ from the medical officer investigating a likely kidney stone. **APPLICATION:** The ideal CDSS acts as an assistant to the crew and aids by guiding decision support based on the context of the scenario, such as those described above. Benefits of a CDSS are found in applications such as emergency assistance, alerts and notifications, prevention, training, guidance for exam procedures, monitoring crew performance and diagnosis of symptoms.

#### Learning Objectives

1. Attendees will be able to identify a minimum of three functions associated with an augmented clinical decision support system for deep space missions and describe some example use cases for different acuity and severity.
2. Attendees will be able to understand the underlying capabilities of a clinical decision support system and constraints imposed by its deployment in a space exploration vehicle.

### [192] MEDICAL TASK SUPPORT FOR AUTONOMOUS SPACE EXPLORATION MISSIONS

Marlei Walton, Doug Ebert, Ashot Sargsyan, Vicky Byrne  
KBR/JSC-NASA, Houston, TX, United States

#### (Education - Tutorial/Review)

**INTRODUCTION:** Successful performance of medical tasks during missions beyond low Earth orbit (LEO) will require novel solutions to replace real-time Earth-based support since communication delays increase as astronauts travel farther from Earth. Key factors to consider when developing autonomous medical support tools for crew use during exploration missions include: self-tailored applicability for users with varied medical experience, task familiarity, and learning styles; modularity and flexibility for incorporation with other medical system elements; commonality with training materials; and extensibility to a wide range of tasks. **TOPIC:** To address the need for autonomy beyond LEO, the Autonomous Medical Officer Support (AMOS) software tool was developed. AMOS shifts the emphasis from pre-flight training and real-time guidance (the current International Space Station [ISS] standard) to a new exploration paradigm of in-flight, just-in-time instruction with little to no ground support, enabling crew medical autonomy. AMOS is an intuitive, easily deployed, browser-based application, and introduces a streamlined skill management system for both medical and non-medical tasks, allowing users with different experience levels to access information as needed. In April 2020, two ISS crewmembers participated in a technology demonstration (TD) using AMOS training and guidance modules for urinary bladder and kidney ultrasound examinations. A non-physician astronaut Operator performed ultrasound exams on another astronaut Subject using the AMOS modules in a fully autonomous fashion; crewmembers also had no prior exposure to the software. AMOS tracked software use and incorporated a user experience survey. Captured images were later analyzed using 8 criteria to rate image quality from 0 (poor) to 3 (excellent). The AMOS TD yielded a positive user experience and successful image collection. Seventeen bladder imaging instances were acquired; all were rated '3' in all 8 rating elements. Twenty-five kidney imaging instances were acquired; image quality averaged 2.6 in all 8 rating criteria. However, as the Operator gained experience, kidney instances collected later in the TD were rated '3' across all criteria. **APPLICATION:** The AMOS platform is an example of a novel autonomous technology solution that provides training and in-mission support using a single training and procedure tool for all phases of medical skill management including acquisition, retention, and application.

#### Learning Objectives

1. The audience will learn about training and guidance capabilities that will be needed to support successful execution of complex medical tasks in an Earth-independent, space-based autonomous fashion.
2. The audience will learn about the Autonomous Medical Officer Support (AMOS) software tool, a recent example of a novel autonomous technology solution that provides training and in-mission support.

### [193] THE EXPLORATION CREW MEDICAL OFFICER OF THE FUTURE

Moriah Thompson, Benjamin Easter, Rachel Passmore, Sharmi Watkins, Steven Piper  
NASA Johnson Space Center, Houston, TX, United States

*(Education - Tutorial/Review)*

**INTRODUCTION:** The current paradigm for Crew Medical Officer (CMO) credentials and training in Low Earth Orbit medical operations is likely to be insufficient for exploration-class missions. Long duration lunar surface stays and Mars missions will require increasing levels of autonomy of the CMO. This presentation will investigate the roles and responsibilities of the CMO of the future, including a discussion of clinical competency and training needs. **TOPIC:** Future exploration missions to Mars will be of longer duration and involve notable communication delays. Evacuation to obtain definitive medical care is not plausible for such exploration missions. Resupply will be limited, and the medical system will have notable mass and volume constraints. Given these realities, the responsibilities of and decision-making burden on the CMO will likely increase, requiring additional skillsets and autonomy. The current training pathway for the CMO will need to expand. Increased emphasis will need to be placed on autonomous evaluation, diagnosis, and treatment of conditions based upon likelihood and severity. The current operational concept of Private Medical Conferences and Private Psychological Conferences will need to change as these become asynchronous. In addition, during emergency scenarios, the CMO will need to be able to respond and initiate care in autonomous fashion without initial assistance or cognitive offloading from the ground. Accordingly, the CMO will likely need additional medical and behavioral health training to better support the crew. According to NASA-STD-3001, a planetary mission requires that at least one physician be included on the crew. Many physician astronauts are practicing clinically in some fashion prior to selection. However, training within the Astronaut Corps strongly favors other skillsets (e.g. EVAs) and may not allow physicians to maintain clinical skills in the way that, for example, a pilot astronaut maintains flight proficiency with T-38 training. **APPLICATION:** This presentation will discuss the various needs of the CMO for exploration missions of the future. An in-depth overview of the additional training elements and methods of maintaining clinical competency will be included.

**Learning Objectives**

1. [The participant will be able to...] Compare and contrast the demands of the ISS Crew Medical Officer of today with the exploration Crew Medical Officer of the future.
2. [The participant will be able to...] Describe the challenges in defining training needs and maintenance of skills for an exploration CMO.

**Wednesday, 05/25/2022**  
**Tuscany A**

**10:30 AM**

## [S-40]: SLIDES: DECOMPRESSION MATTERS

**Chair: William Buck Dodson**

**Co-Chair: Pierre Denise**

### [194] BROOKS DECOMPRESSION SICKNESS RESEARCH FROM 1984-2014

James Webb

Scientific Aerospace Research Consulting, Seattle, WA, United States

*(Original Research)*

**INTRODUCTION:** Efforts to quantify the relationship between venous gas emboli (VGE) and ensuing altitude decompression sickness (DCS) at Brooks AFB/City-Base have had limited success. Nitrogen ( $N_2$ ) is the component causing DCS due to its solubility in human tissue and slow removal even when breathing 100% oxygen ( $O_2$ ) before exposure to high altitude (low environmental pressure).  $N_2$  will form bubbles (VGE) in tissue and blood when it becomes super-saturated at lower environmental pressures. This is analogous to the carbon dioxide in carbonated drinks leaving the dissolved state and becoming bubbles during release of the pressure as the containers are opened. **METHODS:** Data was taken from the Brooks DCS Research database. Subjects include males and females. **RESULTS:** The table below shows that in 40% of the exposures, True Positives (TPs VGE and DCS) were observed and were the most prevalent

outcome. The combined false positives (FPs; VGE but no DCS) and false negatives (FN; no VGE but DCS) at 33% were not very consistent with accurate predictions.

Total Exposures		Outcomes			
3675	2261	1864	1005	806	409
	VGE	DCS	27%	22%	11%
			TN: True	FP: False	FN: False
			Negative	Positive	Negative
					TP: True
					Positive

Nitrogen,  $N_2$ , in the space craft/vessels or in off-Earth (Moon/Mars) habitats can be considerably lowered by replacement with helium (He) and some additional  $O_2$ . As presented at international scientific meetings (AsMA, 2018 & ICASM, 2019), a three-part breathing mixture, Trimix (33%  $O_2$ ; 33%  $N_2$ ; and 33% He) should be able to reduce the concentration of  $N_2$  from 78% to 33% prior to decompression to a space suit environment for EVA. That reduction should lower the blood/tissue  $N_2$  ratio to less than 1.0, eliminating super-saturation and formation of  $N_2$  bubbles (VGE) and DCS. He has been shown to be slower to dissolve in human tissues and faster to leave than  $N_2$ . **DISCUSSION:** Currently, the use of Trimix for extra-vehicular activity (EVA) or extra-habitat activity (EHA) has not been tested to determine its effectiveness and safety. Therefore, use of Trimix requires validation via human subject exposures in hypobaric (altitude) chamber studies.

**Learning Objectives**

1. The audience will understand the relationship between True Positive and False Positive results of altitude exposure in 3675 human subject exposures to altitude at the Brooks laboratory.
2. The audience will understand the advantage of Trimix (33% oxygen/33% Helium/33% Nitrogen) as a breathing mixture for humans during future exposure to very low atmospheric pressure.
3. The audience will understand why use of Trimix must be tested to determine its effectiveness and safety.

### [195] AEROSPACE DECOMPRESSION SICKNESS – A DECADE LONG REVIEW OF AN ACADEMIC HYPERBARIC CENTER

Craig J. Kutz<sup>1</sup>, LCdr Ian Kirby<sup>2</sup>, Ian Grover<sup>3</sup>, Hideaki L. Tanaka<sup>1</sup>

<sup>1</sup>University of California-San Diego Health, San Diego, CA, United States;

<sup>2</sup>Canadian Armed Forces, University of California-San Diego Health, San Diego, CA, United States; <sup>3</sup>University of California-San Diego, San Diego, CA, United States)

*(Education - Case Study)*

**INTRODUCTION:** This case series evaluates all cases of Aviation Decompression Sickness (DCS) treated at a single-center academic quaternary care center from 2012 to present. **BACKGROUND:** The underlying pathophysiology of hypobaric DCS is the same as diving-related DCS, where rapid reduction in ambient pressure results in dissolution of gases in body tissues with subsequent trauma. Yet, based on the innate multifactorial circumstances surrounding hypobaric and hyperbaric DCS, clinical practice in recognition and understanding continues to be unpredictable as it falls in the intersect of aerospace and hyperbaric medicine. Aerospace Medicine specialists and hyperbaricists alike may be less familiar and comfortable with aviation DCS rather than other entities in their respective fields. Thus, our goal was to collate and revisit presumed aviation-related DCS cases presenting to the UCSD Hyperbaric Division over the past decade to further understand the phenomena encountered. **CASE PRESENTATION:** Since November 2012, our case series identified 14 high-performance aircraft pilots, one astronaut and one military parachutist who were diagnosed and emergently treated for aerospace DCS in our multiplace hyperbaric chamber. Additionally, two pilots suffered another independent DCS event, providing 18 total cases. Patients included both sexes (26-45 years-old). Airframes involved primarily the McDonnell Douglas F/A-18. **DISCUSSION:** Aviation DCS is encountered less frequently



than diving DCS, most likely as less people have access to high-performance military flights and unpressurized atmospheric exposure. Less is generally known about military operations, thus some confounding factors may be mistaken for DCS. With this in mind, we reviewed diagnosed cases of aviation DCS independently to search for alternative etiologies. Four independent reviewers with dual backgrounds in hyperbaric and aerospace medicine reviewed each case to determine whether presentations could plausibly have alternative explanations. This retrospective review aimed to identify key characteristics and confounders in diagnosis. We discovered that roughly half of cases treated as aviation DCS may likely have been explained by other phenomena, such as rapid decompression barotrauma, arterial gas embolism, CO poisoning, or anxiety. As human exploration continues to challenge limits of sustainable physiology, the incidence of aerospace DCS may increase and underscores our need to identify and treat properly.

#### Learning Objectives

1. The audience will learn about key characteristics and multifactorial presentations of aviation-related decompression sickness in an attempt to better understand diagnosis and identification.
2. The audience will learn common diagnosis strategies to aerospace decompression sickness (DCS) including key concepts in differentiating alternative underlying pathology.
3. The audience will learn that diagnosing aviation decompression sickness is an unfamiliar area in the fields of aerospace medicine and hyperbaric medicine.

#### [196] VOXEL-BASED ASSESSMENT OF HYPOBARIC HYPOXIA-INDUCED CHANGES ON QUANTIFIED CEREBRAL PERFUSION FROM ARTERIAL SPIN LABELING MRI

Matthew Sherwood<sup>1</sup>, Bianca Cerqueira<sup>2</sup>

<sup>1</sup>KBR Aerospace, Wright-Patterson AFB, OH, United States; <sup>2</sup>KBR Aerospace, JBSA-Lackland, TX, United States

#### (Original Research)

**INTRODUCTION:** Hypobaric hypoxia (HH) negatively impacts neurocognitive performance. Aircrew trainees are briefly exposed to HH to recognize symptoms of hypoxia. A previous magnetic resonance imaging (MRI) study following a single exposure to HH found significantly increased perfusion in white matter (WM) 24-hr post-exposure. No significant differences in gray matter (GM) perfusion were observed between exposed and matched controls at 24-hr or 72-hr post-exposure. We re-assessed a sample of the data using voxelwise analysis (VA) as an alternative to prior global region of interest (ROI) analysis. **METHODS:** A subset of 18 participants was extracted from the original study, approved by the USAF 59<sup>th</sup> Medical Wing Institutional Review Board, and subjected to new analyses. Each subject was exposed to HH at 25,000 ft (7620 m) in altitude chambers by removing their aviator masks for approximately 2-4 minutes. Baseline MRI was acquired 24-hr prior to HH and follow-up MRI was conducted 24-hr and 72-hr post-exposure. MRI included pseudo-continuous arterial spin labeling (pcASL) and T1-weighted imaging. The standard space perfusion maps for the 24-hr and 72-hr post-exposure scans were compared with baseline maps in a VA fashion using paired t-tests. **RESULTS:** Results of the VA paired t-tests revealed significant increases from baseline CBF at both the 24-hr and 72-hr post-exposure scans in the bilateral inferior frontal gyri, the left inferior parietal lobule, left middle frontal gyrus, bilateral medial frontal gyri, bilateral posterior cingulate, left middle temporal gyrus, and the left superior parietal lobule. Findings were localized to GM and no localized changes were observed in WM. **DISCUSSION:** Previously published data identified significant global increases in WM CBF 24-hr post-exposure compared with baseline in an analysis of covariance and non-significant differences at 72-hr post-exposure as well as within GM. Reduced sample analysis indicates the increased WM CBF is not focal, but rather a global effect and, thus, was insignificant at the voxel level. However, increased GM CBF appeared in focal cortical clusters previously undetected. Our findings reveal the importance in performing both global (ROI) assessments of CBF as well as VA to detect altered CBF following HH. Such assessments will

enhance our understanding of cerebral hemodynamics associated with the short-term effects from HH.

#### Learning Objectives

1. Understand the differences between voxelwise and region of interest-based MRI analyses.
2. Understand how hypobaric hypoxia effects cerebral blood flow in aircrew.

#### [197] INVESTIGATION OF ATORVASTATIN TO MITIGATE EFFECTS OF HYPOBARIC NEURONAL INJURY IN A MINATURE SWINE MODEL

Bianca Cerqueira<sup>1</sup>, Holly Chapapas<sup>1</sup>, Afshin Beheshti<sup>2</sup>, John Sladky<sup>3</sup>, Francisco Enguita<sup>4</sup>, Justin Reese<sup>5</sup>, J. Tyson McDonald<sup>6</sup>, Robert Meller<sup>7</sup>, Johnathan Schisler<sup>8</sup>

<sup>1</sup>KBR Aerospace, JBSA-Lackland, TX, United States; <sup>2</sup>KBR at NASA Ames Research Institute, Moffett Field, CA, United States; <sup>3</sup>Brooke Army Medical Center, JBSA-Fort Sam Houston, TX, United States; <sup>4</sup>Instituto de Medicina Molecular Joao Lobo Antunes, Lisbon, Portugal; <sup>5</sup>Lawrence Berkeley National Laboratory, Berkeley, CA, United States; <sup>6</sup>Georgetown University, Washington, DC, United States; <sup>7</sup>Morehouse School of Medicine, Covington, GA, United States; <sup>8</sup>University of North Carolina at Chapel Hill, Morrisville, NC, United States

#### (Original Research)

**INTRODUCTION:** Through neuroimaging, high altitude pilots have been found to increased white matter hyperintensity volume and changes in white matter fractional anisotropy (FA) values. To investigate these changes, a minipig high altitude model was developed to assess neuroimaging and mRNA expression within blood, CSF, and brain tissue. In this study, we assessed if the administration of 20mg Atorvastatin (Lipitor) prior to flight exposure can mitigate the effects of hypobaric using our established miniature swine model. **METHODS:** Miniature swine were exposed to 6 flights with a frequency of every 3 days and flight duration of 8 hours each at an altitude of 30k feet with 100% FIO<sub>2</sub>, were pre-treated with 20mg of Atorvastatin daily starting one week before and through completion of their flights. A control group of animals were kept at sea-level at room air conditions. Blood and CSF samples were collected at baseline prior to the flight procedure, upon completion of flights, and then 28 days after that. Brain tissue samples were obtained upon necropsy 30 days after completion of flights. RNA was extracted from blood, CSF, and brain samples and sequenced for mRNA expression. **RESULTS:** In brain samples, altitude exposure was found to significantly upregulate mRNA expression in Reactome Gene Set pathways associated with L1CAM interactions, protein protein interactions at synapses, RhoA GTPase cycle, activation of NMDA receptors and post-synaptic events, potassium channels, opioid signaling, antigen processing ubiquitination proteasome degradation, signaling by rho GTPases MIRO GTPases and rhoBTB3, diseases of signal transduction by growth factor receptors and second messengers, and RNA polymerase II transcription when compared to sea level controls and were not upregulated in the Atorvastatin plus altitude group. Pathways associated with metabolism of carbohydrates, asparagine N-linked glycosylation, metabolism of amino acids and derivatives, metabolism of vitamins and cofactors, metabolism of water-soluble vitamins and cofactors, DNA repair, metabolism of RNA, and translation were significantly downregulated in altitude exposed animals compare to sea level controls, which were not downregulated in the Atorvastatin plus altitude group. **DISCUSSION:** Statins, such as Atorvastatin, have been used for their putative neuroprotective and anti-inflammatory effects and could potentially reduce the health risks observed in repeated exposure to hypobaric in our pilots.

#### Learning Objectives

1. Atorvastatin ameliorates upregulation of gene expression associated with neuronal signaling pathways after repeated non-hypoxic high-altitude exposure in a minipig model.
2. Atorvastatin ameliorates downregulation of gene expression associated with metabolism after repeated non-hypoxic high-altitude exposure in a minipig model.

### [198] TOXICITY EVALUATION OF HYPERBARIC CARBON TETRAFLUORIDE IN SPRAGUE-DAWLEY RATS

Matthew Makowski<sup>1</sup>, Christopher Sproul<sup>2</sup>, Darin Knaus<sup>3</sup>, Jed Wilbur<sup>3</sup>, Richard Moon<sup>1</sup>

<sup>1</sup>Duke University School of Medicine, Durham, NC, United States; <sup>2</sup>Integrated Laboratory Systems, Morrisville, NC, United States; <sup>3</sup>Creare, Hanover, NH, United States

(Original Research)

**INTRODUCTION:** Decompression sickness (DCS) risk is mitigated by depth-time profiles that constrain undersea operations. In 1965 Keller and Buhlmann shortened decompression times by changing the inert breathing gas during ascent to one with higher molecular weight and lower water solubility. This technique slowed ascent gas uptake and hastened descent gas elimination. Carbon tetrafluoride (CF<sub>4</sub>) is ideal for this use due to inertness, high molecular weight, and low water solubility. A 1972 US patent noted hyperbaric CF<sub>4</sub> use in mice, but limited additional hyperbaric CF<sub>4</sub> safety information exists. The present work tested the hypothesis that hyperbaric CF<sub>4</sub> is nontoxic. **METHODS:** Sprague-Dawley rats were exposed to 8 ATA air (10 males, 10 females) or 8 ATA 79% CF<sub>4</sub>/21% O<sub>2</sub> (25 males, 25 females). Exposures were 30 minutes daily for 5 days. Sex and treatment effects were analyzed with two-way ANOVA. Animal studies complied with Duke University IACUC. **RESULTS:** There was no significant difference in relative weight trend for males exposed to hyperbaric air (2.2 +/- 0.43% day<sup>-1</sup>) compared to CF<sub>4</sub>/O<sub>2</sub> (1.6 +/- 1.1% day<sup>-1</sup>), (p = 0.10). There was a statistically significant difference in females exposed to hyperbaric air (0.5 +/- 0.8% day<sup>-1</sup>) compared to CF<sub>4</sub>/O<sub>2</sub> (-0.2 +/- 0.8% day<sup>-1</sup>), (p = 0.01). However, this weight trend remained within literature cited norms. Histology showed normal brain, spinal cord, lung, lymph nodes, and nasal passages. Blood counts were within or near literature cited norms. Metabolic panel showed no liver or kidney injury. Erythrocyte micronucleus assay evaluated chromosome damage. Males exposed to hyperbaric CF<sub>4</sub>/O<sub>2</sub> had a statistically significant increase in micronucleus frequency (0.13 +/- 0.04%) compared to hyperbaric air (0.09 +/- 0.02%), (p < 0.05). However, both groups were within the range of local historical negative controls. Females had no significant difference in micronucleus frequency between hyperbaric air (0.09 +/- 0.01%) and CF<sub>4</sub>/O<sub>2</sub> (0.11 +/- 0.04%), (p > 0.05). **DISCUSSION:** This study showed no concerning toxicological findings in rats breathing 8 ATA CF<sub>4</sub>/O<sub>2</sub> and supports the safety of breathing hyperbaric CF<sub>4</sub>. Future studies evaluating DCS risk mitigation with CF<sub>4</sub> are needed. Funding through US DOD subcontract through Creare, Inc. (Contract #S604).

#### Learning Objectives

1. The participant will learn about the inert gas parameters that modify the risk of decompression sickness.
2. The participant will learn the benefits of changing the inert gas for ascent from a dive.

### [199] FURTHER TEST AND EVALUATION OF THE AQUA LUNG® PORTABLE HELICOPTER OXYGEN DELIVERY SYSTEM (PHODS) IN THE ALTITUDE CHAMBER

Bobby Bowers<sup>1</sup>, Leonard Temme<sup>1</sup>, Robert Eshelman<sup>1</sup>, Amanda Hayes<sup>1</sup>, Chad Adaway<sup>1</sup>, Paul St. Onge<sup>1</sup>, Aaron McAtee<sup>1</sup>, Frank Petrassi<sup>2</sup>, Dennis Ard<sup>2</sup>

<sup>1</sup>U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, United States; <sup>2</sup>U.S. Army School of Aviation Medicine, Fort Rucker, AL, United States

(Original Research)

**INTRODUCTION:** The Portable Helicopter Oxygen Delivery System (PHODS) provides supplemental oxygen (O<sub>2</sub>) to Army personnel in unpressurized aircraft up to 18,000 feet (ft) above mean sea level (MSL). The PHODS delivers a predetermined bolus of nearly 100% O<sub>2</sub> via a flexible nasal cannula or face mask attached to the user's helmet. Previous PHODS tests and evaluations (T&E) reported its ability to maintain user blood oxygen over altitudes during workload. Here, the T&E metric is reaction time and accuracy, as well as expired carbon dioxide (CO<sub>2</sub>). **METHODS:** The

U.S. Army School of Aviation Medicine altitude chamber enabled the PHODS T&E at ground level (GL), 14,000, and 17,800 ft above MSL. At each altitude, twenty-one Army aircrew volunteers used the PHODS as prescribed in the user's manual to assess the PHODS' performance during 10 minutes (min) of the Perceptual Vigilance Test's reaction time (RT) assessment, 5 min of annunciated reading (AR), and 2 min of self-paced squats as a surrogate physical workload (WL) task. A clinical capnographer (Nonin Life Sense) monitored expired CO<sub>2</sub> via a nasal cannula. **RESULTS:** At each of the three altitudes, the ability of the PHODS to maintain RT was measured prior to TR or WL. The RT was recorded in milliseconds (ms) approximately 100 times randomly over the 10-minute test interval. Statistical analysis of the RT assessed the null hypothesis that RT did not differ over the three altitudes. Results showed that, while the 300 ms RT at 14,000 ft did not differ from the 298 ms RT at 17,800 ft (p = 0.19), both were statistically longer than the 267 ms RT found at GL (p < 0.01). Slopes of CO<sub>2</sub> over time for each task at each altitude differed statistically due to task (χ<sup>2</sup> (2) = 24.35, p < 0.01) but not altitude (χ<sup>2</sup> (2) = 1.02, p = 0.60). **DISCUSSION:** These results will be discussed in conjunction with previously reported peripheral blood oxygen saturation and transcranial infrared spectroscopy of regional cerebral blood oxygen saturation. Nonetheless, in general, while the PHODS is intended to mitigate altitude hypoxia, it does not eliminate all effects of altitude.

#### Learning Objectives

1. The audience will learn about the effects of hypoxia associated with flight in non-pressurized aircraft.
2. The audience will learn about the Portable Helicopter Oxygen Delivery System (PHODS) as the hypoxia countermeasure.

Wednesday, 05/25/2022

Tuscany B

10:30 AM

### [S-41]: PANEL: DEPLOYED COMPREHENSIVE MEDICAL READINESS PROGRAM FOR FLIGHT SURGEONS

Chair: Javier Nieves

Co-Chairs: Douglas Files, Jodie Timberlake

**Panel Overview: BACKGROUND:** Many flight medicine professionals occasionally perform duties in sites outside their normal workplace. Military and civilian aerospace medicine providers must be prepared to work in alternate sites. **OVERVIEW:** This panel includes facilitated discussions of best practices in performing those duties in a deployed setting. Additionally, the current panel and its sister panel renew U.S. Air Force flight surgeons' Comprehensive Medical Readiness Program (CMRP) requirements to make them as ready as possible to perform deployed duties. Discussion: The sessions in this panel will involve travel medicine, mass casualty response, in-flight physiologic emergency response and aeromedical evacuation of sick patients, along with other relevant topics. Participants will update their knowledge and consider whether they can incorporate best practices from other bases in their next deployment.

### [200] DEPLOYED PREVENTION AND TRAVEL MEDICINE

Robert Baltzer, Jodie Timberlake, Douglas Files

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

**MOTIVATION:** Aerospace medicine professionals support airfield operations that affect the safety and health of populations supporting the flying mission. However, airfield operations are not always in the nation of origin, thus flight surgeons and the people they support need to be prepared to deploy worldwide. This presentation will help aerospace medicine professionals to maintain currency by participating in travel

medicine briefings and administrative tasks. **OVERVIEW:** Responsibilities of flight surgeons include serving as the medical expert on travel health issues. This task is complicated by the wide variety of locations where airfield operations can occur. Medical travel guidelines are always changing. Emerging technology may also be involved. This program will allow aeromedical professionals to participate in travel medicine briefings and administrative tasks, such as prescribing medications to prevent tropical diseases. **SIGNIFICANCE:** Health risks to aircrew have expanded with global travel, which is particularly seen in the recent pandemic. Risks are so great that currency in travel medicine must include regular participation in briefings and administrative tasks. Numerous venues exist for flight surgeons to mitigate health risks, and they must also plan ahead. This program offers international aerospace medicine specialists an opportunity to incorporate some of the latest medical guidelines along with tips and techniques.

#### Learning Objectives

1. Learn updates about deployed flight medicine tasks and clinical care standards.
2. Discuss best practices for patient care and travel medicine in a deployed environment.
3. Renew USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (MCRP).

### [201] DEPLOYED MASS CASUALTY RESPONSE

Brian Huggins, Douglas Files, Jodie Timberlake  
U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

#### (Education - Program/Process Review)

**BACKGROUND:** Aerospace medicine professionals often provide mishap response capability including for aircraft crashes, HAZMAT spills, and mass casualty scenarios. This presentation will encourage professionals to maintain currency by participating in a response exercise. **OVERVIEW:** Aerospace medicine professionals are early-in and late-out during disaster relief operations. They determine the medical aspects of toxic and hazardous materials used on an airfield and consult on hazardous spills. They may respond to aircraft mishaps, caring for the initial responders as well as those directly injured. This program will update aeromedical professionals on response issues by providing an opportunity for individuals to participate in a mishap exercise involving an aircraft crash scenario. **DISCUSSION:** Currency in disaster response requires recurring training. Aerospace medicine professionals will improve their understanding of the nuances of dealing with other airfield organizations (i.e. - fire dept, civil engineering, etc), with federal authorities, and with local facilities that interact with the airfield during a disaster response. All participants will have an opportunity to study and discuss the latest disaster response information.

#### Learning Objectives

1. Interface with civilian and military authorities during a disaster scenario.
2. Discuss the particular features of investigating an aircraft crash especially in a military setting.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

### [202] DEPLOYED IN-FLIGHT PHYSIOLOGIC EMERGENCY RESPONSE

Charles Shurlow, Douglas Files, Jodie Timberlake  
U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

#### (Education - Program/Process Review)

**BACKGROUND:** Aerospace medicine practitioners treat aircrew who suffer physiologic problems in flight. This presentation will train them in how to do this, utilizing simulated patient cases. **OVERVIEW:** Aerospace medicine personnel specialize in the effects of normal physiology in abnormal environments. This program will remind aeromedical professionals how to respond to a physiologic incident. **DISCUSSION:** The U.S. Air

Force requires annual updates regarding physiologic incident response. Flight medicine personnel from other areas will also benefit. Flight surgeons will demonstrate how to discuss aircrew issues, understand physiologic causes, and treat the patient. These issues can indicate larger problems which may be present. This physiologic response discussion will give flight surgeons an opportunity to learn about responses, incorporating the latest physiologic response information.

#### Learning Objectives

1. Work with other organizations to treat injured aircrew and investigate what occurred during a physiologic incident in flight.
2. Discuss the particular features of military physiologic incidents, especially in a deployed setting.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

### [203] DEPLOYED AEROMEDICAL EVACUATION

Steven Fogger<sup>1</sup>, Douglas Files<sup>2</sup>, Jodie Timberlake<sup>2</sup>

<sup>1</sup>U.S. Air Force, Misawa Air Base, Japan; <sup>2</sup>U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

#### (Education - Program/Process Review)

**BACKGROUND:** Aerospace medicine practitioners oversee the well-being of patients in flight. They may medically clear patients being transported in an aeromedical evacuation system. This presentation will help professionals to maintain currency by performing medical clearances for simulated aeromedical evacuation patients. **OVERVIEW:** Aerospace medicine professionals specialize in the physiologic effects of flight at altitude. Patients with compromised physiology may also be flown at times. This program will help flight surgeons succeed in protecting patients being transported in aeromedical evacuation systems. One example might be a patient with orthopedic issues being transported for more surgery.

**DISCUSSION:** The U. S. Air Force requires recurring training for flight surgeons. Some of the flight surgeons who attend AsMA have never participated in aeromedical evacuation cases. Other services interface with the U.S. Air Force's aeromedical evacuation system making the training widely applicable. This program will give professionals an opportunity to participate in the medical clearance of aeromedical evacuation patients. It will cover the latest trends and techniques and will be beneficial to all AsMA attendees participating in the session.

#### Learning Objectives

1. Study how to prepare injured persons for air transport in an aeromedical evacuation situation.
2. Discuss the particular features of military aeromedical evacuation from a deployed setting, transporting patients back home.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

Wednesday, 05/25/2022  
Tuscany F

10:30 AM

### [S-42]: PANEL: CLINICAL PRACTICE GUIDELINES: AEROMEDICAL RISK ANALYSIS

Sponsored by the American Society of Aerospace Medicine Specialists

Chair: Dan VanSyoc

**Panel Overview: BACKGROUND:** Review of important conditions of aeromedical importance and interest. **OVERVIEW:** This panel annually reviews various topics of aeromedical interest and discusses how the aeromedical practitioner can effectively approach management of aviators with these conditions. **DISCUSSION:** These conditions and updated discussion will be of benefit to civilian and military flight surgeons as they care for and consider suitability for waiver.



**[204] ALCOHOL USE DISORDER: CLINICAL AND AEROMEDICAL PRACTICE GUIDELINES - PART 1**Terry Correll

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

*(Education - Tutorial/Review)*

**INTRODUCTION:** Alcohol use is widely accepted and utilized in our society and by United States Air Force (USAF) personnel. It is known to be one of the most problematic and common interferences in the careers of many USAF aviators. **TOPIC:** Even legal, sanctioned use of alcohol can have adverse effects on aviation safety and optimal flying abilities. A diagnosis of alcohol use disorder is disqualifying for all USAF flying classes and requires detailed and assured treatment to become eligible for a waiver. This presentation will focus on the diagnosis of alcohol use disorder, new ideas to insure success, and treatment/waiver policy considerations in aircrew.

**APPLICATION:** Although specific for Air Force pilots and aircrew evaluated at the Aeromedical Consultation Service, the underlying issues are common to aviators and waiver processes in all the military services and civilian organizations.

**Learning Objectives**

1. Understand the diagnosis and treatment of alcohol use disorder in aviators.
2. Enable aviation medical specialists to create the best possible waiver package.

**[205] ALCOHOL USE DISORDER: CLINICAL AND AEROMEDICAL PRACTICE GUIDELINES - PART 2**Ryan Peirson

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

*(Education - Tutorial/Review)*

**INTRODUCTION:** Alcohol use remains one of the most expensive threats to public health and is a common reason for interpersonal, medical, and occupational problems—including the military. **TOPIC:** Even legal, sanctioned use of alcohol can have adverse effects on aviation safety and optimal flying abilities. A diagnosis of Alcohol Use Disorder is disqualifying for all USAF flying classes and requires detailed and assured treatment to become eligible for a waiver. This presentation will build on the content in Part One and focus on the elements of successful treatment and waiver outcomes. Effective ways to support aircrew in recovery and achieving remission will be discussed and recent monitoring trends will be reviewed.

**APPLICATION:** Although specific for Air Force pilots and aircrew evaluated at the Aeromedical Consultation Service, the underlying issues are common to aviators and waiver processes in all the military services and civilian organizations.

**Learning Objectives**

1. Participants will understand the diagnosis and treatment of alcohol use disorder in aviators.
2. The participant will have a strategy to improve a waiver submission.

**[206] HEAD INJURY, AEROSPACE MEDICINE CLINICAL PRACTICE GUIDELINE**Joseph Connolly

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

*(Education - Tutorial/Review)*

**INTRODUCTION:** Head injury is a common condition with significant aeromedical concerns. It accounts for about 500,000 hospitalizations and 75,000 deaths annually in the United States, predominantly affects the 15-24 year old age group and is three times more common in males. Head injuries occur in over 70% of individuals involved in motor vehicle accidents. **TOPIC:** Closed head injury is the most frequently encountered head injury type in aviators. While the vast majority of head injuries are classified as mild, about

10% of individuals with good recovery from mild or moderate head injury require some type of continuing medical care services. Head injuries are generally considered disqualifying for flying duties. Aeromedical concerns include impact on flight safety and mission effectiveness from any head injury residuals, future risk of seizures, and effects of any medications used for symptom control. Aeromedical waiver consideration for head injury is based on classification severity, presence or absence of associated symptoms such as headache, dizziness, neurologic or cognitive deficits and seizures. A thorough neurologic evaluation should be obtained as part of aeromedical waiver submission. **APPLICATION:** The clinical assessment, treatment options and aeromedical disposition of head injury will be discussed in this presentation. A brief gap analysis of current evidence will be presented.

**Learning Objectives**

1. Participants will learn how to manage aviators with Head injury including considerations of severity classification criteria, evaluation and treatment strategies.
2. Participants will learn the aeromedical implications of head injuries as well as the military and civilian aeromedical standards for head trauma.

**Wednesday, 05/25/2022****Tuscany 3****10:30 AM****[S-43]: SLIDES: FROM PHYSIOLOGY TO PHYSICAL FITNESS****Chair: Jeff Myers****Co-Chair: Andrew Lam****[207] LUNAR EVA WALKBACK DISTANCE LIMITS: NASA HAUGHTON-MARS PROJECT-2021 BIOMETRIC STUDY OF SPACESUIT WALKS ACROSS LUNAR TERRAIN ANALOGS, OREGON**Sawan Dalal<sup>1</sup>, Pascal Lee<sup>2</sup><sup>1</sup>Baylor College of Medicine, Houston, TX, United States; <sup>2</sup>NASA Ames Research Center, Moffett Field, CA, United States*(Original Research)*

**INTRODUCTION:** Extended EVA (Extravehicular Activity) walks on the Moon present high risks for fatigue, over-expenditure, and injury. Max distance walked was on Apollo 14: ~3 km in 4h34min on flat (0°-5° slopes) mare terrain wearing an 82 kg (181 lbs) (lunar felt weight (lfw): 14 kg) spacesuit and dragging the MET cart. As Artemis targets the south polar highlands with slopes of 0° to 33° and the xEMU suit weighing ~159 kg (350 lbs) (lfw: 27 kg), new lunar EVA walkback distance limits are needed. Early field studies of walkback biometrics at the NASA Haughton Mars Project (HMP) focused on unsuited 10 km walkbacks and highlighted a significantly increased VO<sub>2</sub> in the field vs the treadmill. Here, we collected biometric data during simulated EVA walks across various lunar terrain analogs in Oregon using Collins Aerospace's (unpressurized) analog spacesuit weighing 25 kg (55 lbs). **METHODS:** Our analog study, supported by NASA and with ethics approved by the HMP, considered 3 subjects (2M, 1F), three lunar terrain types (*lunar mare* LM (0°-5° slope), *lunar mare-highland transitional* LMH (0°-10°), and *lunar highlands* LH (0°-25°)), and walks with and without the Collins suit. Data collected included objective measurements: heart rate (HR; continuous monitoring with Polar H10), distance, speed, elevation; and subjective ratings: fatigue (0-10), pain (0-10), exertion (Borg RPE, 6-20), and respiratory exertion (Borg CR10, 0-10). Subjects had to walk 2 km in <1 hour, while keeping HR under 85% max. Data analysis used small number statistics. **RESULTS:** For 2 km LM walks, HR remained <85% max. For LMH, HR exceeded 85% max on uphill slopes for 25% of walkbacks. For LH, HR exceeded 85% max for 73% of walkbacks. For all subjects, fatigue, exertion and respiratory exertion increased over time. Pain included hip and leg soreness. **DISCUSSION:** A 2km walkback in <1 hour on LM in an xEMU mass-class suit appears reasonable. Uphill slope walks will likely cause major exertion rapidly (secs to mins), even on slopes of 10°. Future studies will increase numbers of subjects, walkbacks, terrain

roughness ranges, and time limits, and include in-suit pressurization, thermal control, and higher CG fidelity.

#### Learning Objectives

1. The audience will be able to understand the use (and limitations) of analog environments for simulation and research.
2. The audience will learn about physiologic parameters to determine lunar extravehicular activity walkback limits.

### [208] PEAK HIP REACTION FORCES DURING NEUROMUSCULAR ELECTRICAL STIMULATION OF THE THIGH MUSCLES

Thomas Abitante<sup>1</sup>, Mary Bouxsein<sup>2</sup>, Dava Newman<sup>1</sup>, Kevin Duda<sup>3</sup>

<sup>1</sup>Massachusetts Institute of Technology, Cambridge, MA, United States;

<sup>2</sup>Harvard Medical School, Boston, MA, United States; <sup>3</sup>Draper Laboratories, Cambridge, MA, United States

#### (Original Research)

**INTRODUCTION:** For future long duration spaceflight missions, additional methods of mechanically loading the skeleton may be required to supplement exercise in order to minimize bone loss and reduce the risk of a catastrophic fracture. Neuromuscular electrical stimulation (NMES) can elicit muscular contractions that create strain on bone. However, the potential effectiveness of NMES on the proximal femur during disuse is not known. Hip joint reaction forces (HRF) are a simple metric to calculate and may be used to compare the potential osteogenic effect of different activities. **METHODS:** We measured the maximum isometric force of NMES-induced contractions of the Rectus Femoris and the Hamstring group of 10 subjects (5 male, 5 female), while sitting with the hips and knees at 90 degrees of flexion. We employed simple 2-D biomechanical models of the knee and hip, combined with subject-specific anthropometric measurements and literature derived moment arms to calculate the estimated HRF as a function of body weight (BW). **RESULTS:** The peak HRF were  $1.73\text{BW} \pm 0.95$  and  $0.93\text{BW} \pm 0.51$  for men and women, respectively, with a range of  $1.01\text{BW}$  to  $3.2\text{BW}$  and  $0.24\text{BW}$  to  $1.62\text{BW}$  for each sex. These values are lower than those reported previously for walking and running, with walking varying from  $4.22\text{BW}$  to  $5.41\text{BW}$  and running varying from  $7.49\text{BW}$  to  $10.01\text{BW}$ , depending on speed (Giarmatzis et al 2015). **DISCUSSION:** The force produced during NMES induced isometric contractions of the Rectus Femoris and Hamstring muscles were not high enough to replicate the HRF of terrestrial locomotive activities. However, the ability to reach HRF above  $3\text{BW}$  with NMES, which would have a lower energetic requirement than exercise alone, should be noted. Additionally, previous studies have reported that the forces produced can increase with repeated training. Furthermore, while HRF is a common metric to determine if an activity will have an osteogenic response, it is not definitive. Rather, the strain induced on the proximal femur should be determined and compared across different activities. With an anticipated lower strain produce by NMES, a daily strain stimulus comparable to locomotion could still potentially be achieved with the application of more NMES loading cycles.

#### Learning Objectives

1. The participant will be able to understand the potential negatives of excessive exercise and therefore the need for non exercise based countermeasures to increase the daily loading necessary to reduce bone loss on future long duration spacecraft to a degree that would sufficiently minimize risk on a Mars mission.
2. The audience will learn about Neuromuscular Electrical Stimulation, and the biomechanics of the muscle bone interaction in order to understand the feasibility of the tool as a space based bone loss countermeasure.

### [209] A MATHEMATICAL MODEL OF CARDIOVASCULAR RESPONSE TO SIMULATED SPACEFLIGHT

Alanna Kennard<sup>1</sup>, Karen Ong<sup>2</sup>, Rebecca Blue<sup>2</sup>, Charles Peskin<sup>1</sup>

<sup>1</sup>New York University, New York, NY, United States; <sup>2</sup>UTMB Medical Branch, Galveston, TX, United States

#### (Original Research)

**INTRODUCTION:** Previous attempts at mathematical modeling of the cardiovascular system in the context of spaceflight have frequently focused on post-spaceflight orthostasis, exercise and spaceflight deconditioning, or circulation in microgravity, but less attention has been paid to cardiac circulation in the context of launch and landing hypergravity exposures. We present a mathematical model of the cardiac circulatory system with variable gravitational stress, comparing results to biometric data obtained during actual layperson centrifuge-simulated spaceflight profiles.

**METHODS:** A multi-compartment steady-state cardiac circulation model was developed to incorporate a controller that adjusts heart rate and reserve venous volume such that upper arterial systemic pressure and stroke volume remain constant. The systemic circulation is partitioned into compartments above and below the level of the heart, permitting incorporation of variable gravity and additional cardiovascular stressors of launch and landing. Large arteries, veins, and the right ventricle are modeled compliance vessels, whereas tissues and organs are modeled as resistance vessels. The model considers the case of partial systemic venous collapse in the entry to the thorax, allowing simulation of changes in intrathoracic pressure such as from anti-G-straining maneuvers. Feedback from baroreceptors and the autonomic nervous system constitute an implicit control that monitors the systemic pressure and stroke volume with the goal of holding these variables constant by varying heart rate and reserve systemic volume. Simulations of various spaceflight scenarios involving acceleration were performed and compared with biometric data from human centrifuge subjects. **RESULTS:** We present simulation results of spaceflight-induced acceleration and cardiovascular response, with and without autonomic control. Simulations of various spaceflight scenarios involving acceleration were performed and compared with biometric data from laypersons experiencing centrifuge-simulated spaceflight hypergravity profiles. **DISCUSSION:** While additional data and analysis are desirable to further validate and refine this preliminary model, this approach offers a novel means of quantitative analysis of hypergravity-induced cardiovascular stress and response. This modeling technique may offer insight into anticipated layperson response to spaceflight launch and landing hypergravity.

#### Learning Objectives

1. The audience will learn about mathematical modeling of the circulatory system exposed to variable gravitational stressors.
2. The audience will learn about the role of modeling in risk characterization for future commercial spaceflight endeavors.

### [210] CARDIOVASCULAR, AUTONOMIC, AND CEPHALAD DOSE-RESPONSE TO GRADED LOWER BODY NEGATIVE PRESSURE

Richard S. Whittle<sup>1</sup>, Hrudayavani S. Vellore<sup>1</sup>, Eric A. Hall<sup>1</sup>, Félix Real Fraxedas<sup>1</sup>, Katherine H. Findlay<sup>2</sup>, Nathan Keller<sup>1</sup>, Lindsay M. Stapleton<sup>1</sup>, Bonnie J. Dunbar<sup>1</sup>, Ana Diaz-Artiles<sup>1</sup>

<sup>1</sup>Texas A&M University, College Station, TX, United States; <sup>2</sup>Independent Researcher, College Station, TX, United States

#### (Original Research)

**INTRODUCTION:** Cephalad fluid shift due to exposure to the microgravity environment is hypothesized to be linked to the etiology of spaceflight associated neuro-ocular syndrome (SANS). Lower body negative pressure (LBNP) has been posited as a potential countermeasure to reduce this fluid shift. The aim of this study was to construct dose-response curves for multiple cardiovascular parameters to understand how the level of LBNP influences fluid shifts within the body. **METHODS:** Twelve male subjects (age  $26.9 \pm 2.9$  years, height  $179.0 \pm 8.3$  cm, weight  $84.7 \pm 18.7$  kg) were placed in an LBNP chamber in both supine and  $15^\circ$  head down tilt postures. A graded LBNP profile was applied from  $0$  mmHg to  $-50$  mmHg in  $10$  mmHg increments. Measures of systemic cardiovascular parameters and autonomic indices were taken along with intraocular pressure, ultrasonography of the left and right common carotid arteries and internal jugular veins, and jugular venous pressure. **RESULTS:** The application of



–50 mmHg of LBNP caused a drop in systolic blood pressure from  $133.2 \pm 14.9$  mmHg to  $121 \pm 15.7$  mmHg ( $p = 0.003$ ), whilst diastolic pressure was maintained. Similarly, cardiac output and stroke volume decreased linearly, from  $5.3 \pm 1.1$  l/min to  $4.2 \pm 0.7$  l/min ( $p < 0.001$ ) and  $76.5 \pm 17.9$  ml to  $58.4 \pm 10.1$  ml ( $p < 0.001$ ), respectively. Autonomic indices showed no significant change in vagal activity, but a slight increase in sympathetic nervous activity. Jugular venous pressure and intraocular pressure were reduced with the application of LBNP, however the differential rate slowed at pressures below –20 mmHg. **DISCUSSION:** Over the range of LBNP considered, the systemic response was approximately linear, and dose-response curves can be constructed using linear models. By contrast, intraocular pressure and cephalad blood flow exhibited a non-linear response. This indicates that there is a balance point between achieving the greatest impact in reduction of cephalad fluid whilst minimizing the risk of syncope. The systemic responses to graded LBNP are comparable to dose-response curves generated through graded head-up tilt from supine. Future investigations will compare the LBNP response to a gravity gradient generated via short-radius centrifugation. In addition, a lumped-parameter model of the systemic circulation, head, and eye will be implemented to further examine results.

#### Learning Objectives

1. The audience will learn about quantitative changes in the cardiovascular system and cephalad fluid shift due to the application of lower body negative pressure (LBNP).
2. The audience will learn about the use of lower body negative pressure (LBNP) as a potential countermeasure for spaceflight associated neuro-ocular syndrome (SANS).

### [211] ATHEROGENIC POTENTIAL OF MICROGRAVITY HEMODYNAMICS IN THE CAROTID BIFURCATION: A NUMERICAL INVESTIGATION

Varun Vinayak Kalaierasan, Jason A. Shar, Patricia Strack, Graham Quasebarth, Philippe Sucosky  
Kennesaw State University, Marietta, GA, United States

#### (Original Research)

**INTRODUCTION:** Exposure to microgravity during long-duration spaceflight poses multiple hazards to human health. Although retrograde stagnant flow conditions have been reported in the venous vasculature during extended space missions, the impact of microgravity on cerebral arterial hemodynamics and function remains poorly understood. Therefore, the objective of this study was to quantify computationally the effects of microgravity on hemodynamics and wall shear stress (WSS) characteristics in subject-specific carotid bifurcation geometries.

**METHODS:** Sixteen carotid bifurcation geometries reconstructed from high-resolution ultrasound images were imported into the computational fluid dynamics (CFD) software ANSYS Fluent. Unit-gravity simulations were performed by accounting for both gravitational acceleration and subject-specific mass flow rates at the common carotid artery (CCA) inlet and internal carotid artery (ICA) outlet. Microgravity was simulated by imposing an 18% reduction in mass flow rate, as reported in the literature. Flow stasis was quantified in terms of a flow stasis index representing the volume fraction occupied by velocities lower than 5% of the maximum peak-systolic velocity. WSS was characterized in terms of temporal shear magnitude (TSM) and oscillatory shear index (OSI; 0: unidirectional – 0.5: oscillatory) captured in each bifurcation branch. Statistical difference between unit gravity and microgravity was investigated using Student t-tests and was considered at  $p < 0.05$ .

**RESULTS:** Microgravity resulted in a significant 21% increase in flow stasis index and a significant 22-23% decrease in TSM in all bifurcation branches, while preserving OSI unidirectionality ( $OSI < 0.06$ ). In two anatomies, however, microgravity not only promoted flow stasis but also subjected the ECA to a moderate increase in WSS bidirectionality (0.02-point increase in OSI vs. unit gravity) which contrasted with the population-average trend (0.001-point decrease in OSI vs. unit gravity).

**DISCUSSION:** This study suggests that long-term exposure to

microgravity has the potential to subject the vasculature to atheroprone hemodynamics (i.e., low oscillatory WSS) and this effect may be exacerbated by subject-specific anatomical features. Exploring the impact of these microgravity-induced WSS alterations on tissue biology is needed to better define the risks posed by long-duration spaceflights on cardiovascular health.

#### Learning Objectives

1. The audience will learn that microgravity increases carotid bifurcation flow stasis and maintains wall shear stress (WSS) unidirectionality in most subjects.
2. Additionally, the audience will learn that microgravity generates pro-atherogenic hemodynamics in some subjects.

### [212] INTRAVENOUS FLUID REQUIREMENTS FOR EXPLORATION MISSIONS

Josef Pleticha<sup>1</sup>, Moriah Thompson<sup>2</sup>, Rahul Suresh<sup>2</sup>

<sup>1</sup>Mayo Clinic, Rochester, MN, United States; <sup>2</sup>NASA Johnson Space Center, Houston, TX, United States

#### (Original Research)

**INTRODUCTION.** Intravenous fluids (IVF) administration during exploration missions will be critical to treat conditions that may adversely impact crew health and mission outcome. The anticipated mass/volume constraints and limited shelf-life of IVF will necessitate in-situ generation of IVF. Accordingly, a prototype IntraVenous Fluid GENeration (IVGEN) device has been tested on the International Space Station (ISS) and a miniaturized version of the device (IVGEN Mini) is in development. To inform the IVGEN Mini target performance, an evidence-based, quantitative assessment of IVF needs during the mission is necessary. **METHODS.** The Integrated Medical Evidence Database, Space Medicine Exploration Medical Capability List, and Integrated Medical Model (IMM) report D-20210105-433 (3-year, 4-person crew Mars mission) were reviewed for incidences or occurrences of conditions requiring IVF during exploration missions. Further, a literature search was performed to evaluate IVF requirements for each identified condition and to assess overall IVF needs for the mission.

**RESULTS.** A total of 37 relevant conditions were identified and the IVF requirement for each condition was determined. The condition with the highest IVF requirement (assuming full resuscitation for up to 7 days) was burns with inhalation injury (60.4 L). Next, the IMM framework was applied to estimate the maximum IVF requirement for all conditions occurring during a single mission (144.7 L). However, when incidences of these conditions were considered, those with the highest IVF needs did not represent the conditions most likely to occur. To evaluate the condition's actual mission impact, the Fluid Need Index (FNI), calculated by multiplying incidence by the IVF requirement, was established. Gastrointestinal fluid loss had the highest FNI (4.7 L/condition/mission), followed by burns with inhalation injury (1.7 L/condition/mission). In addition, aggregate FNI was calculated as a sum of the FNIs for each condition, thereby providing a measure of average IVF needs per mission (6.6 L/mission). **DISCUSSION.** Our analysis defines IVF requirements for an exploration class mission, addressing the worst-case mission (144.7 L), worst-case condition (60.4 L) and average mission (6.6L) scenarios. The substantial range of IVF requirements for the mission underlines the need for careful tradeoffs between the mass/volume and capabilities of the IVGEN Mini device.

#### Learning Objectives

1. Understand the considerations underlying intravenous fluid (IVF) resuscitation during exploration class missions and learn about the constraints related to generating IVF in space.
2. Categorize the need for IVF resuscitation by condition and best-case/worst-case/most likely scenario and evaluate the quantitative analysis of IVF requirements during a design reference mission to Mars.
3. Discuss the NASA modeling tools for medical risk prediction during spaceflight and how they can be applied to IVF requirements during exploration missions.

Wednesday, 05/25/2022  
Tuscany 4

10:30 AM

## [S-44]: PANEL: U.S. NAVY AEROSPACE MEDICINE RESIDENCY GRAND ROUNDS

Chair: Jonathan Elliot

Co-Chair: Jennifer Hunt

**Panel Overview:** Case presentations are provided by aeromedical officers as an integrated component of graduate medical education in aerospace medicine. This panel is a grand rounds opportunity in which cases of unique presentation or of interesting aeromedical significance are presented and discussed as they pertain to the operational and aeronautical environment.

### [213] RASH DECISIONS AND THEIR AEROMEDICAL CONSEQUENCES

Jessica Tedford

UTMB Medical Branch at Galveston, Pensacola, FL, United States

(Education - Case Study)

**INTRODUCTION:** A 30-year-old male presented to the Aviation Medicine department with a new onset rash. This case study reviews the relevant workup as well as the ultimate relevant diagnosis and findings.

**BACKGROUND:** Dermatologic disease is a common urgent care and primary care clinical presentation. It is thought that somewhere between 15-36% of patients seen in urgent care settings present for dermatologic reasons. Appropriate workup and management of these cases can improve patient outcomes and satisfaction as well as improve overall safety in the Aviation environment. **CASE PRESENTATION:** The new onset rash of an Aviation Ordinance man was originally treated as pityriasis rosea in the urgent care and later found to be a late-stage manifestation of diabetes mellitus with serious aeromedical and military implications. **DISCUSSION:** This case will discuss several common dermatologic issues as well as the relevant medical issues surrounding the case. It is intended for Aerospace Medicine Residents and Flight Surgeons to aid in determination of flight duty eligibility as well as general military duty eligibility.

#### Learning Objectives

1. Learn about basic dermatologic rash diagnosis through photographic case review.
2. Understand the aeromedical implications of specific conditions and their dermatologic presentation.
3. Review aeromedical duty status eligibility in relationship to Diabetes Mellitus.

### [214] RARE RETINAL ABNORMALITY REVEALED DURING ROUTINE SCREENING OF AN ASYMPTOMATIC AVIATION CANDIDATE

Jay Belmarez, Juan Guerra

Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

**INTRODUCTION:** This case report describes an incidental ophthalmic finding while screening asymptomatic Naval aviation candidates.

**BACKGROUND:** Screening healthy asymptomatic patients can subject individuals to harms such as overdiagnosis, false positives and unnecessary treatments. Periodically, screening asymptomatic Naval aviation candidates may reveal a finding that not only disqualifies a candidate but may also reveal a rare diagnosis which could jeopardize aviation safety if mislabeled as a benign finding. Proper screening of applicant prevents losing aviators to progressive disorders in the middle of their flying career and protects the investment costs made by the U.S. government by training physically qualified individuals. **CASE PRESENTATION:** The subject candidate is an asymptomatic 26-year-old male of Asian descent with aspirations to become an F-35 pilot. The Naval candidate never experienced any ocular

complaints nor was he aware of any family history of vision abnormalities. A thorough ocular examination did not reveal any abnormalities until a direct fundoscopic examination (DFE) revealed bilateral glistening yellow-white crystal deposits predominantly in the maculas and retinal arcades. After considering a wide differential diagnosis to include both medication induced and benign etiologies, and consulting with a civilian ophthalmologist, a diagnosis of Bietti Crystalline Dystrophy was made. Subjects with this autosomal recessive condition often become legally blind by the fourth decade of life. This condition may also be heralded with blurry vision, poor night vision and decreased peripheral vision, conditions which are incompatible with aviation. With no treatment or cure for this condition and the inevitable inability to meet Naval vision requirements for aviation, this aviation candidate was considered non-physically qualified (NPQ) for aviation. **DISCUSSION:** This case highlights the importance of thoroughly screening aviation candidates for any potentially disqualifying conditions. Subjecting this population to screening tests can and does yield false positive results that may prevent a candidate from entering this coveted profession. Failure to capture disqualifying conditions on the other hand can produce catastrophic results such as sudden incapacitation while flying or the physical inability to continue with a career in aviation if the condition is progressive and insidious.

#### Learning Objectives

1. To appreciate the harms of screening healthy asymptomatic candidates with a low prevalence of disease conditions.
2. Understand that a thorough ophthalmologic examination may reveal unknown metabolic conditions in asymptomatic aviation candidates.

### [215] DEPLOYED AIRCREWMAN WITH FEBRILE ILLNESS: A CASE REPORT

Elbert Maloney

U.S. Navy, Pensacola, FL, United States

(Education - Case Study)

**INTRODUCTION:** This case report describes a U.S. Naval Aircrewman who developed a febrile illness while deployed in Hawaii, but there was a delay in obtaining a travel history. **BACKGROUND:** Deployments and travel, an integral part of military life, expose aircrew personnel to pathogens not typically encountered at their home duty station. This presents a conundrum for treating physicians that is made even harder if a detailed travel history is not obtained. For the aircrew this could mean a prolonged illness and a negative impact on operational readiness. **CASE PRESENTATION:** A 35-year-old male U.S. Navy aircrewman reported to medical while deployed to Hawaii for about 6 weeks for two days of sore throat, fevers, chills, and body aches. His exam was notable for a temperature of 100.3°F, bilateral erythematous tonsils without exudate. A group A beta-hemolytic streptococcus rapid test and polymerase chain reaction lab were obtained, both were negative. He was diagnosed with pharyngitis and discharged home. His symptoms continued after deployment prompting his returned to medical at four and six weeks after his initial visit. It wasn't until his second follow up that a travel exposure history was obtained, he endorsed multiple exposures to freshwater while deployed in Hawaii. Additional labs were drawn to include leptospirosis. The leptospirosis labs was negative but showed hyperthyroidism with a normal complete blood count and comprehensive metabolic panel. He was diagnosed with subacute thyroiditis. Full recovery was made at six months post initial presentation. **DISCUSSION:** Even though this case was negative for leptospirosis it highlights the importance of the travel history. Our aircrew travel far and wide, to areas with many different pathogens whose incubation periods vary dramatically from days to months. Without a good travel history, it is impossible to complete an accurate exposure assessment to support a thorough differential diagnosis. Common illnesses are common, but if we don't think about zebras we won't find them. This can result in a protracted illness with possible increased morbidity and mortality among our fliers. To keep them flying we have to keep them healthy.

#### Learning Objectives

1. Participants will gain knowledge specific to the presentation, differential diagnosis, natural course, occupational management and

clinical management from the perspective of the physician managing the clinical case.

- Participants will exercise critical evaluation of the impact of the aeronautical environment on the presentation and the clinical course.

## [216] PROVOKED OR UNPROVOKED? A PULMONARY EMBOLISM IN A YOUNG MAN

Margaret MacClary

*U.S. Navy, Pensacola, FL, United States*

*(Education - Case Study)*

**INTRODUCTION:** A young man presents with a pulmonary embolism of unclear origin. **BACKGROUND:** Pulmonary emboli can be associated with long flights and can be suddenly incapacitating to pilots, and aircrew. Determining the cause affects treatment, grounding periods and risk of recurrence (Kuipers et al, 2014). **CASE PRESENTATION:** A 34 y/o Sailor presented to the ER with sharp right sided chest pain and shortness of breath that started the night before while playing basketball. On initial read of the CT he was found to have a single subsegmental pulmonary embolism (PE). He had returned from a transatlantic flight three weeks prior to onset of symptoms. He was hemodynamically stable and so was started on outpatient oral anticoagulation. Evaluation by Hematology/Oncology thought that the PE was provoked by the recent flight. However, Radiology review of the CT revealed that he had a 5.8x3.1x6.0cm mediastinal mass. Other than an elevated d-dimer of 1920 labs were within normal limits. He was referred to cardiothoracic surgery who thought that the mass was a benign thymus mass and elected to have close observation. Six months later the patient underwent video assisted resection of the mass, which pathology demonstrated to be a benign thymoma. Anticoagulation was stopped for this procedure. The surgeon thought that the PE was due to compression from the thymoma, and so did not resume anticoagulation following the procedure.

**DISCUSSION:** Given the fact that the PE was single and subsegmental anticoagulating the patient was controversial. However, given that he needed to return to active duty a more aggressive approach was chosen. The case was complicated by the discovery of the mediastinal mass. Following its removal, the case was further complicated by the development of pleural effusion, pericarditis, and chronic pain which has kept the patient from returning to duty for the past year and a half. Could a less aggressive treatment course have had the same results and less sequelae? **REFERENCES:** Kuipers, S., Venemans-Jellema, A., Cannegieter, S. C., van Haften, M., Middeldorp, S., Büller, H. R., & Rosendaal, F. R. (2014). The incidence of venous thromboembolism in commercial airline pilots: a cohort study of 2630 pilots. *Journal of Thrombosis and Haemostasis*, 12(8), 1260–1265. <https://doi.org/10.1111/jth.12627>.

### Learning Objectives

- The audience will learn about different causes of pulmonary embolism and their treatments as well as their risks and benefits.
- The audience will learn about a very common problem, pulmonary embolism, that can have many and varied complications.

## [217] MONOGENIC DIABETES IN NAVAL AVIATION: A CASE REPORT OF A NOVEL DIAGNOSIS REQUIRING APPROPRIATE IDENTIFICATION

Terrence Bayly<sup>1</sup>, James Westbrook<sup>1</sup>, Daniel Seeger<sup>2</sup>

<sup>1</sup>Naval Aerospace Medical Institute, Pensacola, FL, United States; <sup>2</sup>Naval Hospital, Naples, Italy, FPO, Armed Forces - Europe, Canada, Middle East, Africa, United States

*(Education - Case Study)*

**INTRODUCTION:** This case report describes a U.S. Naval Flight Surgeon applicant correctly diagnosed with GCK maturity-onset diabetes of the young (MODY) and granted a waiver of medical standards for Naval Aviation training. **BACKGROUND:** Diabetes mellitus is considered medically disqualifying with a waiver of standards not recommended for applicants to U.S. Naval Aviation. MODY is a rare form of monogenic diabetes often misdiagnosed as Type I or Type II diabetes

mellitus though with substantially different pathophysiology. MODY often does not share the same short and long term health risks associated with diabetes mellitus and therefore may not pose the same risks to safety of flight. **CASE PRESENTATION:** A 36-year-old Naval Flight Surgeon applicant was noted to have an elevated fasting blood sugar and borderline hemoglobin A1c as part of an aviation application physical exam. The remainder of his application was normal to include diabetes specific testing indicated in the Naval Aerospace Medical Institute Aeromedical Reference and Waiver Guide. He was appropriately referred to Internal Medicine for further evaluation. Review of his medical record revealed he was first noted to have dysglycemia 10 years prior as part of a previous aviation application physical exam. A partial work-up was conducted at the time though incomplete as the patient was selected for an alternate training curriculum. The astute Internist recognized the patient's otherwise normal lab results, normal body habitus, active lifestyle, and asymptomatic timeline for presentation were consistent with a diagnosis of MODY. Genetic testing confirmed the diagnosis of GCK-MODY. Based on the diagnosis, no further testing or treatment was indicated so the patient was granted a waiver of medical standards to initiate training as a Naval Flight Surgeon.

**DISCUSSION:** This patient likely represents the first diagnosis of monogenic diabetes in U.S. naval aviation. MODY is typically misdiagnosed as Type I or Type II diabetes mellitus which leads to inappropriate treatment. There are many subtypes of MODY, some with little to no risk to safety of flight. Recognition of MODY as a potential diagnosis and knowledge of appropriate genetic testing are critical to the medical risk stratification decision making involved in US Naval Aviation.

### Learning Objectives

- Recognize the clinical characteristics of mature onset diabetes of the young (MODY) and be able to differentiate this diagnosis from Type I and Type II diabetes mellitus.
- Understand the correct diagnostic approach to mature onset diabetes of the young (MODY) as compared to Type I or Type II diabetes mellitus.
- Understand the prognostic differences between the most common types of mature onset diabetes of the young (MODY) and Type I and Type II diabetes mellitus.

## [218] HOW A PERSISTENT COUGH LED TO A DIAGNOSIS OF HODGKIN LYMPHOMA IN A MILITARY AVIATOR

Jacob Duong, Yummy Nguyen

*U.S. Navy, Pensacola, FL, United States*

*(Education - Case Study)*

**INTRODUCTION:** A 27-year-old active-duty Naval Aviator experienced a persistent cough of 5 months. He then presented to an Aerospace Medicine physician and reported additional symptoms of unintentional weight loss, night sweats and fever. This case report describes the diagnosis, treatment and aeromedical disposition of a previously healthy Aviator who was diagnosed with Stage IV Hodgkin's Lymphoma. **BACKGROUND:** Vigilance is paramount even amongst the mundane Sick Call complaints such as an Upper Respiratory Infection. Hodgkin's Lymphoma, also known as Hodgkin's disease, is typically diagnosed between the second and fourth decades of life. Regarding Duties Involving Flight, the Navy's Aeromedical Reference and Waiver Guide's guidance on Hodgkin's disease is that a Waiver is possible in two instances. For Stage I Hodgkin's Lymphoma, a Waiver is possible after two years of completing treatment without evidence of recurrence. For Stage II to Stage IV Hodgkin's Lymphoma, a Waiver is possible after five years status post treatment completion. **CASE PRESENTATION:** When a previously healthy Naval Aviator reported 5 months of an unintentional 15-pound weight loss in addition to a dry cough with night sweats, chills and fatigue to his Flight Surgeon, it became clear that this was not a routine visit. A chest radiograph revealed a mediastinal opacity. A subsequent urgent chest computed tomography confirmed a 14 centimeter anterior mediastinal mass consistent with lymphoma. He was diagnosed with Classical Hodgkin Lymphoma, Stage IVB. Over the next



six months, he successfully completed six courses of chemotherapy and radiotherapy. Nine months from diagnosis, he was considered to be in full remission. He was cleared to fly again in July 2021, with a determination of "not physically qualified but aeronautically adapted for all duty involving flying." **DISCUSSION:** This case report illustrates that a potentially life altering medical diagnosis could always be hiding behind an average Sick Call presentation. This case will also discuss the prevalence, work-up and treatment of Hodgkin's Lymphoma. It will also explore how aeromedical risk assessment overlays with standard medical risk assessment for evaluating a cough. The intended audience for this presentation is for military flight surgeons and Aerospace Medicine Residents.

#### Learning Objectives

1. The audience will learn about aeromedical concerns of Hodgkin's lymphoma.
2. The audience will understand current diagnoses and treatment options regarding Hodgkin's lymphoma.
3. The audience will review common work up for a common cough often encountered in Primary Care.

**Wednesday, 05/25/2022**  
**Tuscany 12**

**10:30 AM**

### [S-45]: SLIDES: FROM FOUNDATIONS TO FRONTLINES: BUILDING TEAM AEROSPACE

**Chair: Joseph LaVan**

#### [219] THE TEACHING OF AEROSPACE MEDICINE IN UK MEDICAL SCHOOLS

Lauren Church<sup>1</sup>, Chloe Mohanadass<sup>1</sup>, Aamna Warsi<sup>2</sup>, Peter Hodgkinson<sup>1</sup>

<sup>1</sup>King's College London, London, United Kingdom; <sup>2</sup>Royal Air Force, Newcastle, United Kingdom)

(Original Research)

**INTRODUCTION:** The fifth report from the United Kingdom House of Lords Select Committee on Science and Technology (2000) recognised the knowledge gap of UK general practitioners surrounding fitness-to-fly and the implications of flight on health. It suggested that all medical graduates should have some knowledge of Aviation and Space Medicine (ASM) to begin to bridge this gap. To achieve this, we must first understand baseline awareness and attitudes to the specialty. **METHODS:** Two concurrent surveys were produced; the first was aimed at medical students and disseminated through gatekeeper organisations (Medical Student Associations at each school). This survey aimed to assess students' prior awareness of ASM, any compulsory or optional teaching they may be aware of, as well as any specialty exposure they might have had through conferences and extra-curricular activities. The second survey was distributed to faculty members of each medical school. This survey asked faculty members to detail any aspect of their curriculum, compulsory or optional, which involved ASM. Both surveys were distributed via Google Forms, with links to the correct survey being included in email format to each of the target groups. This methodology received ethical approval from the Ethics Committee of King's College London. **RESULTS:** There were 53 student responses total from across 10 different UK medical schools. Of these, 4 were discarded due to repeat entries. Of the remaining 49 responders, 74% were not aware that *Aviation and Space Medicine* was a General Medical Council (GMC) recognised specialty, and 96% had received no curriculum-based exposure during their time in medical school to date. 24% of respondents had some exposure to the specialty through extra-curriculars. 78% of respondents to the student survey stated that they wanted more exposure to the specialty of ASM. **DISCUSSION:** Over half of respondents

said that online teaching content would be useful in learning about ASM. Diffuse teaching of the specialty might not be possible due to the availability of experts, however recent times have necessitated remote teaching, which could be utilised to increase accessibility of content. Other strategies to disseminate key ASM topics should be considered, including the training of interested students to deliver lectures and content independently at their home universities, thus allowing for peer-teaching and a lower centralised burden on ASM clinicians and academics.

#### Learning Objectives

1. Understand the current awareness and attitudes to the specialty of Aviation and Space Medicine in UK medical schools, and how this can be extrapolated to medical schools worldwide.
2. The audience will learn about the barriers to and challenges in creating centralised teaching resources for Aviation and Space Medicine, and strategies with which to overcome them.

#### [220] BUILDING THE AEROMEDICAL NURSE PRACTITIONER INTERNSHIP

Jessica Knizel<sup>1</sup>, Christopher Kelly<sup>2</sup>

<sup>1</sup>96 MDG, Eglin AFB, FL, United States; <sup>2</sup>39 AW, Incirlik AB, Turkey

(Education - Program/Process Review)

**BACKGROUND:** In October 2019, the AF created its newest AFSC the Aeromedical NP (AMNP). This role has come at a critical time during the AFMS reform and will help fill the operational void. FNP's now have the opportunity to expand their scope beyond the traditional primary care roles and integrate their experience into the AM enterprise. After successful completion of these didactic courses, the AMNP will complete the AMNP ramp-up guide and IQT to be assigned the AFSC. To enhance the educational foundation of AMP, AMNPs would benefit from concentrated and standardized experiences. **OVERVIEW:** A brief structured internship will solidify the foundational didactic instruction and knowledge gained at AMP. The aims of this discussion are to explore the new roles, hands-on training opportunities and improve the retention. We intend to discuss a proposed initial qualification training pipeline that will cement the foundational guidance provided in AFI 48-149. **DISCUSSION:** We will outline several unique facets of the internship focused on the establishment of a mentoring program, peer training and apply AMP academics to real world operational mission requirements resulting in the production of better qualified and retainable AMJNP. This internship program will be focused on the specific clinical experiences required in the IQT and the AMNP credentialing requirements. The integration of this proposed program would occur prior to starting at their new assignment. This four-week program would partner the AMP graduate with an assigned peer for training at a pre-designated training site. We recognize that many family medicine providers possess a varying degree of understanding of the unique operational and aerospace medicine fundamentals. The primary goal of this AMNP internship program is to close those knowledge gaps prior to beginning this new role as an AM providers. AMNP-internship training site should consist an ideal environment to gain experience with multiple airframes, high frequency of sorties, IFE response, air sickness treatments, flight line operations, waivers and flight medicine sick-call workflows. The AF has several bases that can provide a high density "hands-on" experience to achieve the targeted goals of a short duration operational medicine internship. The opportunity to cultivate the clinical skillset of the AF's newest AFSC is now and posture the AFMS to advance the evolving AM mission of tomorrow's AF.

#### Learning Objectives

1. Explain the some of the qualifications an FNP would need to poses to apply for Aeromedical Nurse Practitioner.
2. List three tasks from the MQT and Ramp-up guide that can be accomplished during the Aeromedical Provider internship.
3. Discuss the potential operational impact of Aeromedical Provider internship.

## [221] THE APPLICATIONS OF PATHOLOGY IN AVIATION AND AEROSPACE INDUSTRY

Mustafa Alaziz

Wright State University, Dayton, OH, United States

(Education - Program/Process Review)

**BACKGROUND:** The specialty of aerospace medicine requires the expertise of many medical disciplines, including pathology. The pathologist's role in aerospace medicine can be divided into two categories, the investigation of aircraft accidents, and the study of tissue and cellular behavior under microgravity. This review aims to provide an insight into the correlation between aerospace medicine and pathology. **OVERVIEW:** The pathological study is considered a vital component of many aviation accidents. Without a full pathological report, many aviation accident investigations would be deemed incomplete. Pathologists conduct these medical investigations with three objectives: (1) reconstructing the sequence of the events, (2) assessing whether safety equipment was used properly, and (3) identifying the cause of the accident. Pathologists in the aerospace industry focus on studying the relationship between microgravity, cellular & molecular changes, and tumorigenesis. Several studies indicated that microgravity induces modifications in gene expression, signal transduction, proliferation, and morphology in various tumor cells by affecting the "mechanical tumor microenvironment." In addition, recent literature indicates that microgravity, radiation, and prolonged stress can cause immune system dysregulation during space flight, impairing the immune system ability to control mutated cells. **DISCUSSION:** A new era of exploration space missions seems to be gaining momentum after decades of distance. Several space agencies are moving forward with plans to establish a lunar presence through the Lunar Gateway. Mars flyby missions should follow these lunar missions, with the ultimate goal of landing humans on the surface of Mars. This fast advancement in the aerospace and aviation industry necessitates more involvement from physicians of different specialties, and academic leaders from various medical fields are encouraged to enhance the role of their trainees to take part in the aerospace and aviation industry.

### Learning Objectives

1. The presentation will provide an insight into the importance of having a background in aerospace medicine for the applicants to the pathology residency and fellowship programs.
2. The audience will learn about the significant role of pathologists in aerospace medicine.

## [222] FOXTROT - FORWARD OPERATING BASE EXPERT TELEMEDICINE RESOURCE UTILIZING MOBILE APPLICATION FOR TRAUMA

Jennifer Stowe

U.S. Army Aerospace Research Laboratory, Enterprise, AL, United States

(Original Research)

**BACKGROUND:** During Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), 10-15% of combat-related trauma injuries involved the eye. There were 170 ocular trauma cases reported in 2018 occurring in deployed locations. The military ophthalmologist's primary mission is to be prepared to manage ocular trauma, especially in an austere environment; however with deployments across the globe, access to ophthalmic care is not easily accessible. The primary purpose of our research is the development of an operationally secure, Health Insurance Portability and Accountability Act (HIPPA) compliant, mobile application (mApp) to provide ophthalmic care to any remote deployed location through a teleophthalmology called FOXTROT. The development of this application will effect the Aerospace Medical community by reducing the number of MEDEVACs needed in theater operations.

**METHODS:** 1. Developed FOXTROT teleophthalmology mApp for ocular trauma utilizing the mobile healthcare environment. 2. Develop a standardized and reproducible protocol for deploying FOXTROT.

**RESULTS:** FOXTROT was fielded in Afghanistan field hospitals. Based on an independent assessment, FOXTROT could potentially save the Military

\$2.4M by preventing costly medical evacuations out of theater.

**DISCUSSION:** There is currently limited access to ophthalmic care at forward-operating bases, especially with ocular trauma.

Teleophthalmology is currently limited in the military and in the civilian sector. FOXTROT teleophthalmology mApp will improve and extend ophthalmic trauma care in remote deployed environments. In addition to field hospitals, it could be utilized for ocular trauma in any remote or austere environment, including ships at sea, disaster areas, and humanitarian missions. It could also be integrated into any medical treatment facility (MTF) or emergency department without an in-house ophthalmologist. Military providers could use the App for ophthalmic consultations during outpatient visits or inpatient encounters, providing a more convenient, comprehensive, and economical solution for managing ophthalmic disease and trauma. FOXTROT would enhance the safety and quality of patient care and lower costs by avoiding some referrals. The transition plan for the FOXTROT platform will include other surgical and medical specialties, including a platform for aviation medicine.

### Learning Objectives

1. Understand the importance telehealth can play in austere environments and in future warfare.
2. Realize the return on investment (ROI) for virtual health in reduction of aviation evacuations.
3. Understand the requirements of virtual health with regards to protection of patient's personal information.

## [223] 5G TELEMEDICINE AND MEDICAL TRAINING: THE FUTURE OF HEALTHCARE FOR THE REMOTE WARRIOR

Paul Young

Joint Base San Antonio 5G Program Management Office, San Antonio, Tx, United States

(Education - Program/Process Review)

**INTRODUCTION:** The Department of Defense (DoD) continues to change based on emerging national threats, fiscal constraints, technological advancements, and warrior skill requirements. In June 2020, Office of the Undersecretary of Defense (Research & Engineering) named Joint Base San Antonio (JBSA) as an experimentation site for 5G augmented reality (AR) support for telemedicine and medical training. Although telemedicine is happening today, it is often inhibited by a lack of adequate digital connectivity supporting the data speeds and volumes needed to provide real-time remote virtual healthcare. Since 5G is a critical strategic technology, the DOD must master 5G networks, which will eventually touch every mission within DOD medicine. As the complexity of DoD medical mission grows to cover many environmental domains, various healthcare challenges must be addressed. Thus, JBSA has created several experiments to work with DoD Virtual Medical Centers and civilian research labs to allow the development of initiatives that incorporate 5G Wi-Fi under the 5G core. The intent is to provide reliable, secure, and faster capabilities for remote care. This introduction of JBSA's phased processes details challenges for utilizing AR, enabling smart device remote use in operational field care, and improving efficiency while also enhancing training or proficiency for all military medics. Key outcomes have been identified by a Joint Medical Steering Committee (MSC) to save lives by providing resilient, fault-tolerant global support. **METHODS:** 1) Partnerships and inclusion of key medical components for the JBSA MSC to delineate concerns regarding remote operational care. 2) Engagements or personnel interviews with Medical Commands along with current civilian entities. 3) Medical Resource analysis of capabilities, risks, and vulnerabilities in DoD Medical Facility assessments for remote care. 4) Key indicators or analysis of battlefield casualty management. 5) Medical equipment end-user operability in 5G-enabled remote settings. **RESULTS:** JBSA 5G experiment activities, and strategic goals will show how 5G technology will augment DoD remote medical care. **DISCUSSION:** Mission demands, tech applications, and remote care under 5G enhancements creates different challenges than those observed under 4G concepts. However, this presentation will allow the operational medicine community to see why 5G advancements will still improve DoD medicine, training, and austere environment care.

**Learning Objectives**

1. Participants will understand the emerging technological advancements of remote medical training and telementoring; discuss medical challenges involved with healthcare and health for the remote warrior.
2. Participants will be able to link medical support initiatives and strategies involved utilizing 5G in learning and training performance to enhance the support of military medical personnel in remote settings.
3. The audience will understand the need to maintain an awareness of 5G capabilities; focus on risk reduction or mitigation for record access; and enhance medical support capabilities while working within a resource-limited environment.

**[224] PROSPECTIVE RISK ANALYSIS USING BOWTIE METHODOLOGY TO IMPROVE THE SAFETY MANAGEMENT OF IN-FLIGHT MEDICAL EMERGENCIES AND GUIDE AEROMEDICAL DATA USAGE**

Peter Hodkinson<sup>1</sup>, Peter Wallace<sup>1</sup>, Apurva Bharucha<sup>1</sup>, Stuart Mitchell<sup>2</sup>

<sup>1</sup>King's College London, London, United Kingdom; <sup>2</sup>Civil Aviation Authority, London, United Kingdom

(Education - Program/Process Review)

**BACKGROUND:** In-flight medical emergencies (IFMEs) are an important consideration for flight safety and can adversely affect aircrew and passengers. Annual commercial flights are predicted to double within the next two decades and so too the opportunities for IFMEs. Effective tools are therefore required to manage these risks and associated mitigation options. This work presents Bowtie methodology as a means of prospective risk assessment and safety management.

**OVERVIEW:** Bowtie methodology is well established in the fields of aerospace operations and medicine but has received limited consideration in aerospace medicine. We have undertaken a literature review and developed a bottom-up guide on how to produce an aerospace medicine Bowtie diagram supplemented by exemplar diagrams involving three key scenarios within the commercial aviation sphere. Based on these exemplar diagrams a review of current aeromedical data will be presented to demonstrate the practical application and potential benefits of Bowtie methodology in aerospace medicine. **DISCUSSION:** Risk management underpins aerospace medicine practice and the Bowtie provides a novel tool to support this work. The examples presented demonstrate its potential to inform efforts to mitigate the risk of a clinically significant incident in-flight and reduce the impact of such incidents where these efforts do fail. The Bowtie provides a framework for identifying and visualizing measures at all stages of event progression, from IFME prevention through to outcome mitigation. Critically it also provides a framework to review and direct the collection of aeromedical data at each of these stages as well as highlighting potential gaps in current data. Such applications of the Bowtie in aerospace medicine provide a framework for critical analysis of safety management systems around IFMEs, allowing their continuous monitoring and improvement through systematic aeromedical data collection and utilization. Whilst qualitative methods are presented in this work, the Bowtie diagram lays the foundation from which more robust quantitative models can be developed. These evidence-informed probabilistic risk assessment and machine learning-based optimization models would provide data driven risk management strategies, further enhancing safety management within aerospace medicine.

**Learning Objectives**

1. To understand and appreciate the unique benefits of applying Bowtie methodology in the prospective risk analysis and safety management of in-flight medical emergencies at all stages of event progression, from incident prevention through to outcome mitigation.
2. To review current aeromedical data collection and usage in improving the safety management of in-flight medical emergencies.
3. To learn how to construct a Bowtie diagram for aeromedical applications.

Wednesday, 05/25/2022  
Tuscany 5/6

10:30 AM

**[S-46]: POSTERS: HUMAN PERFORMANCE:  
PAN TOPIC LOOK**

Chair: Ray King

**[225] WHY DOES THE INCIDENCE OF LASER ATTACKS ON AIRCRAFT INCREASE DESPITE REDUCED NUMBERS OF FLIGHTS DURING THE COVID-19 PANDEMIC?**

Frank M. Jakobs<sup>1</sup>, Diana Hering<sup>1</sup>, Manuela A. Hoffmann<sup>2</sup>, Christina Waizenegger<sup>1</sup>, Lothar Bressen<sup>1</sup>

<sup>1</sup>German Air Force Centre of Aerospace Medicine, Fürstentfeldbruck, Germany; <sup>2</sup>Federal Ministry of Defense, Johannes Gutenberg-University, Bonn/Mainz, Germany

(Original Research)

**INTRODUCTION:** Laser illumination of civilian and military aircraft by handheld laser devices is still a non-resolved problem in international air traffic. However, according to the available statistics, absolute numbers of incidences did not drop as expected due to the reduced air traffic in the COVID 19 pandemic. This study aimed to calculate the actual numbers of laser illumination incidents relative to uncanceled flights performed during this period. **METHODS:** Statistical data of laser illuminations were collected from the official websites of the US Federal Aviation Authority (FAA), and the German Civil Aviation Authority/Flight Safety Department. (DFS), which records data of military events as well. Data were calculated per million flights and compared to the pre-COVID period of 2018. Comparative analysis was performed between US and German data. **RESULTS:** Absolute numbers of laser incidents within the FAA increased from 5,663 reports in 2018 to 6,213 reports in 2019 and 6,852 reports in 2020. This relates to a 10.3% increase in 2019 and a 20.9% increase in 2020 as compared to the numbers of 2018. Since the numbers of commercial flights significantly dropped during the COVID-19 lock-down, relative numbers of illuminations nearly doubled from 557 per million flights in 2018 to 1,063 in 2020. In German airspace, absolute numbers of incidences went down during the pandemic from 426 in 2018 to 362 in 2019, and 209 in 2020, respectively. Very similar to the US statistics, exclusion of cancelled flights resulted in an increase from 116 to 151 events per million flights in 2020, reflecting a relative change of +30.7%. **DISCUSSION:** Our data confirm a relative increase of laser aircraft illumination events despite of reduced air traffic due to the COVID-19 pandemic in at least two nations with consequent laser monitoring and reporting over the past 10 years. Although it appears unlikely that these results are coincidence, it should be considered that national security and rescue aircraft operations, which might have increased during the pandemic, are commonly not included in commercial cargo and passenger statistics. We conclude that further research is needed before drawing misleading conclusions from these statistics.

**Learning Objectives**

1. The audience will learn about the safety risks of illuminating aircraft by handheld laser devices.
2. The audience will learn about drawing correct conclusions from epidemiological data.

**[226] CAN TELEMENTORING EFFECTIVELY TEACH SURGICAL SKILLS TO MEDICAL STUDENTS AND PROFESSIONALS: THE BENEFIT TO RURAL COMMUNITIES**

Matthew Terry

University of Edinburgh, Edinburgh, United Kingdom

(Original Research)

**INTRODUCTION:** Telehealth has become popular in the COVID-19 pandemic due to social distancing rules and fewer in-person interactions. Surgical care is disproportionately affected by these constraints.



Telementoring – an experienced surgeon (mentor) guiding a less experienced mentee through surgery – allows surgical training from a distance. Research on telementoring is limited. This literature review aims to compare the efficacy of telementoring against non-telementored controls to teach surgical skills to medical professionals. **METHODS:** Four databases (Ovid Medline, Ovid Embase, PubMed, Cochrane) were searched using predetermined criteria to identify 11 studies comparing telementoring to a non-telementored control. The chosen studies were analyzed for procedural length; complications, length of stay & blood loss; ability to complete procedure; multiple choice scores & learning curves; procedural scores; errors; and mentee confidence. **RESULTS:** Results for procedural length were mixed. There were no significant differences in length of stay, complication rates, or blood loss between groups. Telementored groups had greater success in completing procedures, higher multiple-choice scores, and shorter learning curves. Procedural scores increased in telementored groups. Fewer errors were made by telementored groups. Mentee confidence was similar between groups or telementored groups had significantly increased confidence compared to the control.

**DISCUSSION:** Telementoring creates higher surgical success rates than non-telementored controls. It is most beneficial when the mentee has little-to-no experience, few resources to learn a procedure, or a challenging procedure. Telementoring may increase operative times due to communication barriers, which may result in increased blood loss. Telementoring improved procedural performance and decreased errors most when mentees had a low skill level. Mentees were able to learn procedures faster, score higher on multiple choice tests and increase confidence with telementoring. Patients' in-hospital recovery times and the number of unexpected injuries were similar with or without telementoring. Telementoring is an effective way to teach medical professionals and disseminate surgical knowledge. Telementoring is becoming more accessible and affordable, helping rural/remote communities to improve surgeon competence and confidence. Further research should address telementoring barriers and optimize the teaching experience.

#### Learning Objectives

1. Understand how telementoring technology is able to be used in surgical education.
2. Recognize and appreciate the health inequalities and barriers to healthcare that affect rural communities.

### [227] PROPHYLACTIC SPLENECTOMY FOR LONG DURATION SPACEFLIGHT: PANDORA'S BOX OR PANACEA?

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(Original Research)

**INTRODUCTION:** The spleen is a secondary lymphoid organ which maintains lymphocytes and initiates the adaptive immune response. There is debate whether astronauts traveling to space should undergo a prophylactic splenectomy prior to long duration spaceflight. Risks to the spleen during flight include radiation and trauma. However, splenectomy also carries significant risks. **METHODS:** Systematic review of data published over the past two decades regarding risks associated with splenectomies, side effects from splenic irradiation by proton emission, radiation dosage required leading to adverse effects to the human body, and radiation risks to the spleen from long duration spaceflight. **RESULTS:** Acute risks of splenectomy include intraoperative mortality rate of 3% to 5%, mortality rate from postoperative complications of 30%, thromboembolic event of 10%, portal vein thrombosis of 55%, mortality from postoperative pulmonary embolism at relative risk of 4.53. Delayed risks of splenectomy include overwhelming post-splenectomy infection (OPSI) at 42% at 5 years post splenectomy, mortality rate as high as 60% for pneumococcal infections, and development of malignancy with relative risk of 1.53. The risk of hematologic malignancy increases significantly when individuals reach 40Gy of exposure, which is significantly higher than the theorized 0.1Gy from a 20 month round trip to

Mars. However, solar particle events could increase this radiation to as much as 1.4Gy. Lower doses of radiation increase the risk of hyposplenism more so than hematologic malignancy. **DISCUSSION:** For protection against hematologic malignancy, the benefits of prophylactic splenectomy do not outweigh the risks. However, there is a possible risk of hyposplenism from long duration spaceflight. It might be beneficial to prophylactically provide vaccines against encapsulated organisms for long duration spaceflight to mitigate the risk of hyposplenism.

#### Learning Objectives

1. The audience will learn the risks associated with removal of the spleen, or a splenectomy.
2. The audience will learn the risks to the spleen from long duration spaceflight.
3. The audience will understand the risk tradeoffs between splenectomy and in-flight risks.

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

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(Education - Program/Process 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. In all instances a holistic approach must be taken, involving the patient themselves 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.

**COMMON PROBLEMS & FOOTWEAR:** 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 themselves) 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 rationale in the table below. Such footwear recommendations are given based on the assumption that cabin crew have 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.

Biomechanics	During Flight	During Flight	Off Aircraft	Off Aircraft	Orthotics
	Flat Cabin Shoe	Wedge Cabin Shoe	Lower Block Heel Court Shoe	Narrow High Heel Court Shoe	
Lisfranc Injury or Fracture				wearing a small heel 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	addressing underlying foot mechanics, over-pronation or hypermobility with specialised top coat materials to reduce shearing stress must be prescribed

### Learning Objectives

1. The audience will learn about the significance of wearing the correct style of footwear and how it can aid rehabilitation in lower limb musculoskeletal issues.
2. The audience will become more aware of the different types of injury and musculoskeletal issues that may occur in the lower limbs of commercial cabin crew.
3. The audience will understand that wearing particular types of footwear can actually impede the rehabilitation of lower limb musculoskeletal related symptoms.

### [229] A HUMAN FACTORS ANALYSIS OF AIR MEDICAL TRANSPORT ACCIDENTS: THREATS TO SAFETY

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#### (Original Research)

**INTRODUCTION:** Helicopter Emergency Medical Services (HEMS) has grown remarkably since its inception despite evidence arguing against a "Golden Hour". Today, there are approximately 1,515 HEMS operators in the United States, transporting 400,000 patients annually. This paper reports the aggregated results of three investigations using The Human Factors Analysis and Classification System (HFACS) and the predominant threats faced by the HEMS industry. **METHODS:** The results of three studies were combined to provide a clearer picture of threats faced by the industry and whether these threats have changed over time. All accidents reported by the National Transportation Safety Board (NTSB) as HEMS occurring between 1990 and 2018 were coded across 3 separate investigations using HFACS. This resulted in a sample size of 264 accidents. **RESULTS:** From 1990 to 2000 there were 73 accidents identified. Skill based errors (70%) and decision errors (37%) were the highest contributors to unsafe acts. Most fatalities occurred in transit from hospital or home base (76%) in nighttime conditions or IMC. From 2000-2012 there were 147 accidents identified. Perceptual errors (17%) and skill-based errors (11%) were the largest contributors to unsafe acts resulting in fatalities. Overall, 60% of accidents happened at night. Of accidents occurring in transit, 36% were attributed to flight into IMC. From 2012-2018 there were 44 accidents identified. Half of the accidents occurred at night and 7 accidents involved flight into IMC (15%). Most fatalities happened at night (85%). Most accidents were due to skill-based errors (41%) and decision errors (23%). **DISCUSSION:** Studies 1 and 2 revealed that the majority of fatal HEMS accidents are the result of perceptual errors and decision errors while enroute to a patient, with the most fatalities occurring in transit from hospital or home base with dark night or flight into IMC as factors in the majority of these accidents. Results of the third study indicated that accidents as a result of inadvertent flight into IMC were mostly the result of skill-based or decision errors. Despite efforts to mitigate environmental factors over the years, nighttime flying and weather remain a consistent and deadly threat to the HEMS industry.

#### Learning Objectives

1. The audience will learn about how to apply the Human Factors Analysis and Classification System (HFACS) in the analysis of air medical transport accidents.
2. The audience will learn about the predominant threats to crew and patient safety in the air medical transport industry.

### [230] ESTIMATION OF FLIGHT ILLUSIONS AND PERCEPTUAL PROBLEMS CONTRIBUTING TO AVIATION ACCIDENTS CAUSED BY SPATIAL DISORIENTATION

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#### (Original Research)

**INTRODUCTION:** Previous studies have reported that spatial disorientation (SD) is associated with over 25% of aviation accidents. However, few studies have estimated the specific flight illusions and perceptual problems that contribute to such SD-related accidents. The purpose of this study is to organize the definitions of flight illusions and perceptual problems, and to create a simple tool for estimating what flight illusions might have been experienced in aviation accidents caused by SD. **METHODS:** We categorized flight illusions and perceptual problems as described in extant literature, and extracted environmental factors related to visual and vestibular input responsible for these illusions. We then created a simple tool that semi-automatically determines the types of illusions by selecting the presence or absence of these factors. Using this tool, we analyzed 29 aviation accidents in Japan (civilian and military) in which SD was a suspected cause. **RESULTS:** A total of 102 flight illusions and perceptual problems, as described across five previous studies, were classified into 57 types of illusions. In an analysis of 29 aviation accidents, the most frequently categorized SD-related illusion was loss of spatial orientation in bad weather conditions (83%). Featureless terrain was the second most common (41%). **DISCUSSION:** A standardized method of estimating SD-related illusions is needed, since most wellknown classification systems do not include the estimation of specific illusions. These results highlight the specific flight illusions that contribute to SD, and is particularly useful for the prevention of accidents through education and training. Although this study is but one of many attempting to achieve this goal, it is difficult to accurately classify SD illusions when the concerned pilots are deceased. It is desirable to record the pilot's vision and physiological state during the flight and reflect upon the estimation of sensation via the spatial orientation model for more valid estimations in the analysis of SD accidents.

#### Learning Objectives

1. The participant will learn about a new simple tool for the estimation of specific flight illusions and problems contributing to SD accidents.
2. The participant will understand the types of flight illusions and perceptual problems associated with past SD accidents in Japan.

### [231] SPATIAL DISORIENTATION SCENARIOS FOR THE AW159 WILDCAT HELICOPTER WITHIN A SYNTHETIC TRAINING ENVIRONMENT

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#### (Education - Program/Process Review)

**BACKGROUND:** Spatial Disorientation (SD) may result from improper sense of aircraft position, motion, or attitude with respect to the fixed coordinate system of the earth's surface and the gravitational vertical. SD has remained a significant cause of aviation mishaps for military and civilian operations writ large. SD-directed training should enhance aircrew awareness of vulnerability, increase knowledge of preconditions, and reinforce standard mitigation techniques and maneuvers with disorientation. **OVERVIEW:** SD instruction for British Army rotary-wing (RW) pilots begins with initial aviation medicine training that includes classroom academics and disorientation simulation (DISO) prior to starting basic rotary wing flying training. Upon completion of the joint RW Military Flying Training System, pilots move to advanced airframes. For the AW159 Wildcat, in-service SD training continues within a high-fidelity full mission simulator with bespoke scenarios designed to set pre-conditions for and contribute to SD. **DISCUSSION:** Ten separate training scenarios have been jointly developed with multidisciplinary input including aviation medicine, qualified helicopter instructors, and simulation technicians. Uniquely, these scenarios are embedded within other routine simulator periods focused on non-SD training objectives so that crews are not necessarily anticipating SD or solely focused on an expected or pending SD situation. Particulars of these scenarios are of broad academic interest to aerospace medical professionals and specifically provided within this forum for unique perspective and discussion among SD professionals.

**Learning Objectives**

1. Participants will broadly recognize inherent vulnerability, preconditions, and standard mitigation measures with respect to RW SD.
2. Participants will appreciate unique capabilities and challenges presented by SD training through immersive simulation.

**[232] AN EXPERIMENTAL EVALUATION OF GALVANIC VESTIBULAR STIMULATION AS A DISPLAY MODALITY**

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*(Original Research)*

**INTRODUCTION:** While auditory and visual displays dominate information transfer, other sensory modalities, including the vestibular system, have been proposed to reduce operator information load. In galvanic vestibular stimulation (GVS), electrical current signals the vestibular sensors nominally involved with spatial orientation perception and balance. Here, however, we demonstrate the feasibility of communicating non-orientation information. **METHODS:** This research quantified human subjects' ability to distinguish between two GVS cues, as assessed with just noticeable difference (JND) thresholds. Eight participants with no known vestibular dysfunction (5F, 3M, ages 20-26) provided informed consent for protocols approved by the University of Colorado-Boulder IRB. Using a 2-alternative forced-choice task, participants reported which of two bipolar GVS cues had a higher frequency. The first cue was a 50 Hz pedestal cue and the second varied in frequency according to an adaptive staircase. Subjects completed 300 trials between 7 different environmental conditions. The proportion of trials in which a subject reported the second cue to have the higher frequency was plotted against the difference in frequency between second cue and pedestal, and a psychometric curve was fit, providing 1-sigma thresholds. Participants performed standing Romberg and tandem walk tasks while receiving 10 Hz, 50 Hz, or no GVS cues. A Friedman test was performed on the number of missteps a subject made in the eyes-closed tandem walk task. **RESULTS:** There was no significant difference in JND threshold across environmental conditions. Thus, data was pooled across condition, and a single JND threshold was calculated per subject (Avg.: 12.07Hz; Range: 5.42-19.57Hz). All subjects successfully completed standing Romberg and tandem walk tasks in all conditions. In the eyes-closed tandem walk task, GVS was shown to have no significant effect on number of missteps ( $p = 0.37$ ).

**DISCUSSION:** We demonstrated that bipolar GVS cues were distinguishable from one another, robust to different environments, and not destabilizing. By these metrics, we believe that frequency modulated GVS is a viable display modality. Future work includes testing subject ability to distinguish between other current modulations (e.g., polarity, amplitude, duration, etc.), testing subject ability to recall cues and associate cues with meanings, and assessing additional operational environments.

**Learning Objectives**

1. Understand that subjects could differentiate the frequency of GVS cues with an average JND threshold of  $\pm 12$ Hz (range across subjects: 5.4-19.6 Hz) relative to a pedestal cue of 50Hz.
2. Understand that the ability to differentiate GVS cues was robust to walking, standing, sitting, passive motion, and loud background noise.
3. Understand that GVS cues had no significant destabilizing effects on subjects when standing or walking.

**[233] RABIN CONE CONTRAST COLOR VISION TEST REPEATABILITY INDICES**

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*(Original Research)*

**INTRODUCTION:** The repeatability of the INNOVA Systems (Burr Ridge, IL) Rabin Cone Contrast test for normal color vision is reported to be excellent (Chay et al. 2019). However, there is little information available about the test repeatability for a cut-off score of 55 that allows individuals with mild color vision defects to qualify as pilots in the United States Air Force and Navy. Little information is available as to the between-session repeatability for the sensitivity of each eye. The purpose of this study is to determine these values. **METHODS:** Monocular chromatic thresholds were measured for the L-cone, M-cones, and S-Cones. Sixty color-normal (CVN) subjects and 68 subjects with a red-green color vision defect (CVD) participated. Color vision was classified using the Rayleigh color match. Ninety-three percent of the CVNs and 86% of the CVDs returned within 10 to 15 days to repeat the test. **RESULTS:** The between-session AC1 coefficient of agreement regarding normal/abnormal red-green color vision was 0.97 (95% CI of 0.92 to 1.0). The between-session repeatability for the 55 cut-off was lower at 0.88 (95% CI of 0.80 to 0.97). The lower repeatability was primarily due to 45% of the CVD who passed the first session but failed at the second session. Because the between-eye and session differences were not normally distributed, the limits of agreement (LOA) between eyes and the coefficients of repeatability (COR) between sessions were based on the median differences and the 2.5 percentile and 97.5 percentile scores. The median values for the between-eye differences and the between-session differences were all near zero. The CVN between-eye LOAs were -10 to 15 units for the L cone,  $\pm 10$  units for the M-cone and -5.0 to 10 units for the S-cone. The CVN between-session CORs were similar for the respective cone mechanisms. The deutan LOAs and CORs were -30 to 40 units for the L-cone and -45 to 40 for the M-cone. The protan LOAs and CORs were -25 to 60 for the L-cone and -30 to 20 for the M-cone. The S-cone LOAs and CORs were  $\pm 10$  units for both the protans and deutans. **CONCLUSION:** The CVN LOAs were slightly lower than the previous results. The LOA and COR for the CVDs were at least 3 times larger than the CVN values for the L and M-cone stimuli, but similar to the CVN values for the S-cone. This between-session variability could be sufficient to erode the repeatability of the test when using a cut-off score of 55.

**Learning Objectives**

1. Understand the overall repeatability of the Cone Contrast Test for the two pass/fail scores.
2. Understand the differences in the between-eye and between-session limits of agreement.

**[234] SEX-RELATED DISPARITIES IN THE IMMUNE RESPONSE TO TOZINAMERAN AND ITS IMPACT ON AIR TRANSPORTATION**

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*(Original Research)*

**OVERVIEW:** The benefits of high vaccination rates against the novel coronavirus disease (COVID-19) in the context of air transportation include (1) traveler's protection, (2) protection of fellow travelers, and (3) protection of residents at destination or transit stops. However, as vaccination rates increase, unwanted side effects increase. While clinical evidence indicates enhanced immunity in females as compared to males, little is known about the respective differences in vaccination-related side effects. In this study, we investigated the sex-related occurrence of side effects caused by the mRNA vaccine Tozinameran (BNT162b2). Data of 1,065 first-time vaccinated volunteers were retrospectively analysed by the University Medical Center of the University Mainz/Germany using standard statistical software. Of these, 632 (59%) were female, while 433 (41%) were male. Sex-related occurrence rates of vaccine-related side effects were addressed and stratified according to strength and pattern of recorded immune



responses. Group-related differences were analysed by  $\chi^2$ -test, Pearson correlation and exact Fisher's test at 5% significance level. Unwanted side effects were seen in 36% (228/632) of females, while in the male group, only 27% (117/433) of study subjects showed vaccination reactions ( $p=0.002$ ). Substratification revealed local reactions in females in 28% (178/632), as compared to 22% (96/433) in males ( $p=0.032$ ), while systemic reactions in females were seen in 15% (95/632) of cases, as compared to 10% (42/433) in males ( $p=0.012$ ). The most frequent local side effects were inflammatory responses at the injection site, whereas the most frequent systemic reactions were fatigue, headache, and subfebrile body temperature. Our results indicate that Tozinameran-related local and systemic reactions may affect females more than males. This is consistent with previous studies reporting a more reactive female immune system with stronger antiviral response and increased immunity against COVID-19. We suggest that future vaccination strategies using Tozinameran should reflect such sex disparities considering lower dosage and later booster vaccination for females. With emphasis on medical fitness and human performance, this might be the better regimen for vaccination of female aviators as well.

#### Learning Objectives

1. The participant will learn about gender-specific differences in the immune response to vaccination against the novel coronavirus disease (COVID-19), taking into account the impact on air transportation.
2. The participant receives suggestions for future vaccination strategies against the novel coronavirus disease (COVID-19), taking into account the gender differences.

### [235] DEVELOPMENT OF INDIVIDUAL HELMET SYSTEMS – MRI BASED DETERMINATION OF THE CENTER OF GRAVITY OF THE HEAD

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#### (Original Research)

**INTRODUCTION:** Headaches and neck pain are a common problem among military helicopter and jet pilots. Modern helmet systems, which are equipped with an increasing number of sensory systems, are the main contributors to this problem due to increasing overall weight. Individual helmet systems, adjusted to a pilot's particular anatomical conditions represent a promising development. Crucial for the customization, an individual determination of the center of gravity (CG) of the head and neck as well as the calculation of the moments of inertia is needed. In a feasibility study, we therefore investigated whether an individual in vivo determination of the CG of the head was possible using MRI. **METHOD:** MRI images of the head were obtained 5 times consecutively from one subject (male, 30 y) using a modified sequence protocol with a isotropic resolution of 1 mm<sup>3</sup>. Two neuroanatomically experienced radiologists processed all 5 data sets plus a selected data set 5 times. Each voxel was assigned its specific tissue (background, air, bone, muscle, brain, connective tissue, fluid, fat) based on a semiautomated segmentation process using a imaging software (3D Slicer). Multiplied by the specific tissue density, each voxel's own mass could be calculated. A customized MATLAB code generated the individual center of gravity from the obtained mass data and transferred it to a coordinate system. **RESULTS:** The intraoperative and interoperative variability of the two radiologists was determined based on the volume deviation of each segment relative to the total volume. In the 5-fold repeated segmentation of the selected data set, radiologist 1 showed a volume deviation over all segments of 0.94% and max. 3% in the muscle segment and radiologist 2 showed a variability of 0.35% with a max. deviation of 2% in the bone segment.

**DISCUSSION:** We present a new approach to determine the individual head CG using selected MRI data and a dedicated segmentation algorithm and processing code. This method provides one of the basic steps for optimized development of individual helmet systems. Limitations are the required expertise of the neuroanatomists as well as the only indirect representation of bones in MRI. Nevertheless, the first

results showed good reliability and the calculated total masses and CGs are comparable to results from previous cadaver studies. A planned study of over 100 subjects will demonstrate the validity and downstream practicality of the technique.

#### Learning Objectives

1. The participant will be informed about the possibilities of MRI imaging to visualize individual anatomical conditions.
2. It will be shown why it is important to customize new helmet systems to the individual user.

### [236] CURRENT PREVALENCE OF NECK PAIN IN UK MILITARY AIRCREW

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#### (Original Research)

**BACKGROUND:** Neck pain is known to be a potential consequence of military flying associated with exposure to high G, the use of head mounted equipment and the need to achieve unfavourable postures. There is a need to understand the prevalence of neck pain amongst aircrew and identify associated factors in order to tailor mitigating strategies. The NATO HFM RTG 252 on Aircrew Neck Pain Prevention and Management has recently published recommendations to help quantify and mitigate neck pain. In order to allow comparison across nations of prevalence of neck pain in military aircrew a set of core questions were recommended. The aim of this work was to establish the prevalence of neck pain in the UK military aircrew population using the NATO recommended core questions.

**METHOD:** A questionnaire, based on NATO core questions, was developed and distributed to all UK military aircrew via an e-survey in March 2019. Questions on neck pain experienced over the 12 month period prior to the survey together with exercise and activity undertaken outside of flying, platform flown and head equipment worn were asked. The NATO definition of significant flight related neck pain was used. **RESULTS:** 596 responses were received across all aircraft platform types. Significant flight related neck pain was reported by 51% of fast jet (FJ), 17% of FJ trainer, 41% of rotary wing (RW) and 22% of multi-engine aircraft aircrew. 22%, 21% and 8% of FJ, RW and ME respondents respectively perceived neck pain to have an impact on safety during a 'worst-case' flight. Significant associated factors ( $p < 0.05$ ) included Night Vision Goggle (NVG) use in the past 12 months (FJ and ME) and time spent wearing NVGs (RW). Time sitting at work, excluding in the aircraft, was also a significant factor associated with neck pain for FJ aircrew ( $p=0.01$ ). **CONCLUSIONS:** Neck pain continues to be reported by UK military aircrew. For the first time in the UK, duration spent sitting at work has been identified as an associated factor. This may have the most potential to be easily implemented in order to add to the suite of interventions to help address aircrew neck pain.

#### Learning Objectives

1. The audience will understand the prevalence of neck pain in UK fast jet, rotary wing and multi engine aircrew.
2. The audience will understand the factors associated with neck pain in UK aircrew.

### [237] THE SPLEEN IN SPACE: POSSIBLE CONTRIBUTIONS TO ALTERED HEMOSTATIC PHYSIOLOGY AND CIRCULATION IN MICROGRAVITY

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#### (Original Research)

**OBJECTIVE:** To review the literature for information pertaining to splenic involvement in observed alterations in homeostatic physiology and circulation during spaceflight. **INTRODUCTION:** Terrestrially, the spleen filters blood, stores blood products, produces antibodies, and influences

blood volume. To date, studies of splenic physiology related to spaceflight have focused largely on its contribution to immune function, leaving the spleen's possible roles in achieving homeostasis unexplored. The recent findings of in-mission internal jugular deep vein thrombosis and reversed IJV flow highlight the importance of developing a more detailed understanding of circulation and homeostasis in microgravity, in which the spleen may play one or more critical roles. **METHODS:** A literature review of splenic function in microgravity and microgravity analogs was completed. NIH/PubMed and the NASA Technical Reports Server were searched by combining the terms "spleen" and "splenic" with "gravity" or "bed rest" and "head down" in humans and other animal models published in English between 1958 and 2021. Russian and Japanese articles and abstracts available in English translation were also considered. **RESULTS:** 36 full articles and one abstract were returned in the initial search, which was then hand-searched and supplemented by forward and reversed reference and snowball search for a final total of 63 articles. **CONCLUSION:** This review of the literature suggests the spleen may play a key role in hematological changes observed in flight including increased platelet count, reduced RBC mass and longevity, spaceflight anemia, and orthostatic hypotension. Decreased RBC mass could partially be a result of the spleen's erythrocyte quality control function reacting to microgravity. Indirect evidence suggests nominal splenic functions, including central-baroreceptor-driven increased venous, arterial blood sequestration, and sympathetic nervous system down-regulation, may all contribute to observed physiologic responses to rostral fluid shift in spaceflight including orthostasis. Increased platelet count seen in terrestrial splenic stress states are also seen during spaceflight, introducing an intriguing line of inquiry regarding microgravity's potential role in inducing a version of transient splenomegaly followed by a stress-induced platelet release, with associated concern for a concomitant increased risk of venous thromboembolism.

#### Learning Objectives

1. The audience will learn about the nominal hematologic and circulation-based functions of the spleen.
2. Participants will receive the results of a review of the literature discussing the current understanding of how those nominal splenic functions may be altered in spaceflight.
3. Participants will learn about how the spleen's altered functions in microgravity may impact crew health and safety and the possible next steps of investigating mechanisms for further understanding and intervention.

### [238] 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 (VO<sub>2</sub>) 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 VO<sub>2</sub> 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.

Wednesday, 05/25/2022  
Tuscany C,D,E

2:00 PM

### [S-47]: PANEL: EMERGING MEDICAL BEST PRACTICES IN SPACE TRAVEL

Sponsored by ANAHPs

Chair: Annette Sobel  
Co-Chair: Smith Johnston

**PANEL OVERVIEW:** Space operations are exceedingly complex, with growing levels of autonomy and self-reliance. Challenges to human performance and thus the space operational human-system are physiologic and psychologic with vary degrees of extreme conditions as backdrop. Some medical issues may be anticipated, others not, based upon historical data, use of analogues, and improved modeling and simulation. This panel consists of Subject Matter Experts spanning multiple inter-professional communities of commercial and government space travel medicine, across a variety of mission profiles. These communities include, but are not limited to: private commercial space travel companies (Axiom Space, and others), government entities (FAA, NASA), and academic/public-private partnerships (Translational Institute for Space Health at Baylor College of Medicine, UTMB at Galveston). The format of this panel will consist of analyses of actual or anticipated medical challenges, integrated with priorities for science and technology insertion and counter-measure development, and historical analysis. Emerging best practices in this community will be discussed and scientifically/experientially debated among the panelists. The panel will also address areas for future medical consideration and prioritization of space medicine research and technology development, preventive medicine, health maintenance, diagnostics, assessment, and training. Finally, a discussion of the current fora, to include ASTM International, and emerging initiatives available for information-sharing and space medicine community advancement to meet these emerging challenges, will be summarized.

### [240] COMMERCIAL SPACE CLINICAL ASSESSMENT, MEDICAL RESEARCH AND RESIDENCY TRAINING AT THE UNIVERSITY OF TEXAS MEDICAL BRANCH AT GALVESTON

William (Ed) Powers

UTMB Medical Branch at Galveston, Galveston, TX, United States

(Original Research)

**INTRODUCTION:** Historically, medical standards for spaceflight have been established by government space agencies that reduce medical risk by selecting exceptionally healthy people. The commercial space industry now offers spaceflight to individuals with known medical conditions requiring a new level of risk assessment. UTMB is a leader in commercial spaceflight medical assessment and research and it is also the location of the only space medicine focused aerospace medicine residency training program. **METHODS:** UTMB performed medical evaluations for many of the commercial space passengers who have traveled to the ISS on Russian Soyuz spacecraft. Sixteen medical evaluations have been performed and six of those individuals flew to the ISS. UTMB continues to perform medical evaluations for two commercial space companies. UTMB is a charter

member of the Federal Aviation Administration Center of Excellence for Commercial Space Transportation and has received a number of FAA research grants. These projects have focused on various medical issues for commercial space travelers. The current project strives to develop occupational medicine standards for space workers and to determine the appropriate medical tests and medical monitoring required. UTMB's Aerospace Medicine Residency Program includes clinical experience with many of the commercial space companies in order to prepare specialists for the future. **RESULTS:** Several commercial spaceflight clinical evaluation cases will be reviewed in the presentation. The status of the current FAA funded research project will be reviewed and discussed. A brief description of UTMB's training flow for the residency program will also be presented. **DISCUSSION:** UTMB continues to provide medical evaluations for commercial space travelers. Some assessments have led to medical interventions that would not normally have been required in standard medical practice in order to decrease the medical risk for spaceflight. UTMB also continues to perform medical research supported by the FAA. Results from the current study will provide the commercial space industry with guidelines for the evaluation of space workers and reduce the risk of flying those individuals who would have previously been disqualified for flight. Experience with commercial space clinical practice and research allows UTMB to provide training for physicians in the Aerospace Medicine Residency Program which is critical for preparing future space medicine practitioners.

#### Learning Objectives

1. The participant will gain an understanding of the complexity of human performance needs across a broad spectrum of space missions.
2. The participant will learn about advances in science, technology and countermeasures useful to the space medicine community.
3. The audience will gain an appreciation for the opportunities for autonomous-human systems integral to space travel.

### [241] MEDICAL EVALUATION AND ACCEPTANCE OF THE PRIVATE SPACE FLIGHT PARTICIPANT (SFP)

James Vanderploeg

*Self, Granby, CO, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** The desire among individuals to purchase a space flight in the private sector extends far beyond the typical physical, mental, and experience parameters seen in government programs. Medical standards and evaluation criteria for career astronauts in government space programs such as NASA, ESA, and the ISS Partners are very specific and strict. Applying these same standards to private individuals would eliminate many who would be SFPs who could safely undertake a single suborbital or orbital space flight. **DESCRIPTION:** Over the past 20 years a number of private citizens have successfully completed orbital and suborbital space flights, including stays on the International Space Station. Waiting in the wings are hundreds more who expect to undertake a space flight in the near future. Among these individuals exists a broad range of medical issues, advanced age, and physical limitations. The FAA and other organizations have published various guidelines to assist in the development of evaluation procedures, but no regulatory standards exist upon which to base acceptance decisions. The commercial space flight operators have engaged medical teams and developed approaches to evaluate these individuals, assess their medical risk to themselves, to other passengers, and to mission success, and make decisions as to acceptance to fly.

**DISCUSSION:** The flight surgeons and medical advisors engaged by commercial space flight operators have developed and implemented medical questionnaires, examination and evaluation procedures, and decision trees to provide advice and recommendations to the operators on acceptance to fly private SFPs. Among the challenges faced by the flight surgeons conducting these evaluations have been SFPs with multiple chronic medical conditions, advanced age, physical and psychological limitations, and various disabilities. Best practices that have evolved from performing these medical assessments will be discussed as well as

recommendations for the future development of commonly employed procedures across the industry.

#### Learning Objectives

1. The audience will learn about the complexity of medical issues encountered in evaluating private space flight participants.
2. The participant will gain an understanding of the emerging best practices in medically evaluating space flight participants for private space flights.

### [242] MEDICAL SCREENING APPROACHES FOR SPACE FLIGHT PARTICIPANTS – THE FAA PERSPECTIVE

Melchor Antunano

*Federal Aviation Administration, Oklahoma City, OK, United States*

*(Education - Program/Process Review)*

**OVERVIEW:** Human commercial space travel is finally emerging and the medical risks faced by space flight participants (SFPs) must be effectively managed in order to ensure their health and safety. Each SFP is different in terms of age, gender, current health status, and physical fitness. All SFPs must be able to cope with the environmental and operational risk factors of space flight. The relevance of these risk factors will vary depending upon the design of the space vehicle, the vehicle flight profile, the type of flight (suborbital vs orbital), and duration of the flight. The environmental risk factors include weather, wildlife strikes, barometric pressure, ambient temperature extremes, solar and galactic cosmic radiation, microgravity/weightlessness, space debris, and post-emergency landing or post-crash survival issues. Operational risk factors include acceleration profile, flight profile, cabin and/or suit pressurization profile, noise and vibration exposure during flight, breathing air, cabin and/or suit temperature and humidity, physical hazards in the cabin, and impact/crash exposure factors (vehicle crashworthiness, occupant restraint systems, personal protective equipment, and emergency evacuation). After 60+ years of human space flight there is still limited space medicine knowledge/experience regarding non-professional astronauts with a variety of clinically significant pathologies. Space flight is associated with physiological and psychological changes which may cause or worsen a number of pre-existing medical conditions during flight, and may adversely impact a space flight participant's health and compromise his/her safety. US commercial human spaceflight operators are required by the FAA to complete an informed consent process with their SFPs. Operators must disclose for each mission, each known hazard and risk that could result in 1) A serious injury, death, disability, or total or partial loss of physical and mental function; 2) That there are hazards that are not known; and 3) That participation in spaceflight may result in death, serious injury, or total or partial loss of physical or mental function. Operators must present this information in a manner that can be readily understood by prospective SFPs with no specialized education or training, and must disclose it in writing. This presentation will discuss various approaches that have been proposed (with FAA involvement) for the medical screening of SFPs to manage medical risks during space flight.

#### Learning Objectives

1. The participant will be able to understand different approaches to perform medical screening of space flight participant candidates.
2. The participant will learn about FAA's role in the medical aspects of human commercial space transportation.

### [243] TRISH'S ENHANCING EXPLORATION PLATFORMS AND ANALOG DEFINITION PROGRAM: A PLATFORM TO COLLECT, STORE AND RELEASE COMMERCIAL ASTRONAUTS' DATA

Emmanuel Urquieta

*Baylor College of Medicine/Translational Research Institute for Space Health, Houston, TX, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** The Translational Research Institute for Space Health (TRISH) a partner to NASA's Human Research Program has developed



Enhancing eXploration Platforms and Analog Definition (EXPAND), a platform that aims to collect, store, standardize, de-identify and release medical, research and biobanking data from commercial civilian astronauts among multiple spaceflight providers. **OVERVIEW:** With the recent increase in commercial spaceflight activities, the need has arisen to develop a centralized repository to normalize and harmonize the different data from civilian commercial astronauts. Different design reference missions, providers, vehicles and international civilian astronauts makes these efforts challenging. An encompassing program with capabilities to deploy research, collect medical data, centralize biobanking and strict governance has been deployed successfully in one pilot study during the Inspiration 4 mission. In the future, the coded and de-identified data collected from this and future missions will be available to researchers to enhance spaceflight safety and to develop new countermeasures.

**DISCUSSION:** The EXPAND program is based on 3 key components: TRISH/ NASA expertise, commercial spaceflight partners and civilian crew cooperation and consenting. The research deployed through commercial spaceflight providers is optimized to be as unobtrusive and minimal time requirements from crewmembers. Regardless of the nationality of the civilian astronauts, the program includes thorough compliance with privacy and ethical requirements while staying as nimble as possible. The data, biosamples and medical information collected is then harmonized, coded and de-identified. The final goal of this program is to share this data and biosamples with investigators with the end objective of increasing the diversity and number of human spaceflight data available. This is the first step to developing new countermeasures, medical standards and medical evidence for the unique civilian astronaut population. This research is supported by the Translational Research Institute for Space Health (TRISH), funded under NASA Cooperative Agreement NNX16AO69A.

#### Learning Objectives

1. The audience will learn about the challenges of collecting data from commercial spaceflight astronauts.
2. The audience will understand at a general level one approach to harmonize the data collection from a medical and research perspectives using commercial spaceflight providers.
3. The participants will gain a unique perspective on the current state of space biomedical research implemented in civilians flying with commercial spaceflight providers.

Wednesday, 05/25/2022

2:00 PM

Tuscany A

### [S-48]: SLIDES: NECK AND BACK PAIN: ASSESS, QUANTIFY, MITIGATE

Chair: Anthony Turner

Co-Chair: Bethany Shivers

#### [244] FLEXIBLE, SENSORIZED WEARABLES ENABLING RAPID, QUANTIFIABLE ASSESSMENT OF LOWER BACK HEALTH

Kian Moslehi<sup>1</sup>, Xiaoli Zhang<sup>1</sup>, William Price<sup>1</sup>, Behzad Moslehi<sup>1</sup>, Minoru Shinohara<sup>2</sup>, Shane Koppenhaver<sup>3</sup>

<sup>1</sup>Intelligent Fiber Optic Systems Corporation, San Jose, CA, United States;

<sup>2</sup>Georgia Institute of Technology, Atlanta, GA, United States;

<sup>3</sup>Baylor University, Waco, TX, United States

#### (Original Research)

**INTRODUCTION:** Aviation physicians lack a quantifiable, objective method of assessing lower back health when making the critical decision of whether aircrew members are fit to return to duty. Pain is highly subjective and is sometimes minimized by aviators eager to return to flight, which can lead to further injury during aggressive flight maneuvers, a reluctance to engage in aggressive flight maneuvers, or simply a degradation in performance during critical moments of challenging missions.

**METHODS:** A multidisciplinary engineering and physiological research

team led by Intelligent Fiber Optic Systems Corporation (San Jose, CA) is developing a novel method of quantifying lower back health status including pain and muscle function. The innovation is based on the first-ever combination of fiber-optic strain sensors and multiple ultrasound scanners in a flexible, wearable harness that enables patients to perform physical maneuvers while under examination. Computer vision based on advanced artificial intelligence (AI) and machine learning (ML) algorithms utilizes Principal Component Analysis to detect the state change between contraction and relaxation in each muscle. Principal components are extracted for each frame, and the Euclidian distance between principal components of two consecutive frames is used for state detection purposes. Quantitative muscle features related to pain levels, injury status, and/or propensity for re-injury are automatically extracted from the B-mode images of the contraction and relaxation states in each muscle, with advanced image processing techniques. By building a supervised machine learning model, these extracted muscle features can be used as input to predict the pain level and functional status of the patients as model output. **RESULTS:** The team fabricated an engineering prototype and trained its computer vision capability on collected ultrasound videos taken during compound physical movements. We are continuing the research with physicians to rigorously verify the clinical utility of the measurements and refine clinical workflow insertion pathways.

**DISCUSSION:** The innovation will provide breakthrough assessment capabilities to aerospace physicians in making difficult return-to-duty decisions, and will find spin-off opportunities in other physically demanding professions such as construction and logistics, as well as professional sports, which faces a similar criticality in return-to-work risk and reward tradeoff.

#### Learning Objectives

1. The audience will learn of cutting-edge research into enhanced health assessment capabilities to guide return-to-work decision-making.
2. The audience will learn how artificial intelligence and machine learning are enabling computer vision systems to enhance measurement of previously subjective factors including pain and muscle condition.

#### [245] LOW BACK FATIGUE FROM PROLONGED 'HELO-HUNCH' SEATING WITH AXIAL LOAD

Peter Le, Charles Weisenbach

Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, United States

#### (Original Research)

**INTRODUCTION:** Military helicopter aviators report a high prevalence of low back pain (LBP) as one of the issues associated with prolonged seating in a 'helo-hunch' posture. A potential mechanism for LBP is muscle fatigue from constant low levels of muscular activation for stabilization in non-neutral postures. Over time, the oxygen content declines in the musculature, thereby affecting oxidative metabolism leading to increased muscular coactivation, fatigue, and eventually LBP. Axial loading from survival gear may also exacerbate the postures, thereby accelerating fatigue. The aim of this study was to evaluate muscle fatigue through Near-Infrared Spectroscopy (NIRS) as a function of changes in localized muscle oxygenation during prolonged 'helo-hunch' seating with a simulated axial load. **METHODS:** Twenty subjects (10 M, 10 F) participated in the study. Subjects sat for three continuous hours in a simulated helicopter seat while wearing a 20lb weighted vest to simulate aviator equipment. NIRS sensors were placed bilaterally on the lumbar erector spinae and calculated as a relative change in tissue saturation index (TSI) in 30-minute time blocks. **RESULTS:** Statistically significant ( $\alpha=0.05$ ) decreases in mean TSI were observed in the right erector spinae (RES) and left erector spinae (LES) for time ( $p<0.0001$ ). The largest changes were seen between the 30-60-minute block relative to the 0-30-minute block (RES=-0.72%; LES=-0.77%), followed by the 60-90-minute block relative to the 30-60-minute block (RES=-0.28%; LES=-0.29%). **DISCUSSION:** Localized muscle oxygenation decreased in the low back as a result of prolonged sitting the 'helo-hunch' posture, which may be an indicator of fatigue and precursor to LBP. Findings from this study inform a need for further investigations on low back muscle fatigue from prolonged seating with axial loading.

Understanding these changes may provide insights into the interaction of survival gear and postures on aircrew endurance.

#### Learning Objectives

1. The audience will learn how near-infrared spectroscopy may be used to investigate localized muscle fatigue in ergonomics research.
2. The audience will learn how muscle fatigue may be seen through changes in muscle oxygenation over time.

### [246] PREVALENCE OF NECK AND BACK INJURY IN U.S. AIR FORCE PILOTS

Molly Wade, Justin Reed, Derek Haas, Josh Baker, Victor Heh  
U.S. Air Force, Wright-Patterson AFB, OH, United States

(Original Research)

**INTRODUCTION:** Military pilots are exposed to numerous occupational stressors that contribute towards neck and back injury, such as repeated Gz exposure, head-supported mass (helmets, helmet-mounted displays, and night vision goggles (NVG)) and sitting for prolonged periods of time. High performance aircraft (HPA) pilots experience repeated Gz exposure with head-supported mass and have relatively shorter duration missions when compared with non-HPA pilots (i.e. bomber, mobility, reconnaissance) and Remotely Piloted Aircraft (RPA) pilots who have longer mission durations and very minimal Gz exposure. Furthermore, some non-HPA pilots use extra head-supported mass depending on the mission, which may contribute to neck and back injury. How the stressors of different mission sets contribute to spinal injury is yet to be fully elucidated. The purpose of this study was to investigate the current prevalence of spinal medical encounters for various occupational exposure types. **METHODS:** A cross-sectional retrospective analysis of active-duty United States Air Force (USAF) pilots M2 medical records was conducted to determine the prevalence from 2018-2019 in four groups of pilots: HPA pilots, non-HPA pilots that wear NVGs, non-HPA pilots whom do not wear NVGs, and RPA pilots. Prevalence was defined as documentation in the medical records of at least one spinal encounter among USAF active duty pilots in the two-year cohort. Univariate associations between pilot characteristics and occurrence of spinal injury were determined using Chi-square test of independence or Fisher's exact test. Adjusted odds ratios and confidence intervals were calculated utilizing logistic regression. **RESULTS:** The total number of pilots in the cohort was 13,219. The prevalence of at least one spinal medical encounter in the study period for the entire cohort was 27.9%; while HPA pilots, non-HPA pilot who use NVGs, non-HPA who do not use NVGs, and RPA pilots had a prevalence of 39.7%, 24.6%, 24.1%, and 24.1% respectively. Neck injury in particular was significantly higher than expected in HPA pilots. **DISCUSSION:** The primary finding in this study is that HPA pilots are at a higher risk for neck and back injury than non-HPA with NVGs, non-HPA, and RPA pilots. Understanding the relationship between occupational stressor exposure and the resulting injury risk is an important step in developing effective injury prevention programs specific to the unique operational demands of each mission set.

#### Learning Objectives

1. The audience will learn about neck and back injury rates found in medical records in various pilot groups.
2. The audience will learn about which factors and/or mission sets increase the relative risk of neck and back injury.

### [247] PROPOSED FIGHTER AIRCREW INITIAL EVALUATION TOOL

Abigail Santek, Robert Russell, Nicholas Carabello, Michelle Schneider  
Nellis AFB, Las Vegas, NV, United States

(Original Research)

**INTRODUCTION:** A human performance initiative was installed into fighter squadrons to address chronic neck & back pain. Fighter aircrew

movement map was developed to evaluate aircrew in & out of their high-intensity work environment. The current contract movement screen, the Functional Movement Screen™, looks at an individual's weight-bearing movement on the ground. Nellis' success in identifying trends in movement patterns has inspired a further in-depth study to validate FAMMS' effectiveness & accuracy as a movement screening tool.

**METHODS:** For in-jet measurements, aircrew wore all equipment and set up his flying environment. Postural measurements were taken of hip, thoracic spine, & head position. Active range of motion (RoM) of cervical spine rotation were taken with a goniometer. This process was done in and out of the jet, with and w/o the helmet. A hand-held dynamometer was used to measure strength of the upper anatomy. McGill core testing was used to test core endurance. Neck flexion & extension endurance protocols were used to test the endurance of neck musculature.

**RESULTS:** Initial results from 68 pilots showed specific MDS patterns & identified areas of weakness in the middle & lower fibers of the trapezius rather than isolated within the cervical musculature. Consistent deficiencies in cervical ROM in & out of the jet also found. A subjective increase in forward head posture was noted. The largest musculature strength asymmetries were located in the middle & lower trapezius as well as both endurance metrics. F-35 showed the most dynamic results. Group average measurement results for 12 volunteer pilots are as follows: Cervical RoM, in jet, w/o and with helmet 69° and 68°. Cervical RoM, out of jet, w/o and with helmet 72° and 73°. For strength measurements, shoulder internal rotation had 19% asymmetry when compared left to right. Middle trapezius had 11% asymmetry, lower trapezius had 17% asymmetry & neck lateral flexion had 15% asymmetry. **DISCUSSION:** Self-selection sample bias & small sample size make broad conclusions about data collected inappropriate. However, results show that this measurement tool could objectively provide baseline assessment for evaluating flight environment impacts on musculoskeletal systems as well as in aircraft mobility capabilities. An additional component will be added into the evaluation to examine the lower/posterior chain. Due to interest, the data population continues to grow.

#### Learning Objectives

1. The participant will be able to understand the study design & rationale for a specific fighter air crew evaluation.
2. The audience will learn about the different effects each MDS has on a pilot and how that correlates to the pain patterns each pilot feels. Fighter air crew work in a unique environment with unusual demands. To appropriately evaluate those stressors, fighter aircrew need an evaluation that fits their environment.
3. The audience will learn specifically how the 5th gen and legacy MDS affects pilots postural position and pain patterns.

### [248] REDUCING THE OPERATIONAL, MEDICAL, AND FINANCIAL BURDEN OF NECK AND BACK PAIN AMONG NAVAL AIRCREW

Bethany Shivers<sup>1</sup>, Daniel R Clifton<sup>2</sup>, Sarah de la Motte<sup>3</sup>

<sup>1</sup>Naval Air Warfare Center Aircraft Division, Naval Air Station Patuxent River, MD, United States; <sup>2</sup>Uniformed Services University, Henry M. Jackson Foundation for the Advancement of Military Medicine, Bethesda, MD, United States; <sup>3</sup>Uniformed Services University, Bethesda, MD, United States

(Education - Program/Process Review)

**BACKGROUND:** Neck and back pain (N&BP) have significant effects on operational capabilities and medical readiness of aircrew resulting in lost duty days, attrition, and long-term disability. Naval Aviation leadership and fleet aircrew have requested materiel and non-materiel strategies for reducing such N&BP in aircrew. Historically, efforts to identify, prevent, and/or treat N&BP have been hampered by factors such as aircrew resistance to reporting pain, lack of 'field-expedient' diagnostic tools, and a lack of strategies meeting aircrew's specific needs. This presentation will discuss the consolidated efforts of the Uniformed Services University's Consortium for Health and Military Performance (USU-CHAMP) and the Naval Air Warfare Center Aircraft Division (NAWCAD) to improve identification,

prevention, and treatment of N&BP among Naval aircrew. **OVERVIEW:** USU-CHAMP has a JPC-5-funded research effort designed to identify factors that will improve assessment, prediction, prevention & management of back pain in US Navy and Marine Corps aircrew. The USU-CHAMP effort aims to 1) improve the assessment and prediction of back pain using psychosocial measures, as well as an objective assessment of back function using a novel motion assessment device; and 2) improve the design and implementation of prevention and management strategies for back pain. The NAWCAD Naval Aircrew Conditioning Program (NACP) will implement a program consisting of three components to address N&BP: 1) an evidence-based aircrew-specific holistic education and exercise intervention program tailorable to unique individual and operational needs; 2) on-site athletic training/strength and conditioning specialist staff to develop trust with aircrew allowing more serious N&BP prevention through early intervention; and 3) easy to access health- and performance-related facilities and equipment. **DISCUSSION:** The consolidated effort has the potential to reduce the operational, medical, and financial burden of N&BP among aircrew. Written support for the effort has been provided by commanders of the Naval Safety Center, the Naval Aviation Warfare Development Command (NAWDC), and the US Naval Academy (USNA), with NAWDC and USNA committing to serve as pilot locations. This will be a multi-year, multi-site effort at Naval Air Station (NAS) Patuxent River (Patuxent River, MD), NAS Fallon (Fallon, NV), and the USNA (Annapolis, MD).

#### Learning Objectives

1. The audience will learn about on-going efforts to address neck and back pain in US Naval Aircrew.
2. The audience will learn about the challenges and historical roadblocks associated with wide fielding of a neck and back pain mitigation strategy.

**Wednesday, 05/25/2022**

**2:00 PM**

**Tuscany B**

### [S-49]: PANEL: HEALTH COMPREHENSIVE MEDICAL READINESS PROGRAM FOR FLIGHT SURGEONS

**Chair: Talib Ali**

**Co-Chair: Douglas Files, Jodie Timberlake**

**Panel Overview: BACKGROUND:** Flight surgeons perform a variety of operational tasks in addition to clinical medicine. **Overview:** The current panel will discuss how flight surgeons perform shop visits, work with fatigue countermeasures, give human factors briefings and perform food and water safety visits. **DISCUSSION:** This panel will present up-to-date information on best practices in performing non-clinical aerospace medicine tasks. Flight surgeons from different backgrounds will compare and contrast what they have learned. Through this process U.S. Air Force flight surgeons will complete requirements of the Comprehensive Medical Readiness Program for flight surgeons. Acting as ambassadors they will take this information back to their base and share it with colleagues.

#### [249] HEALTH FATIGUE COUNTERMEASURES

Kallyn Harencak<sup>1</sup>, Douglas Files<sup>2</sup>, Jodie Timberlake<sup>2</sup>

<sup>1</sup>Joint Base Andrews, Prince Georges County, MD, United States; <sup>2</sup>U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

**BACKGROUND:** Aerospace medicine professionals sustain maximal aviator performance. One key issue in this field involves the use of medication to improve operator performance. Flight surgeons may prescribe hypnotics to help aviators sleep prior to a sortie and in special circumstances prescribe stimulants to improve performance during critical phases of flight. This presentation will instruct aerospace medicine

professionals in the proper usage of performance-enhancing medication for aviators. **OVERVIEW:** Aerospace medicine professionals study physiologic effects and risks of flight. In order to ensure mission completion and individual well-being flight surgeons sometimes prescribe medication for use. At times, hypnotics assist aircrew to sleep prior to a mission while other medications improve pilot alertness during critical phases of flight. This program will update flight surgeons on medical and other fatigue countermeasures. **DISCUSSION:** The U. S. Air Force requires annual training regarding the use of performance enhancing medication which this session can provide. Many other services also use performance-enhancing medication. This program will demonstrate potential techniques and will renew participants' requirements for the Comprehensive Medical Readiness Program (CMRP).

#### Learning Objectives

1. Consider non-pharmaceutical measures for fatigue avoidance in operational and other aviation settings.
2. Discuss the particular features of using pharmaceuticals for military operations.
3. Renew Comprehensive Medical Readiness Program requirements for the flight surgeon career field.

#### [250] HEALTH THROUGH WORKSITE SHOP VISITS

Jodie Timberlake, Douglas Files

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

**BACKGROUND:** Aerospace medicine professionals help maintain the well-being of various populations supporting flying missions. Performing industrial hygiene shop visits – particularly with industrial hygienists - do just that. This presentation will assist aerospace medicine professionals to maintain currency by participating in a virtual industrial hygiene shop visit. **OVERVIEW:** Changing guidelines and standards make it challenging for individuals to maintain currency in readiness areas. This program will update aeromedical professionals on how to perform shop visits. Participants will participate in a virtual inspection, emphasizing potential toxic chemical exposures. They will also discuss what to seek besides toxic substance exposures, and how to pass useful knowledge to the workers. **DISCUSSION:** Industrial hygiene shop visits may be performed by occupational health specialists in their efforts to affect the safety of employee populations. These shop visits are also common practice in military settings. AsMA attendees will take back to their practice the latest guidelines, tips, and techniques for performing a shop visit as well as an understanding of the importance of the shop visit to workers' health.

#### Learning Objectives

1. Review updates on the flight surgeon task of performing shop visits as part of an occupational medicine program.
2. Discuss best practices for occupational medicine shop visits with other participants.
3. Renew USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (MCRP).

#### [251] HEALTH HUMAN FACTORS BRIEFINGS

Jeffrey Lawson<sup>1</sup>, Jodie Timberlake<sup>2</sup>, Douglas Files<sup>3</sup>

<sup>1</sup>88th Medical Group, Wright-Patterson AFB, OH, United States; <sup>2</sup>U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, Ohio, United States; <sup>3</sup>U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

**BACKGROUND:** Aerospace medicine personnel present briefings regarding health, safety, human factors, etc. to aircrew and other staff. This presentation will assist professionals to maintain readiness by participating in a human factors briefing. **OVERVIEW:** It is often useful for flight surgeons to present medical talks to aviators. These briefings can occur during initial



flight training, safety meetings, or after aircraft crashes. This program will reinforce techniques to help flight surgeons present human factors topics by providing an opportunity for individuals to participate in a human factors briefing scenario. **DISCUSSION:** Aerospace medicine professionals often present human factors briefings as part of their work. Our role in the aviation community encompasses promoting health and safety in the communities we serve. The U.S. Air Force has determined that currency in human factors briefings should be performed on a recurring basis. Attendees will discuss the factors regarding how to improve briefing styles.

#### Learning Objectives

1. Discuss best practices regarding briefing styles and how to talk to aviators.
2. Participate in cross-talk about aircraft mishap issues and how to brief on this type of issue.
3. Renew USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (MCRP).

### [252] HEALTH THROUGH FOOD AND WATER SAFETY

Mike Lang, Douglas Files, Jodie Timberlake

*U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States*

#### (Education - Program/Process Review)

**BACKGROUND:** Aerospace medicine professionals participate in public health and preventive medicine operations. Performing sanitation or food/water vulnerability assessments are often assigned tasks. This presentation will assist aerospace medicine professionals to maintain currency by participating in a virtual food/water vulnerability inspection. **OVERVIEW:** Aerospace medicine professionals take responsibility for the safety, health, and well-being of their populations. Flight medicine experts perform sanitation and food/water vulnerability assessments in order to ensure mission completion and flying safety. This program will update aeromedical and allied professionals on sanitation and food/water vulnerability inspection issues through individuals participating in a virtual inspection regarding a food safety/epidemiology case. **DISCUSSION:** Food and water vulnerability inspections should be performed regularly at airfields and other workplaces. Lapses can affect mission completion and flying safety. This session will give preventive medicine and occupational health personnel an opportunity to learn the latest guidelines in how to perform these inspections. International professionals will gain insight into United States food standards and how performing these inspections might positively affect airfield safety and health in their own countries. Professionals from all countries will benefit from these food, and water inspection cases.

#### Learning Objectives

1. Discuss best practices regarding food safety and water safety, particularly in a military setting.
2. Discuss best practices regarding food safety and water safety, particularly in a military setting.
3. Renew USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (MCRP).

**Wednesday, 05/25/2022**

**2:00 PM**

**Tuscany F**

### [S-50]: SLIDES: HEAD & HEART: TOPICS ON NEUROLOGY & CARDIOLOGY

**Chair: Denise Baisden**

**Co-Chair: Phillip Souvestre**

### [253] CLINIC CASE: OPTIC NEUROMYELITIS IN A CIVIL AVIATOR

Patricia Barrientos<sup>1</sup>, Giancarlo Conde<sup>2</sup>, Alexandra Mejia<sup>3</sup>, Johana Giraldo<sup>3</sup>, Maria Angelita Salamanca<sup>1</sup>

<sup>1</sup>Aerocivil - Civil Aviation Authority of Colombia, Bogotá, Colombia;

<sup>2</sup>Universidad de Cartagena, Cartagena, Colombia; <sup>3</sup>National University of Colombia, Bogotá, Colombia

#### (Original Research)

**INTRODUCTION:** The optic neuromyelitis is an inflammatory and autoimmune illness of the central nervous system. It is characterized by attacks of optic neuritis and myelitis, being able to produce blindness, great neurological disability and even the short term death. Some years ago it was considered as a form of multiple sclerosis. Currently, it is considered a different disease, on the basis of the clinical, imaging, serology and immunopathology profile. Until the moment an effective treatment doesn't exist, the therapy is centred in the treatment of the acute attacks, the medical prevention of the complications and the rehabilitation. It is important to analyze the crew member possibilities under this condition to return to flight, managing the safety risk. **METHODS:** Here in it is presented the case of a man of 27 years old male patient, aviator. He is reported based on his clinical findings which began with cervical pain associated with paresthesias in hands and lower limbs. Finally diagnosed and treated as a seronegative optic neuromyelitis spectrum disorders: antimog, medically controlled, autoimmune etiology. **RESULTS:** The case was reviewed and discussed at a medical board in order to decide a waiver possibilities. **DISCUSSION:** This article is a revision of this not very common illness, considering aeromedical implications and the requirements for making decisions regarding about psychophysical fitness and the possibilities for giving a waiver to safety sensitive aeronautical personnel.

#### Learning Objectives

1. The audience will be able to understand the aeromedical considerations to decide about risk and aviation safety when a crew member has this kind of neurological conditions.
2. The audience will be able to understand how the medical and scientific advances play the role to change the aeromedical considerations about fitting to fly.

### [254] MULTIPLE SCLEROSIS IN CIVIL AVIATORS: CASE SERIES

Johana Giraldo<sup>1</sup>, Giancarlo Conde<sup>2</sup>, Alexandra Mejia<sup>1</sup>, Maria Angelita Salamanca<sup>3</sup>, Patricia Barrientos<sup>3</sup>

<sup>1</sup>National University of Colombia, Bogotá, Colombia; <sup>2</sup>Universidad de Cartagena, Universidad Rafael Nuñez, Cartagena, Colombia; <sup>3</sup>Aerocivil - Civil Aviation Authority, Bogotá, Colombia

#### (Original Research)

**INTRODUCTION:** Multiple sclerosis (MS) is a CNS disease, with different phenotypic and variable course, demyelinating, chronic and autoimmune that progressively affects the individual, compromising their occupational and social role. The aim is to make known the atypical presentation in flight pilots and the considerations by aeronautical regulation in Colombia for patients with MS. **METHODS:** A case series is reported, four patients with MS, aged 33, 38 and 44 years respectively. 33-year-old male, manifestation of August 2019, with sensory and cervical symptoms, high lesion load, treated with alemtuzumab. 38-year-old female, begins in March 2020, with sensory symptoms in legs and genitals, high lesion load, with lesions in different CNS topographies, ocrelizumab is indicated with a favorable response and remission of symptoms. Male 44 years old, beginning 2001, with episodes of optic neuritis and outbreaks of central sensory and motor symptoms, required initial management with interferon B1 a, changed to fingolimod, due to persistence of new demyelinating plaques and new events, management of high lesion load is indicated with ocrelizumab. **RESULTS:** All the four cases were reviewed and discussed individually in medical boards, the aviation safety risk was taken into account to consider granting a waiver. **DISCUSSION:** MS is of unknown cause. In Colombia it is an orphan and disabling disease. The consideration could be to fly with a operational limitations that allow aviation safety risk mitigation and periodic controls by neurologist which must be report complications.

**Learning Objectives**

1. The audience will be able to understand how the medical and scientific advances play the role to change the aeromedical considerations about fitting to fly.
2. The audience will be able to understand the aeromedical considerations to decide about risk and aviation safety when a crew member has this kind of neurological conditions.

**[255] TAKOTSUBO SYNDROME IN AN AIRCREW**

Sarita Dara, Kathy Ferrier, Dougal Watson

Civil Aviation Authority of New Zealand, Wellington, New Zealand

**(Education - Case Study)**

**INTRODUCTION:** The case report outlines the aeromedical assessment of a pilot who presented with new ECG abnormalities during aviation medical assessment that were attributed to Takotsubo syndrome. **BACKGROUND:** Takotsubo syndrome also known as "broken heart syndrome", "stress cardiomyopathy" and "Apical ballooning syndrome" can present with a range of features including transient left ventricular dysfunction and ECG changes that mimic acute myocardial infarction. **CASE PRESENTATION:** A 59 y old male pilot presented to his aviation medical examiner for renewal of his medical certificate. He was recently made redundant from his airline job. His ECG showed new widespread T wave abnormalities suggesting possible anterior ischemia. He reported no symptoms and there was no past history of any cardiac problems. He had been under significant stress in the preceding weeks due to job loss and the impact of COVID -19 pandemic on the aviation sector. Further cardiac assessment was undertaken. Echocardiogram showed normal left ventricular size and function with no wall motion abnormalities. On exercise testing he completed approx. 9 minutes of stress electrocardiography achieving 10.2 METS, stopping at Stage 3 Bruce Protocol. Resting ECG showed T wave inversion, which normalised with exercise and no ST changes were noted, test was negative for ischaemia. CT Coronary Angiogram showed elevated calcium scores and evidence of mild to moderate coronary artery disease. Follow up ECG approximately 3 weeks later was reported by the Cardiologist as virtually normal with some late T wave changes in lateral chest leads. Also Cardiac MRI was done which showed normal heart size and function with no regional wall motion abnormalities and no evidence of cardiac scarring to suggest previous myocardial infarction or any concerning pathology. Given the transient widespread ECG changes, the possible explanation for his presentation was noted to be Takotsubo syndrome, in the context of the loss of occupation and its financial and social ramifications. We note that the pilot did not strictly meet the clinical diagnostic criteria for Takotsubo Syndrome. He was eventually returned to flying with full Class 1 and 2 privileges. **DISCUSSION:** Takotsubo syndrome is an uncommon condition. This case highlights possible Takotsubo Syndrome in an aircrew who was completely asymptomatic but with known stressors and provides an overview of clinical considerations for aeromedical disposition.

**Learning Objectives**

1. Have a better understanding of the clinical approach and diagnostic criteria for Takotsubo syndrome.
2. Learn from this unique case about the approach taken to consider aeromedical certification.

**[256] A REVIEW OF CORONARY ARTERY DISEASE RISK STRATIFICATION IN US MILITARY AVIATORS: EXPANDING MILD- AND MODERATE-RISK GROUPS**

Caleb James<sup>1</sup>, Timothy Crawford<sup>2</sup>, Edwin Palileo<sup>1</sup>, Eddie Davenport<sup>1</sup>

<sup>1</sup>U.S. Air Force, Wright Patterson AFB, OH, United States; <sup>2</sup>Wright State University Boonshoft School of Medicine, Dayton, OH, United States

**(Original Research)**

**INTRODUCTION:** Cardiovascular disease is the leading causes of morbidity and mortality in industrialized nations. Previous aeromedical literature has used annualized risk of an event to define three groups of mild (<1%), moderate (1-3%), and severe (>3%) risk. When applied to those with coronary artery disease (CAD), aggregate stenosis groupings of 1-49% were considered mild risk, 50-119% were considered moderate risk, and >119% were considered severe risk. Current recommendations are to allow unrestricted flying in mild-risk individuals, restrict moderate-risk individuals to non-high-performance flight, and disqualify severe-risk individuals. The purpose of this study is to determine if aggregate risk groupings can be safely broadened. **METHODS:** Aggregate stenosis data was obtained via left heart catheterization in 1501 male military aviators who were screened as high-risk for CAD on annual screening physical between 1971 and 2000. Demographics, history, labs, and vital signs were obtained prior to catheterization. Individuals were followed to cardiac event or termination of the study. The four experimental risk groups were defined as 0% stenosis, 1-95% aggregate with no single vessel stenosis (SVS) >70%, >95% aggregate with no SVS >70%, and any SVS >70%. **RESULTS:** Annualized risk of cardiac event for groups was <0.1%, 0.6%, 2.7%, and 3.8%, respectively. Experimental groupings, family history of CAD, and BMI were independent risk factors for 10-year cardiac event risk. **DISCUSSION:** Expanding the upper limit of the mild-risk aggregate stenosis grouping from 50% to 95% appears to safely broaden unrestricted flight duties in aircrew with CAD. Expanding the moderate-risk group to include all individuals with >95% aggregate with no SVS >70% did increase the annualized risk, but maintained the risk under 3%. This increase in risk was mostly due to regrouping those with 50-95% aggregate into the mild-risk category.

**Learning Objectives**

1. Understand the risk of cardiac event associated with aggregate stenosis groupings.
2. Identify and stratify aviators at-risk for cardiac event in clinical practice.

**[257] CARDIOVASCULAR RISK ESTIMATION IN CIVIL AIRCREW: AN OBJECTIVE ANALYSIS**

Devdeep Ghosh<sup>1</sup>, SS Rao<sup>2</sup>

<sup>1</sup>Institute of Aerospace Medicine, Bangalore, India; <sup>2</sup>AFCME, New Delhi, India

**(Original Research)**

**INTRODUCTION:** Early detection of cardiovascular morbidity in aircrew is possible due to routine medical evaluation. It depends on age, ethnicity, demography and life style. Risk of sudden in-flight incapacitation is closely related to pre-existing cardiovascular pathology. It is the most common reason of grounding an aircrew. Bringing objectivity during routine evaluation of cardiovascular status will help to screen the aircrew who needs special attention and help the individual to know his present cardiac status. **METHOD:** A cross sectional study was carried out over three months amongst 213 civil aircrew with mean age 36 years (Indian male: 35.6±11.59 years, Indian female: 27.9±4.46 years, Foreign pilot: 46.3±13.27 years) who have reported to Institute of Aerospace Medicine for medical examination. ASCVD risk through pooled cohort equation as well as relevant metabolic risk factors were estimated and analyzed. **RESULT:** Amongst 198 Indian civil aircrew, predicted 10 years ASCVD risk was 2.6±2.40% and lifetime risk was 28.6±14.02%. In 15 foreign pilots (All male), predicted risk is higher than Indian aircrew with 10 years estimated risk 6.2±3.83% and lifetime risk 42.9±6.77%. Indian male and female aircrew have low lifetime predicted risk (<39%) in comparison to foreign aircrew. Amongst male Indian pilot with high 10 years risk, 50% are active smoker and all are occasional alcohol consumer. Amongst male Indian pilots with high lifetime risk, 25% are active smoker and 60% are occasional alcohol consumer. Female aircrew with high lifetime risk are occasional alcohol consumer. Amongst foreign aircrew with high 10 years risk, 40% are active smoker and 40% are occasional alcohol consumer. Whereas, in high lifetime risk group, 27.27% are active smoker and 66.67% are occasional alcohol consumer. **DISCUSSION:** ASCVD scoring gives an excellent platform for objective analysis of cardiovascular status to predict long term

cardiovascular morbidity and mortality. It also recommends necessary preventive measures. Instead of single factor, individual's age, modifiable risk factors viz. smoking, alcohol consumption as well as blood pressure, BMI, WHR, ethnicity have been found to have cumulative role to adversely affect cardiovascular health status. The study aimed at quantifying cardiovascular risk factors as an evidence based focussed preventive approach for civil aircrew to identify individual at risk and stress upon the preventive intervention.

#### Learning Objectives

1. The audience will understand the fact that bringing objectivity during routine evaluation of cardiovascular status will help to screen the aircrew who needs special attention and help the individual to know his present cardiac status.
2. The audience will understand that ASCVD risk scoring gives an excellent platform for objective analysis of cardiovascular status to predict long term cardiovascular morbidity and mortality. It also recommends necessary preventive measures.

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

Denis Bron, Thomas Syburra

Aeromedical Center, Duebendorf, Switzerland

(Original Research)

**INTRODUCTION:** Family history is a major 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 analyse 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. More studies are needed.

#### Learning Objectives

1. Learn about the current impact of genetic testings in atherosclerotic.
2. Learn about the current genetic testing options in atherosclerotic diseases.
3. Learn about possible preventive measures in atherosclerotic diseases for flight crew.

Wednesday, 05/25/2022

Tuscany 3

2:00 PM

### [S-51]: PANEL: DEVELOPING AN EXTREME ENVIRONMENT MEDICAL SYSTEM – LESSONS FROM THE ORION SPACECRAFT

Chair: Douglas Ebert

Co-Chair: David Reyes

**PANEL OVERVIEW:** NASA's Artemis missions will return to the Moon for the first time since the days of Apollo using the Orion spacecraft as a core transportation element. This panel provides an overview of the development process for the resource-constrained Orion medical system with a review of methods, lessons learned, and applicability to the design of medical capabilities for extreme and austere environments. Topics include modeling approaches to medical system design as well as issues associated with the overwhelming shift towards mobile computing platforms within the miniaturized medical device market. The first panel presentation will provide an overview of the methods used to determine which medical conditions to treat and the resources required. A portion of that work is based on probabilistic risk assessment performed using NASA's Integrated Medical Model, which is the topic of our second report. Due to extreme mass and volume constraints, the team included novel approaches to medical care that leverage mobile health devices (mHealth) and other digital diagnostic devices. The opportunities and challenges associated with incorporation of this new generation of mobile-connected devices are detailed in the next presentation, where we discuss trade-offs amongst NASA requirements, treatment capabilities, mass/volume constraints, and data transmission challenges. In the fourth report, we discuss the integration of medical capability within the vehicle and the broader mission, using the example of medical oxygen. Finally, a contingency scenario is discussed, where we review the medical considerations of a sustained cabin depressurization event. This panel will be useful for those persons planning medical care for extreme environments such as expeditions, far forward deployed military and commercial spaceflights.

### [259] A SEMI-QUANTITATIVE APPROACH TO BUILDING THE ORION SPACECRAFT MEDICAL KIT

David Rubin<sup>1</sup>, Doug Ebert<sup>1</sup>, Chris Haas<sup>2</sup>, James Pavela<sup>3</sup>, Derek Nusbaum<sup>2</sup>, Josef Schmid<sup>3</sup>, Chris Van Velson<sup>3</sup>, David Reyes<sup>2</sup>, David Alexander<sup>3</sup>

<sup>1</sup>KBR, Houston, TX, United States; <sup>2</sup>UTMB Medical Branch, Galveston, TX, United States; <sup>3</sup>NASA, Houston, TX, United States

(Original Research)

**INTRODUCTION:** The Orion spacecraft needs a comprehensive medical system to support its crewmembers during upcoming Artemis lunar missions. Identification of this system's components requires an understanding of mission constraints and likely medical conditions. A combination of modeling, subject matter expertise, and historical analysis was used to define the medical system components. **METHODS:** Medical conditions from NASA's Exploration Medical Conditions List, augmented by subject matter expertise, were ranked based on 1) likelihood of that condition occurring during the mission, 2) the complexity of treating the condition, and 3) the futility of attempting to treat the condition. From this ranking, a "plan to treat" condition list was developed and resources for the diagnosis and treatment of those conditions were identified. A final resource list was determined by including only resources that treated these conditions and met expected vehicle and crew skill constraints. **RESULTS:** Of 216 conditions considered ("best case" and "worst case" of 108 unique conditions), 77 "best case" and 51 "worst case" conditions were selected to be included on the "plan to treat" list. Across these 128 condition cases, 479 unique resources were considered and 139 resources were selected for inclusion in the Orion medical system. **DISCUSSION:** The identification of spacecraft medical capabilities and resources is a function of 1) potential medical events, 2) the ability of crewmembers to use the selected medical resources, and 3) mass, volume, and power constraints dictated by the vehicle and mission. Even a well-provisioned medical system does not guarantee that all medical conditions during a mission can be diagnosed and treated; the goal is to minimize medical risk, recognizing that risk cannot be fully eliminated. The methodology used to identify Orion medical system resources provides flight surgeons with an effective framework on which to make informed resource choices, document decisions, and minimize risk. The outcome of this methodology was not simply a resource list, but a record of the step-by-step decision making and justification process. The process developed during this work can be used



to design medical systems for future missions and may also be useful for the design of medical kits used in other austere environments.

#### Learning Objectives

1. Learn about a semi-quantitative process for identifying medical resources to build medical kits for extreme environments.
2. Learn about spaceflight mission constraints that influence the selection of medical resources.

### [260] ORION MEDICAL KIT DESIGN USING THE INTEGRATED MEDICAL MODEL

Eric Kerstman<sup>1</sup>, John Aellano<sup>2</sup>, Lynn Boley<sup>3</sup>, David Reyes<sup>1</sup>

<sup>1</sup>UTMB Medical Branch, Galveston, TX, United States; <sup>2</sup>MEI Technologies, Houston, TX, United States; <sup>3</sup>KBR, Houston, TX, United States

(Original Research)

**INTRODUCTION:** As the National Aeronautics and Space Administration (NASA) plans for human exploration missions, the mass and volume constraints of new vehicles present challenges in designing medical kits for these missions. A lunar orbital mission designated as Artemis is planned for 2022 using the new Orion vehicle. The Integrated Medical Model (IMM) is an evidence-based decision support tool used to assess mission risk due to in-flight medical events. The IMM was used to inform the preliminary design of a medical kit for the Artemis mission (IMM Service Request S-20180815-406). **METHODS:** The IMM generated optimized medical kits for a 21 day Artemis mission with 4 crew. Since the IMM is baselined to the International Space Station, it was modified to better reflect the Orion vehicle and environment. The IMM optimization routine was set to generate medical kits that maximized crew health within specified constraints. One medical kit had a mass constraint of 20 pounds and no volume constraint. The other medical kit had a mass constraint of 20 pounds and a volume constraint of 0.0137 m<sup>3</sup>. The primary outputs were a list of medical resources for the optimized medical kits and the probabilities of medical events. Additional outputs were Crew Health Index (CHI), the probability of medical Evacuation (EVAC) and medical Loss of Crew Life (LOCL), and influential medical conditions. **RESULTS:** The optimized medical kit with only a mass constraint resulted in a mean CHI of 97.20%. The mean probability of EVAC was 0.0065 and the mean probability of LOCL was 0.0005. The optimized medical kit with mass and volume constraints resulted in a mean CHI of 97.20%. The mean probability of EVAC was 0.0074 and the mean probability of LOCL was 0.0005. **DISCUSSION:** The IMM generated optimized lists of medical resources for the Artemis lunar orbital mission within predefined mass and volume constraints. These lists of medical resources and probabilities of medical events was used to inform the preliminary design of a medical kit for the Artemis mission. Additional subject matter expertise and operational experience was used to develop a preliminary Orion medical kit for this mission. The next step is to use the resources for this preliminary Orion medical kit as input data for the IMM to verify that the resultant CHI and probabilities of EVAC and LOCL are acceptable. Further modifications to the Orion medical kit may be considered based on these results.

#### Learning Objectives

1. The audience will learn about the use of PRA (Probabilistic Risk Assessment) to inform the development of medical systems for remote environments.
2. The audience will learn how the resource constrained environment of spaceflight impacts medical risk.

### [261] TURNING LIMITATIONS INTO OPPORTUNITIES IN THE DEVELOPMENT OF THE ORION MEDICAL SYSTEM: INCORPORATION OF MHEALTH DEVICES

Douglas Ebert<sup>1</sup>, David Reyes<sup>2</sup>, Peter Schneider<sup>3</sup>, Chris Haas<sup>2</sup>, David Rubin<sup>1</sup>, Chris VanVelson<sup>4</sup>, Marcus Higgins<sup>1</sup>

<sup>1</sup>KBR, Houston, TX, United States; <sup>2</sup>UTMB Medical Branch, Galveston, TX, United States; <sup>3</sup>Leidos, Houston, TX, United States; <sup>4</sup>NASA, Houston, TX, United States

(Original Research)

**INTRODUCTION:** Selection of medical devices for the Orion medical system is a complex task which is dependent on the current state of terrestrial technology. In this work we review the interplay between NASA requirements, constraints, and opportunities for synergy during the development of the Orion medical system. **METHODS:** The “plan to treat” list of conditions, and subsequently the medical resource list for the Orion Artemis II lunar flyby mission was completed using semi-quantitative methods. During this process, some medical resources were excluded to comply with mass and volume limits, while other resources applicable to multiple medical requirements were prioritized for inclusion. Choices were also examined considering NASA level of care standards for the Artemis design reference missions. As a means to optimize capabilities in spite of mass and volume constraints, ideas for integration of multiple devices into a single platform were explored, including a ‘hackathon’ challenge which was conducted to generate and evaluate concepts for combining medical devices into a single app-based mobile device (ultrasound, ECG, etc.).

**RESULTS:** The Orion team identified 128 medical conditions that we “plan to treat”, with 139 unique medical resources to address these conditions, including 5 digital diagnostic devices (ECG, otoscope, stethoscope, pulse oximeter, and blood pressure monitor). During selection of these digital devices the team noted that miniaturized medical devices often use mobile device platforms (mHealth), some displaying and transmitting data exclusively via mobile device. Of the 5 initially selected devices, all are capable of mobile connection, one which cannot function without a mobile device (ECG). Furthermore, only one of these devices connects natively to a Windows platform, which is currently the only operating system available on Orion. **DISCUSSION:** Significant savings in mass and volume as well as training and usability improvements can be achieved by leveraging mHealth technologies. However, the platform presents significant challenges for deployment within the Artemis Program including lack of internet connectivity, incompatible operating systems, and radiation concerns. Each of these drawbacks are surmountable with investment in the supporting vehicle architecture, which may become necessary to support the technology trends seen in commercially available medical devices today.

#### Learning Objectives

1. Learn about the opportunities and challenges of leveraging mHealth devices in the development of medical capabilities for austere environments.
2. Learn about the constraints of the NASA spaceflight environment with regards to digital medical device integration.

### [262] EARLY SYSTEMS INTEGRATION STRENGTHENS ORION MEDICAL CAPABILITIES

Christopher Haas<sup>1</sup>, Christopher Van Velson<sup>2</sup>, David Rubin<sup>3</sup>, David Reyes<sup>1</sup>

<sup>1</sup>UTMB, Galveston, TX, United States; <sup>2</sup>NASA, Houston, TX, United States;

<sup>3</sup>KBR, Houston, TX, United States

(Original Research)

**INTRODUCTION:** The Orion spacecraft has significant mass and volume constraints, which limits resources that can be provided for medical use. Sharing of resources between vehicle systems is therefore required to meet design requirements. This presentation will illustrate resource sharing within the Orion vehicle using oxygen as a case study. **METHODS:** Oxygen is stored aft of the crew compartment in the Orion Service Module and can be delivered on-demand through an oxygen port in the Orion Crew Module (CM). The use of oxygen for medical purposes must be balanced against the pressure and flammability limits of the Orion CM. Meeting requirements for use of oxygen for medical purposes during Artemis missions relies on collaboration between multiple vehicle system stakeholders. **RESULTS:** A requirement for medical oxygen availability was included early in the development of the NASA Human Systems Integration Requirements (HSIR), but the challenge of balancing medical oxygen use with the environmental control constraints for total cabin pressure and flammability limits needed resolution. Provision of oxygen to a

crewmember also required an analysis of the mass/volume constraints of the medical kit and which devices were best suited for use in the Orion CM. In addition, a determination was necessary on whether the duration of oxygen use, as constrained by pressure and flammability limits, would be effective in addressing conditions identified as being within the scope of the medical system. As part of this process, alternative methods of oxygen delivery were discussed such as use of the intravascular pressure suit.

**DISCUSSION:** A traditional development flow often designs vehicles first, then introduces human systems integration later in the cycle, putting medical systems at a disadvantage. Early connections between crew health stakeholders and other development teams reduces costs and schedule overruns, while providing the best medical capabilities possible. Logistics planning for austere environment missions should include medical stakeholders from the beginning so that the best medical capability can be provided.

#### Learning Objectives

1. Understand the interplay between different systems to optimize medical capabilities in an austere vehicle environment.
2. Understand the interplay between different stakeholders to optimize medical capabilities in an austere vehicle environment.

### [263] MEDICAL CARE DURING CONTINGENCY SUITED RETURN FOR THE ORION ARTEMIS MISSIONS

Christopher Van Velson<sup>1</sup>, Tina Bayuse<sup>2</sup>, David Rubin<sup>3</sup>, Kevin Rosenquist<sup>4</sup>, Doug Ebert<sup>2</sup>, James Pavela<sup>1</sup>, Derek Nusbaum<sup>5</sup>, David Reyes<sup>5</sup>, David Alexander<sup>1</sup>

<sup>1</sup>NASA, Houston, TX, United States; <sup>2</sup>KBR, Houston, TX, United States; <sup>3</sup>KBR, Asheville, NC, United States; <sup>4</sup>JES Tech, Lino Lakes, MN, United States; <sup>5</sup>UTMB, Houston, TX, United States

(Education - Program/Process Review)

**INTRODUCTION:** If the Orion spacecraft were to suffer an unrecoverable cabin depressurization, the capsule would be uninhabitable; the crew would be required to remain wearing pressure suits for up to 6 days (144 hours) for return to Earth. The medical team needs to predict and manage impacts to crew health during this scenario. **METHODS:** NASA flight surgeons determined a list of likely medical conditions during a 144-hour suited return scenario. Conditions were then ranked according to their medical and mission impact. Considering the constraints of the suit, depressurized cabin, and pharmacologic limitations, NASA pharmacists and flight surgeons developed a matrix of potential medications and delivery methods to address these conditions. Options were presented to Orion Program boards, and solutions were determined based on overall mission risk. **RESULTS:** Skin breakdown, infection, anxiety, insomnia, nausea, vomiting, and other conditions were deemed likely in this scenario. To address these and other conditions, medications and their delivery methods (injection, liquids, crushed pills, unaltered pills, compounding, etc.) were assessed for feasibility and effectiveness. Limitations of the suit, the depressurized environment, coupled with drawbacks associated with altering medication and the stability of compounded medications drove the development of a tool to deliver unaltered pills through the existing suit helmet drink port. The physical dimensions of medications appropriate to the treatment of the indicated conditions were measured, and medications were down-selected based on the dimensions of the helmet port. Medications that treat multiple conditions were preferred. **DISCUSSION:** Due to the constraints of medication administration methods at vacuum, pharmacology, and cost of redesigning the suit system, delivering unaltered pills through the existing helmet port was chosen. This method does not allow treatment to a terrestrial standard of care given the extreme austerity of this contingency, but the goal was simultaneous minimization of medical and overall mission risks. Future drug formulations may improve our limited medication options. The process used to determine the components of care in this scenario demonstrate the interplay between medical and mission constraints, engineering, and risk management, and may be useful for persons designing medical capabilities for extreme survival situations in austere environments.

#### Learning Objectives

1. The audience will learn about the methods used to address crew health during an extreme environment contingency situation.
2. The audience will learn about the important considerations for the stability of medications in spaceflight.

Wednesday, 05/25/2022  
Tuscany 4

2:00 PM

### [S-52]: PANEL: OPTIMIZING TREATMENT PLANS IN AVIATORS AND ASTRONAUTS UTILIZING HEALTHY LIFESTYLE INTERVENTIONS – PART 1

Chair: Andrew Correll

**Panel Overview: INTRODUCTION:** What if we could optimize every treatment plan we prescribe, decide it more collaboratively with patients, get more buy in, empower and energize our patients, and get better and more sustainable results? We can, if we regularly incorporate healthy lifestyle interventions in our treatment planning. **TOPIC:** The literature supports the robust efficacy of healthy lifestyle interventions, even compared to psychotherapy and pharmacotherapy in mental health. Neurology finds healthy lifestyle to be important in its disorders. NASA emphasizes healthy lifestyle in its astronaut corp. All of medicine has outstanding literature support in this area. There typically is a synergistic effect when healthy lifestyle interventions are utilized in a multifaceted treatment plan. At the United States Air Force School of Aerospace Medicine's Aeromedical Consultation Service, we have surveyed our aviators regarding the effectiveness of psychiatric medications, psychotherapy, and healthy lifestyle interventions and all interventions are rated as equally efficacious, even when healthy lifestyle interventions are not typically prescribed as principal treatments. How helpful could healthy lifestyle interventions be if we prescribed them more as first line and augmentation strategies in our treatment plans? **APPLICATION:** This panel will review the helpfulness of healthy lifestyle interventions when incorporated in the treatment plan and culture. We will review our data on USAF flyers, review the relevant literature, describe how NASA utilizes these principles, and invite discussion/ideas on how to improve medical treatment planning utilizing healthy lifestyle interventions.

### [264] SHOULD WE PRESCRIBE HEALTHY LIFESTYLE INTERVENTIONS TO AVIATORS AND ASTRONAUTS?

Terry Correll

U.S. School of Aerospace Medicine, Englewood, OH, United States

(Education - Tutorial/Review)

**INTRODUCTION:** Incorporating healthy lifestyle treatment interventions may be a cost effective and easy way to enhance the efficacy of psychiatric/medical treatment provided to aviators and astronauts. However, does the efficacy of lifestyle interventions in the literature warrant that providers replace precious appointment discussion time about medications and psychotherapy with any discussion of healthy lifestyle choices? **TOPIC:** This panel presents an overview of current research examining what is known about the efficacy of healthy lifestyle behaviors—such as exercise, healthy eating, and sleep interventions—against pharmacotherapy and psychotherapy for common mental illnesses such as depression, anxiety, and PTSD. Analysis from self-reported Likert scales of the beneficial effects of antidepressants, psychotherapy, and healthy lifestyle behaviors from over 100 aviators will be presented. **APPLICATION:** Knowing what treatment options are available clinically can help inform decision-making for the best patient outcomes possible. Knowing that there is reasonable scientific evidence to support prescribing an enjoyable activity like exercise alongside antidepressants can help empower the clinician and treatment plan to be more effective.

**Learning Objectives**

1. Review what treatment options are available clinically that can help inform decision-making for the best patient outcomes possible.
2. Empower the clinician and treatment planning to be more effective knowing that there is scientific evidence to support prescribing enjoyable activities alongside standard treatments.

**[265] RELIGIOUS AND SPIRITUAL PRACTICES AS HEALTHY LIFESTYLE INTERVENTIONS**Justin Bunn*U.S. Air Force, Wright-Patterson AFB, OH, United States**(Education - Tutorial/Review)*

**INTRODUCTION:** Engaging with religious and spiritual practices have been shown to improve coping of individuals diagnosed with chronic physical health conditions, such as chronic pain, cancer, and diabetes. These practices have also been shown to improve mental health outcomes by boosting positive emotions and helping to neutralize negative emotions, while also potentially being a life-enhancing factor and a coping resource. When applied to aviators, these healthy lifestyle factors are likely to be of great benefit across any physical and/or mental health difficulty, while potentially enhancing the performance of aviators by reducing overall levels of distress. **TOPIC:** Koenig (2012) notes both qualitative and quantitative research suggesting that religious and spiritual practices aid individuals in more effectively approaching adversity. He describes both external adversity (difficult environmental circumstances) and/or internal adversity (genetic predisposition or vulnerability to mental disorders). This presentation discusses the possible utilization of religious and spiritual practices as a healthy lifestyle intervention to improve overall physical and mental health.

**APPLICATION:** This presentation will review the potential efficacy of utilizing religious and spiritual practices as healthy lifestyle interventions to improve coping with stressors experienced by aviators, while potentially enhancing their performance through mitigation of stress. It will invite discussion on how these practices might be of benefit and how they might be applied in the aerospace environment. **RESOURCES:** 1. Koenig, H.G. (2012). Religion, Spirituality, and Health: The Research and Clinical Implications. *International Scholarly Research Notices*, 2012, 1-33.

**Learning Objectives**

1. The audience will learn about the efficacy of utilizing religious and spiritual practices as healthy lifestyle interventions to improve coping with stressors experienced by aviators.
2. The participant will learn how these practices might be of benefit and how they might be applied in the aerospace environment.

**[266] AN OVERVIEW OF FATIGUE MANAGEMENT SERVICES AT THE NASA JOHNSON SPACE CENTER**Charles Dukes<sup>1</sup>, Pam Baskin<sup>2</sup><sup>1</sup>UTMB/KBR/NASA, Houston, TX, United States; <sup>2</sup>KBR/NASA, Houston, TX, United States*(Education - Tutorial/Review)*

**INTRODUCTION:** To maintain optimal performance, astronauts must obtain sufficient sleep duration and quality. The Johnson Space Center's Fatigue Management Services offers active astronauts multiple fatigue countermeasures, both before and during human spaceflight operations, to maintain and enhance their performance. **TOPIC:** Astronauts commonly report sleep problems before and during spaceflight, and this can cause severe decrements in their performance and pose a substantial risk to the mission. Countermeasures such as education regarding fatigue management, personalized assessments, ground tested medications, and sleep shifting schedules can optimize astronaut performance prior to launch. Other objective measures for discerning cognitive deficits due to fatigue are also employed, including performance vigilance testing. Furthermore, use of the Oura Ring, a wearable device, provides objective data regarding the duration and

quality of sleep. Countermeasures used during spaceflight include adjustments of the solid-state lighting system to mitigate circadian desynchrony, blue light blocking glasses, strategic naps, and schedules for sleep shifting. Medications can be used to treat insomnia and to mitigate fatigue during critical events such as launch, docking, deorbiting, and reentry. The Johnson Space Center Fatigue Management Service provides an array of services to individually enable active astronauts to achieve adequate duration and quality of sleep, optimizing crew performance and overall success of the mission. **APPLICATION:** This presentation will provide an overview of how the Johnson Space Center Fatigue Management Services optimizes astronaut and crew performance. It will stimulate discussion about the importance of sleep duration and quality and the challenges faced in the aerospace and micro gravity environment.

**Learning Objectives**

1. The audience will learn about the different elements of the Fatigue Management Program at the NASA Johnson Space Center.
2. The audience will learn the impact that fatigue has on performance in the operational environment of spaceflight.
3. The audience will learn the importance of fatigue management as an important component of maintaining a healthy lifestyle.

**[267] BIOHACKING FLIGHT MEDICINE'S BEST IN 2022: OPTIMIZING READINESS AND HEALTH WITH LIFESTYLE & PERFORMANCE MEDICINE**Regan Stiegmann*U.S. Air Force Veteran (2011-2022), Castle Rock, CO, United States**(Education - Program/Process Review)*

**BACKGROUND:** A 2021 *Military Medicine* publication states the Department of Defense spends more than \$3 billion annually on medical costs of lifestyle-related morbidity and military service members and veterans engage in unhealthy behaviors at a rate higher than civilian populations. **OVERVIEW:** We recruit the healthiest men and women in America to serve in the United States Military. As the healthiest men and women in the country serve their tours of duty, something drastic happens to them during their time in uniform. Once our active service members separate or retire, transitioning into Veterans, they also transition into the unhealthiest American demographic in this country. What are we doing to the health of our Soldiers, Sailors, Airmen, and Marines? **OVERVIEW:** The Veterans Health Administration (VHA) is the largest integrated healthcare system in the United States. It includes 1,243 facilities spread across the nation along with 170 medical centers and 1,063 outpatient centers that provide state of the art medical care to over five million Veterans. Similarly, the Department of Defense (DOD) is the largest employer in the country with over 1.3 million men and women on Active Duty, and 742,000 civilian personnel. Another 826,000 serve in the National Guard and Reserve force and more than 2 million military retirees and their family members receive benefits. **DISCUSSION:** Estimates suggest that the DOD annually spends \$10-\$17 billion treating chronic degenerative (and largely preventable) diseases every year in this country. Consistent increases in health care spending have become a key concern in within the DOD, and DOD Military Health System (MHS) leadership have started to recognize the need to lower health care costs as part of the MHS strategic framework. Every year, more Americans die from cardiovascular diseases than the number of American lives lost in World War I and World War II combined. This is due lack of emphasis and financial incentives centered around preventive and lifestyle strategies. A new military framework is being integrated within medical treatment facilities, managed under the Defense Health Agency (DHA). We as health experts are primed to execute the DHA mission by means of subsequent Lifestyle/Performance medicine integration. Lifestyle/Performance medicine and the DHA quadruple aim are means to the same endpoint, as Lifestyle/Performance medicine has the potential to increase readiness, improve health, improve care delivery, and decrease cost.



**Learning Objectives**

1. Describe how in 2022 Lifestyle & Performance Medicine is being integrated into the military and medical treatment facilities of the Department of Defense, the VA, and DHA.
2. Discuss various Department of Defense strategies that focus on implementing Lifestyle Medicine measures for our Soldiers, Sailors, Airmen, and Marines and their families.
3. Discuss how military readiness and deployability is directly impacted by the 6 pillars of Lifestyle Medicine, and how the MHS/Defense Health Agency's quadruple aims align within the field of Lifestyle Medicine.

**Wednesday, 05/25/2022****2:00 PM****Tuscany 12****[S-53]: PANEL: AEROSPACE DENTISTRY**

*Sponsored by the International Association of Aerospace Dentistry*

**Chair: Michael Hodapp****Co-Chairs: Jose Dominguez-Mompell, Juan Lara Chao**

**Panel Overview:** Aerospace Dentistry is an ever-evolving profession. In the last twenty years materials, equipment, and techniques have changed drastically. Modern dental lasers not only enhance early diagnostic capabilities but allow many procedures to be performed without the need for local anesthetics. Recent advances in dental materials are esthetic, have wear properties that mimic enamel, and can be bonded, which reduces the risk of odontocrexia or loss of restoration during barometric changes in atmospheric pressure. Trauma should always be considered when planning a mission. What are the best methods to handle a traumatic situation in a remote environment? Ideas from two experienced oral surgeons will be presented with the primary goal making the best of a bad situation. Spaceflight is progressing at a rapid pace, and long duration missions are on the horizon. As missions are extended consideration will need to be given to control of the microflora environment. The primary goal of this panel is to address the many ways that dentists and doctors can improve methods to enhance the safety of pilots, divers, and astronauts so they can perform their duties without oro-facial complications and allow the crewmembers to perform their duties with a minimum of oral complications.

**[268] DIGITAL GUIDE SURGERY IN IMPLANT DENTISTRY: HOW DO OUR TREATMENTS REALLY IMPROVE?**

Daniel Robles<sup>1</sup>, Jose Luis Dominguez-Mompell Pico<sup>2</sup>, Juan Lara Chao<sup>2</sup>

<sup>1</sup>Miguel de Cervantes European University, Valladolid, Spain; <sup>2</sup>DL Cirugia Oral, Madrid, Spain

*(Education - Tutorial/Review)*

**INTRODUCTION:** In recent years, Dentistry has evolved as digital tools changed the course of the profession. The implantology sector is part of daily clinical practice, and its continuous development is increasingly closer to the virtual world. Thus, conventional surgical techniques have been giving way to newer techniques, involving a change in the way of seeing implant surgeries. **TOPIC:** Guided surgery arises from the evolution of three-dimensional images in combination with computer planning software. It is based on prosthetic rehabilitation for the proper positioning of implants, providing aesthetic and functional advantages that will, consequently, give long-term treatment success. **APPLICATION:** There are currently two types of surgical techniques for implant placement: the conventional freehand technique and the computer-guided surgery technique. The latter encompasses all the advances related to three-dimensional images and digital work, so its use is booming within the sector. Digital implantology is here to stay, providing professionals with diagnostic tools, planning and surgical techniques that have renewed the previous ones and will continue to evolve in the coming years.

**Learning Objectives**

1. The participant will be able to know the benefits of the use of guides in implant dentistry and how this use can make our treatments shorter, painless and accurate.
2. the audience will learn about the process to design and manufacture of surgical guides.
3. the audience will learn about where we are in digital dentistry and what can we expect of the digital tools.

**[269] THE IMPORTANCE OF PERIODONTAL DISEASE IN MICROGRAVITY**

Victor Lloro Boada<sup>1</sup>, Laura Giovannoni<sup>2</sup>, Vicente Lozano De Luaces<sup>3</sup>, Eduardo Chimenos Küstner<sup>2</sup>

<sup>1</sup>Human Anatomy and Embryology Unit, Experimental Pathology and Therapeutics Department, Faculty of Medicine and Health Sciences, Health University of Barcelona Campus, Barcelona, Spain; <sup>2</sup>Odontology Hospital UB, Odontostomatology Department, Faculty of Medicine and Health Sciences, Health University of Barcelona Campus, Barcelona, Spain; <sup>3</sup>Faculty of Medicine and Health Sciences, Health University of Barcelona Campus, Barcelona, Spain

*(Education - Tutorial/Review)*

**INTRODUCTION:** Microgravity is one of the various conditions that affect the oral and systemic health status during space missions. Periodontal disease is a chronic inflammatory disease of periodontium and its advanced form is characterized by periodontal ligament loss and destruction of surrounding alveolar bone. The periodontal disease is one of the most common oral condition of human population. Perturbations of the oral microbiome through lifestyles can have detrimental consequences for the general and oral health. The conditions of life outside the earth (mainly microgravity and isolation) could produce dysbiosis in the oral cavity. In dysbiosis, the equilibrium of the oral ecosystem is disrupted, allowing disease promoting bacteria to manifest and cause conditions such as gingivitis and periodontitis. **APPLICATION:** Promoting a balanced microbiome is therefore important to effectively maintain or restore oral health, both on Earth and in zero gravity conditions.

**Learning Objectives**

1. The participant will be able to understand oral dysbiosis cause conditions such as gingivitis and periodontitis.
2. The participant will be able to understand microgravity and isolation are factors in oral dysbiosis.

**[270] DENTAL TRAUMA. GUIDELINES FOR AIRCREW MEMBERS/MILITARY STAFF**

Juan Lara Chao<sup>1</sup>, Jose Luis Mompell<sup>1</sup>, Ramon Mompell<sup>2</sup>, Daniel Robles<sup>3</sup>, Soumaya Berrazzouk<sup>4</sup>

<sup>1</sup>DL Cirugia Oral, Madrid, Spain; <sup>2</sup>Doctores Mompell Mico, Madrid, Spain; <sup>3</sup>Universidad Europea Miguel de Cervantes, Valladolid, Spain; <sup>4</sup>Universidad Complutense de Madrid, Madrid, Spain

*(Education - Case Study)*

**INTRODUCTION:** Dental traumatism is one of the most common situations at a dental office. Would an aircrew/military member know how to act in case of dental traumatism? **BACKGROUND:** Guidelines of how to act depending the severity and dental structures affected will be analyzed. **CASE PRESENTATION & DISCUSSION:** Several different situations involving dental traumatism will be discussed. From a simple concussion, to an enamel fracture (Small fracture) To a complete dental avulsion will be considered. Emergency treatment on the field, and future considerations will be discussed from an aircrew acting point of view.

**Learning Objectives**

1. The participants will learn a guideline about how to diagnose an emergency concerning dental trauma.
2. The participants will learn a guideline about how to face an emergency treatment concerning dental trauma.

**[271] WOULD YOU LET THIS PATIENT FLY?**

Jose Luis Mompell<sup>1</sup>, Juan Lara Chao<sup>1</sup>, Ramon Mompell<sup>2</sup>,  
Daniel Robles<sup>3</sup>, Rafael Gomez de Diego<sup>4</sup>

<sup>1</sup>DL Cirugia Oral, Madrid, Spain; <sup>2</sup>Doctores Mompell Mico, Madrid, Spain;

<sup>3</sup>Universidad Europea Miguel de Cervantes, Valladolid, Spain; <sup>4</sup>Universidad Rey Juan Carlos, Madrid, Spain

(Education - Case Study)

**INTRODUCTION:** Many patients/aircrew members/military personal may consult to an AME/Flight Surgeon about, present, past or future dental treatments. Dentistry is not normally studied at medical schools leading to a lack of knowledge on how to face certain very common situations in people's daily life. **BACKGROUND:** This presentation will try to provide some kind of guideline of how to act when a patient comes to consultation asking about some of the most common dental treatments performed or to be performed in relation with their future flying plans. **CASE PRESENTATIONS & DISCUSSION:** Cleaning and polishing, Implant treatment, filling, root canal treatment, and extractions will be evaluated from a flight surgeon point of view and how these medical acts may affect or not the capability of flying, as a passenger or as a crewmember.

**Learning Objectives**

1. Understand how aviation dentistry may play a crucial role in aerospace medicine.
2. Learn how to face some of the most dental related situations that may come to an AME/Flight surgeon office.

**[272] LASER TECHNOLOGY AND SAFETY IN AEROSPACE DENTISTRY**

Michael Hodapp

Private Practice, Houston, TX, United States

(Education - Tutorial/Review)

**BACKGROUND:** Pilots, divers, and astronauts have special considerations when it comes to dental care. A simple dental procedure that requires local anesthetic grounds a crewmember and prevents them from performing their duties for a period of twenty-four hours. In addition, when a dental procedure is performed with local anesthetic, bite adjustments may be compromised due to neuromuscular inhibition, and the pulpal response cannot be determined until the dental anesthetic has completely worn off. Thanks to recent advances in laser technology carious lesions can be detected early, even around existing restorations, and several dental procedures can be performed without the need for local anesthetic. This not only eliminates the drug that grounds the crewmember, but also lends to more accurate occlusal adjustments, a reduction in heat and vibration transfer to the pulp during the tooth preparation, and there is an immediate knowledge of the pulpal response after treatment. This not only can eliminate the twenty-four-hour grounding period, but by having an immediate sense of the pulpal response ensures that the pilot or diver can perform their duties with little worry of pulpal pain occurring during barometric changes in atmospheric pressure. This presentation will discuss the technology behind the modern digital laser systems, that enhance early diagnostic capabilities, and the technology that allows the modern digital systems to produce the energy to minimize heat and maximize the ability to ablate efficiently and effectively without the need for local anesthetics, and comment on what the future may hold by combining these new laser systems.

**Learning Objectives**

1. How modern digital lasers are changing the way we practice dentistry, and how they can improve safety for pilots, divers, and astronauts.
2. What is the best wavelength for targeting hard and soft tissue to minimize heat and maximize the ability to ablate efficiently.
3. How can laser light enhance our ability to detect caries early, and which wavelength works best around existing restorations.

Wednesday, 05/25/2022

Tuscany 5/6

2:00 PM

**[S-54]: POSTERS: HUMAN PERFORMANCE: FATIGUE, ATTENTION**

Chair: Monica Malcein

Co-Chair: Ian Mollan

**[273] CHANGES IN ALERTNESS AND PERFORMANCE OVER TIME DURING LONG-HAUL FLYING ACROSS MULTIPLE TIME ZONES**

Lucia Arsintescu<sup>1</sup>, Cassie Hilditch<sup>1</sup>, Kenji Kato<sup>2</sup>, Kevin Gregory<sup>3</sup>, Erin Flynn-Evans<sup>3</sup>

<sup>1</sup>San Jose State University Research Foundation, Mountain View, CA, United States; <sup>2</sup>ASRC Federal, Mountain View, CA, United States; <sup>3</sup>NASA, Mountain View, CA, United States

(Original Research)

**BACKGROUND:** Long-haul pilots experience high levels of fatigue and circadian disruptions due to long work hours and flying over multiple time zones. The aim of this study was to describe changes in alertness and performance among flight crews during long-haul flights crossing multiple time zones. **METHODS:** All pilots flying long-haul operations from a single airline were eligible to participate. All participants collected data for ~2 weeks of their normal work schedule within airline operations, with at least two long-haul rotations, including rest days and layovers. Participants wore an Actiwatch throughout the entire study period and completed a sleep diary (at bedtime, upon waking up and after each nap). Each participant completed a 5-min Psychomotor Vigilance Task (PVT) and a Karolinska Sleepiness Scale (KSS) pre-flight, on top-of-descent (TOD; inflight) and at the end of each flight (post-flight). Response speed (1/RT x 1000), lapses (RT > 500 ms), and alertness were assessed over time pre-flight, TOD, post-flight, using mixed-effects models with participant as a random factor. Linear models were assumed for response speed and alertness, while a negative binomial distribution was specified for lapses due to overdispersion. **RESULTS:** Forty-four long-haul pilots participated in the study (5 female; mean age 44.25 ± 10.06 yrs; mean flight hours 9834.3; ± 5334.1 hrs). Lapses increased post-flight relative to pre-flight ( $F(2, 665) = 3.67, p < 0.05$ ). There was a main effect of response speed ( $F(2, 665) = 21.45, p < 0.001$ ) with slower speed inflight and postflight compared to preflight ( $p < 0.001$ ). The KSS increased over time from  $M = 4.02 (\pm 1.35)$  preflight to  $M = 5.15 (\pm 1.58)$  inflight, to  $M = 6.7 (\pm 1.51)$  postflight ( $F(2, 701) = 182.63, p < 0.001$ ). **DISCUSSION:** Our preliminary analyses showed that both performance and subjective alertness worsened from the beginning to the end of a flight. Additional analyses will be conducted to investigate the changes in alertness and performance by direction of travel, sleep history, and flight timing and duration.

**Learning Objectives**

1. The participant will learn about alertness and performance in long-haul pilots during flights across multiple time zones.
2. The participant will learn about the impact of sleep on flight performance in long-haul pilots.

**[274] LITERATURE REVIEW ON CRANIAL ELECTROTHERAPY STIMULATORS AS A FATIGUE MANAGEMENT TOOL TO MANAGE INSOMNIA IN AEROSPACE**

Shane Clark<sup>1</sup>, Pamela Baskin<sup>2</sup>, Charles Dukes<sup>3</sup>

<sup>1</sup>University of Florida, Fleming Island, FL, United States; <sup>2</sup>KBR Inc., Johnson Space Center, Houston, TX, United States; <sup>3</sup>UTMB Medical Branch, Galveston, TX, United States

(Education - Tutorial/Review)

**INTRODUCTION:** As one of the NASA-listed risk factors for long-term spaceflight, sleep and circadian rhythm changes are becoming increasingly important with planned missions to Mars. In addition to decreased overall sleep time while in orbit, astronauts also experience worsened sleep

quality. Due to this, the use of pharmaceutical sleep aids is around ten times greater for astronauts than on the ground. The use of cranial electrotherapy stimulators (CES) may be a useful tool in lessening the pharmaceutical burden and helping treat this important condition. **TOPIC:** To date, methods of nonpharmaceutical sleep aids including CES such as Alpha Stim and Fisher Wallace stimulators have not been evaluated for use in spaceflight to treat insomnia. PubMed and Google Scholar were utilized for a literature search utilizing the words "Alpha Stim," "Fisher Wallace," "Cranial Electrotherapy Stimulation" and "Insomnia." There were 8 CES studies addressing insomnia, with 5 studies utilizing the Alpha Stim, 3 using older models of CES, and 0 studies using the Fisher-Wallace stimulator. Five of the studies (2 Alpha Stim and 3 older models) addressed healthy participants with insomnia. The 2 Alpha Stim papers and one older model study were short in duration (1-5 nights), were not significant but the values were trending upwards and almost significant on the last nights. The final 2 studies both showed significant improvements in participants' insomnia. The last 3 studies were limited as they primarily focused on the treatment of other comorbid conditions. These studies were prolonged, lasting at least 6 weeks, and did show significant improvement in self-reported insomnia with the Alpha Stim. Many Systemic reviews and further studies that addressed the safety of CES, showed that virtually all the patients experienced no side effects from the procedure. The few reported side effects reported were minor, such as headaches.

**APPLICATION:** The treatment of insomnia with CES shows mildly positive results that could indicate it has potential for use during spaceflight. Studies indicate that the device is extremely safe and can be successfully self-administered. In addressing insomnia, the Alpha Stim device is more extensively studied over the Fisher-Wallace Stimulator. Research has not shown benefit in short-term use of the device but would require longer-term consistent usage.

#### Learning Objectives

1. Understanding the potential usages for cranial electrotherapy stimulation for aerospace.
2. Understanding the benefits and limitations of cranial electrotherapy devices for aerospace.

#### [275] SLEEP AND FATIGUE ESTIMATE COMPARISON: COMMERCIAL FITNESS WATCH VERSUS RESEARCH-GRADE ACTIGRAPH WATCH

Megan Morris<sup>1</sup>, Bella Veksler<sup>2</sup>, Alex Gaines<sup>3</sup>, Chao Pan<sup>1</sup>, Michael Krusmark<sup>4</sup>, Glenn Gunzelmann<sup>1</sup>

<sup>1</sup>Air Force Research Laboratory, Wright-Patterson AFB, OH, United States;

<sup>2</sup>TIER1 Performance Solutions, Covington, KY, United States; <sup>3</sup>U.S. Air Force Academy, CO, United States; <sup>4</sup>CAE, Wright-Patterson AFB, United States

#### (Original Research)

**INTRODUCTION:** Objective fatigue assessments are typically produced from research-grade actigraph device sleep estimates input into biomathematical fatigue models. However, these devices have limitations in operational settings due to manual data processing requirements and lack of additional desired features (e.g., navigation), suggesting commercial fitness devices might be more appropriate. The current study compares sleep estimates and resulting fatigue assessments between the Garmin fenix<sup>®</sup> 5X and Micro Motionlogger<sup>®</sup> in an operational sample. **METHODS:** Thirty-six volunteer Airmen (majority male) at Joint Base Charleston provided 35 usable data sets over a 14 day period. The study was designated Not Human Subjects Research by the Air Force Research Laboratory Institutional Review Board. Volunteers wore both fitness and actigraph watches on separate wrists (randomly assigned) and completed an activity log to denote sleep and watch off-wrist period times. We collected sleep statistics from the fitness watch and performed two scoring implementations with the actigraph watch data (manual and semi-automatic down-interval calculation). We then compared sleep estimates from the devices relative to activity log information with linear mixed effects analyses and compared resulting fatigue assessments from a biomathematical fatigue model with descriptive statistics. **RESULTS:** The fitness watch tended to moderately overestimate sleep minutes (~ 55 minutes) and very

slightly underestimate wake minutes (within 15 minutes) per sleep period, with very slightly earlier start times and later end times (within 15 minutes) compared to both scoring implementations of the actigraph data. Several naps and some primary sleep periods outside of normal sleep hours were not identified by the fitness watch. The fitness watch fatigue predictions where on average lower than the scoring implementations of the actigraph data. Although these differences were negligible for most participants, for some participants fatigue estimates were much lower or higher due to overestimated sleep periods or missing sleep periods outside of normal sleep hours, respectively. **DISCUSSION:** The fitness watch can produce significant under or overestimation of fatigue during missions. Developers must continue to increase the accuracy of sleep metrics produced from commercial fitness watches in order to provide an ideal device to capture sleep estimates in the field for effective fatigue assessment.

#### Learning Objectives

1. Learning Objective 1: Understand limitations of commercial fitness devices in regard to estimating sleep.
2. Learning Objective 2: Understand the implications of commercial fitness device sleep estimate limitations in terms of assessing fatigue in an operational context.

#### [276] REAL-TIME INDIVIDUALIZATION OF FATIGUE ASSESSMENT AND PREDICTIONS IN A MOBILE APPLICATION

Bella Veksler<sup>1</sup>, Megan Morris<sup>2</sup>, Ian Davis<sup>3</sup>, Glenn Gunzelmann<sup>2</sup>

<sup>1</sup>TIER1 Performance Solutions, Covington, KY, United States; <sup>2</sup>Air Force Research Laboratory, Wright-Patterson AFB, OH, United States; <sup>3</sup>Ball Aerospace, Fairborn, OH, United States

#### (Original Research)

**INTRODUCTION:** Fatigue is a pervasive factor across myriad communities within the Air Force, resulting in costly consequences. It is imperative for organizations to properly assess and manage fatigue to ensure effective and safe mission execution. Current fatigue risk management (FRM) tools, such as those based on biomathematical fatigue models, can be effective for assessing and predicting fatigue. However, a common limitation is that fatigue predictions are based on group averages. The current effort uses data from the Psychomotor Vigilance Test (PVT) to individualize predictions from the Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) biomathematical fatigue model for greater accuracy. **METHODS:** Five SAFTE model parameters were modulated using a simulated annealing (SA) approach. Modulation was tested with Root Mean Squared Error (RMSE) and ANOVA analyses in a Not Human Subjects Research study, designated by the Air Force Research Laboratory Institutional Review Board, with four separate archival data sets of PVT performance (89 participants total, ages 22-40, majority male, protocols: 88-hour total sleep deprivation (TSD), 62-hour TSD, shift work, and 8, 6, and 4-hour sleep restriction). The personalization capability was then integrated into a mobile app implementation of the SAFTE model, where parameters are modulated each time the user completes the PVT task, producing updated fatigue predictions. **RESULTS:** Individual PVT bout median response time predictions had an average RMSE of 21.57 for the SA model compared to 39.79 for the default model. Total RMSE significantly improved across time with the SA model in all studies and conditions,  $p < .001$ , and produced less deviation later in the study protocol compared to the default model. In the app, the modulation requires about 1 second of execution time to complete a run for a week's worth of sleep data. This includes 1000 iterations of the SA model. **DISCUSSION:** The current effort resulted in significant improvement in fatigue predictions in a mobile implementation of the SAFTE model using an SA individualization approach. This app can be placed in the hands of operators to increase the effectiveness of FRM. Follow-on work will focus on validating the mobile implementation fatigue predictions in real time.

#### Learning Objectives

1. Learn about an individualization approach for biomathematical fatigue model predictions.
2. Understand the implications of implementing individualization approaches in mobile fatigue risk management tools.



## [277] HYPOXIA AND HYPOXIA-REOXYGENATION DOWNREGULATE EXPRESSION OF VIRAL ENTRY GENES AND TOLL-LIKE RECEPTOR PATHWAY GENES IN HUMAN AIRWAY EPITHELIAL CELLS

Chu-Mei Huang, Chao-Ju Lin, Yun Chang, Yi-Hui Chen

National Defense Medical College Graduate Institute of Aerospace and Undersea Medical, Taipei, Taiwan (Greater China)

(Original Research)

**INTRODUCTION:** Given the critical role of Toll-like receptor pathway components in determining disease severity of both COVID-19 and chronic obstructive pulmonary disease (COPD), it was of interest to study whether exposure to hypoxia or hypoxia-reoxygenation further exacerbate the inflammatory response of the COPD airway epithelial cells. **MATERIALS AND METHODS:** Normal (NHBE) and COPD-diseased (DHBE) human bronchial epithelial cells derived from Caucasian age-matched donors were obtained from Lonza Biotechnology Company and cultured under normoxia (21% O<sub>2</sub>) for consecutively 6 days, or cultured under 24/24-hour cycles of H/R (i.e., 1% O<sub>2</sub> and 21% O<sub>2</sub> alternately) for 6 days in total, or cultured under 1% O<sub>2</sub> for consecutively 3 days followed by 21% O<sub>2</sub> for consecutively another 3 days. Total mRNAs were then extracted followed by microarray analyses. **RESULTS:** In both NHBE and DHBE cells cultured under both intermittent H/R and consecutive hypoxia, the mRNA levels of the Toll-like receptor *TLR4*, its adaptor *MYD88*, the downstream kinases *IRAK4* and *PI3K* subunits *PIK3C2B* and *PIK3C2G*, the interferon regulatory factors *IRF5* and *IRF7*, the AP-1 transcription factors *ATF1*, *ATF3* and *ATF7*, together with the interferons *IFNA1*, *IFNA2*, *IFNA7*, *IFNA14* and *IFNG* as well as the interferon receptors *IFNGR1* and *IFNGR2* were all significantly decreased, in concordant with the significant decreases in the expression of the MERS coronaviral receptor *DPP4* and the influenza receptor *ST3GAL4*. Interestingly, the mRNA levels of the SARS-CoV-2 entry factors *ACE2* and *TMPRSS2* as well as the HCoV-229E receptor *ANPEP* were significantly decreased by both intermittent H/R and consecutive hypoxia in the DHBE but not the NHBE tissues, in concordant with the significant decreases in the expression of the TLR-downstream kinases *IRAK3*, *PIK3CB*, *IKBKE* (IKKε), *IKBKG* (IKKγ), the kinase binding factor *TAB2*, the AP-1 transcription factors *JUNB*, *JUND*, *FOS* and *ATF4*, the pro-inflammatory cytokines *IL12A* and *CCL5* (RANTES), and interferon *IFNA5* in the DHBE but not the NHBE tissues.

### Learning Objectives

1. Understanding the respective effects of consecutive hypoxia and intermittent hypoxia-reoxygenation on the expression levels of coronaviral and influenza viral entry genes.
2. Understanding the respective effects of consecutive hypoxia and intermittent hypoxia-reoxygenation on the expression levels of Toll-like receptor pathway genes.
3. Understanding the potential therapeutic effects of consecutive hypoxia and intermittent hypoxia-reoxygenation on coronaviral and influenza viral transmissibility as well as COVID-19-associated cytokine storm.

## [278] NEAR-INFRARED SPECTROSCOPY DURING HYPOBARIC HYPOXIA TRAINING IN A HIGH-ALTITUDE CHAMBER

Andreas Werner

German Air Force - Centre of Aerospace Medicine, Koenigsbrueck, Germany

(Original Research)

**INTRODUCTION:** Flying staff is endangered by altitude-induced oxygen (O<sub>2</sub>) reduction. Hypoxia is an O<sub>2</sub> lack at the cellular level which leads to disturbances of the functional and structural metabolism, and finally necrosis. Peripheral O<sub>2</sub>-saturation (SpO<sub>2</sub>) monitoring is standard during the hypobaric hypoxia training (hht) in our high-altitude chamber. Physiologically, hypoxia induces a centralization; therefore, we postulated that this monitoring could be insufficient. Near-infrared spectroscopy (NIRS) is an entirely new technique measuring central oxygenation (rSO<sub>2</sub>) relatively. Aim of the study was the comparison of peripheral to central oxygenation. **METHOD:** 108 voluntary training participants (written

informed consent, 99 men; 34.9 ± 7.5 ys; 180.5 ± 6.9 cm; 81.2 ± 9.6 kg; 34.9 ± 2.1 kg/m<sup>2</sup>; 99 righthander, 21 smokers) were included in the study. The profile of the hht was: plateau at 25kft (acute) and mild hypoxia at 15kft. The standard monitoring was 1-ch-ECG, Hf, and SpO<sub>2</sub> (Masimo®, M55). The regional O<sub>2</sub> measurement (frontal brain tissue) was obtained bihemispheric with NIRS (INVOS™, 5100C). The trainees were asked to report their hypoxia symptoms. After data synchronization, the characteristics were analyzed. **RESULTS:** The values for SpO<sub>2</sub> and rSO<sub>2</sub> were significantly different (p<.001) and not correlated (CCC .002). Percental desaturation of rSO<sub>2</sub> and SpO<sub>2</sub> were significantly different (p<.001) and weakly correlated (CCC .488). The bias of both methods is high and the limits of agreement with >10% unacceptable. There were found no differences in left and right NIRS (p ns, CCC .838). The duration for reoxygenation for rSO<sub>2</sub> and SpO<sub>2</sub> were significantly different (p <.001); rSO<sub>2</sub> recovers delayed (25s vs 58s [25kft], 40s vs 92s [15kft]). rSO<sub>2</sub> is less interference prone than SpO<sub>2</sub> (95 vs 0 events). **DISCUSSION:** The NIRS oximetry is a valid method measuring central oxygen saturation. A bihemispheric measurement seems to be unnecessary. It detects the regional hypoxia reliably, and hypoxia symptoms correlate significantly better with the rSO<sub>2</sub> curves. NIRS is a valuable supplement to monitor blood saturation. Pulse oximetry during hypoxia demonstration was delayed and did not reflect the symptoms correctly concerning the time axis. The delay in reoxygenation found in rSO<sub>2</sub> could maybe explain the somnolent behavior. Further investigations will show if NIRS could be used as the new monitoring. Conceivable, this could be to monitor trafficking aircrews and increase safety.

### Learning Objectives

1. The audience will learn that NIRS oximetry is a valid method of measuring central oxygen saturation, but it is unnecessary to record bihemispheric.
2. The audience will learn that comparing SpO<sub>2</sub> and rSO<sub>2</sub>, the central measurement correlates more precisely to the subjective symptoms than the periphery.
3. The audience will understand that the partial somnolent behavior after hypoxia could be explained by the delay in central reoxygenation, which is not seen by peripheral resaturation.
4. The audience will be able to relate that NIRS monitoring should be better to detect loss of consciousness earlier.

## [279] RELATIONSHIP BETWEEN MAXIMUM VOLUNTARY VENTILATION AND EXERCISE ENDURANCE AT ALTITUDE FOLLOWING RESPIRATORY MUSCLE TRAINING

Courtney Wheelock, David Hostler

University at Buffalo, Buffalo, NY, United States

(Original Research)

**PURPOSE:** Respiratory muscle training (RMT) has been shown to improve exercise endurance at sea level and at altitude by lowering respiratory muscle fatigue. The goal of this analysis was to determine the relationship between maximum voluntary ventilation (MVV, L·min<sup>-1</sup>) and endurance performance at altitude following RMT.

**METHODS:** Male subjects were randomly assigned to complete either RMT (n=8, VO<sub>2</sub>max: 39.0 ± 4.7 ml/kg·min<sup>-1</sup>) or placebo training (n=8, VO<sub>2</sub>max: 38.2 ± 8.8 ml/kg·min<sup>-1</sup>). Pulmonary function and VO<sub>2</sub>max testing were completed at sea level before and after RMT. Subjects cycled to exhaustion (55% of VO<sub>2</sub>max) in a hypobaric chamber depressurized to 3,658 m before and after RMT. Both groups completed RMT or placebo training for 30-min, three times per week, for four weeks. During training sessions, the placebo group inspired for 5-sec, held their breath for 5-sec, and then exhaled for 5-sec, every 30-sec, while the RMT group breathed through spring loaded valves into a bag that maintained isocapnia for 30 min (bag volume=55% vital capacity; breath frequency=0.60-MVV/bag volume). **RESULTS:** VO<sub>2</sub>max did not change in either group. MVV increased in the RMT group (6.1 ± 2.3%, p=0.02) but not in the placebo group (4.3 ± 10.6%, p=0.41). No other changes in pulmonary function were found following RMT. Cycle time to exhaustion (TTE) improved in the RMT group (22.8 ± 35.7%, p=0.047)

but not the placebo group ( $6.1 \pm 18.5\%$ ,  $p=0.28$ ). There was a positive correlation between percent change in MVV and percent change in TTE after RMT ( $R^2=0.55$ ;  $p=0.04$ ), which was not found in the placebo group ( $R^2=0.01$ ;  $p=0.81$ ). **CONCLUSIONS:** Exercise endurance at altitude improved following RMT and was related to the magnitude of improvement in MVV measured during sea level pulmonary testing. Specific changes in pulmonary function after RMT may predict improvements to endurance performance at altitude.

#### Learning Objectives

1. Understand the positive performance impact that respiratory muscle training has on endurance exercise at altitude.
2. Acknowledge the potential for predictive tests at sea level to determine improvements in respiratory muscle function and performance at altitude.

### [280] PHENOMENAL ADAPTION OF THE BRAIN DURING SERVE SUSTAINED HYPOXIA TRAINING – A DIAGNOSTIC APPROACH

Sven-Erik Soenksen<sup>1</sup>, Ulrich Limper<sup>2</sup>, Hans Juergen Noblé<sup>3</sup>, Jens Tank<sup>2</sup>, Frank Jakobs<sup>3</sup>, Sven Kuehn<sup>4</sup>

<sup>1</sup>German Air Force Centre of Aerospace Medicine (GAF CAM), Munich, Germany; <sup>2</sup>German Aerospace Center, Cologne, Germany; <sup>3</sup>German Air Force Center of Aerospace Medicine (GAF CAM), Fuerstenfeldbruck, Germany;

<sup>4</sup>German Central Military Hospital, Koblenz, Germany

#### (Original Research)

**INTRODUCTION:** Knowledge about high altitude exposure and hypoxia training has been fundamentally increased due to cerebral magnetic resonance imaging (cMRI). [1-3] cMRI revealed alteration in human central nervous system like subclinical edema formations and subtle brain findings. Yet, brain structure alterations and recovery after adaptation to high altitude have barely been investigated. **METHODS:** We enrolled two healthy professional mountaineers for a 35 day (Subject A and B) exposure to normobaric hypoxia. We performed seven cMRI at baseline (BL), acclimatization phase (AP), three times during stable hypoxia (H1, H2, H3) and at recovery examination after one (R1) and four (R4) months at normoxia. cMRI included morphological sequences, Time of Flight angiography (ToF) and Diffusion Tensor techniques (DTI). **RESULTS:** Hypoxia decreased arterial partial pressure of oxygen to a minimum of 36 mmHg in A and 33 mmHg in B. Both subjects experienced high-altitude sickness symptoms. However, none progressed to cerebral edema. Both subjects showed increased white matter volumes (max.: A: 4.3%(H2); B: 4.5%(H2)) and decreased grey matter volumes (A: -3.1%(R1); B: -3.9%(R1)) and CSF volumes (A: -2.7(H2); B: -5.9%(H1)) from AP to R1. The number (A: 26(BL) to 126(H3); B: 11(BL) to 17(H1-3)) and volumes (A: 285%; B: 140%) of white matter lesions (WMH) increased in hypoxia but had fully vanished on R4. Diffusion values (FA, MD, RD, AD) tended to alter in hypoxia. The intracranial arterial volume increased considerably during hypoxia (max.: A: 8.1%(H2); B: 5.1%(H3)) and had recovered at R1. Sustained hypoxia was associated to increased cerebral venous volumes.

**DISCUSSION:** The acclimatized human brain demonstrates remarkable hypoxia tolerance by maintaining its functionality at arterial oxygen partial pressures as low as 20 mmHg. [5] However, our findings suggest morphological cerebrovascular alterations emerge in severe, sustained hypoxia. [4] A massive increase in number and volume of reversible WMH, likely caused by collapse of the capillary barrier [1], uncovered brain areas of subclinical microangiopathic damage. Whether sustained hypoxia may serve as a stress test of the brain to early uncover cerebral morphological markers of pathological processes should be further investigated. **RESOURCES:** [1] Idorishvili et al. 2019; [2] McGuire et al. 2019; [3] Hoffmann et al. 2020; [4] Kuehn et al. 2019; [5] Bailey et al. 2017.

#### Learning Objectives

1. The participant will learn about reversible adaption of central nervous system.

2. The audience will learn about normobaric hypoxia effects detected on cMRI scans before, during acclimatisation and recovery phase. Our reportings are linked to recent trends in aviation medicine.

### [281] NEW QUALITY OF HYPOXIA AWARENESS TRAINING: INTEGRATION OF A REDUCED OXYGEN BREATHING DEVICE (ROBD) IN A DISORIENTATION TRAINER

Michael Nehring, Helmut Fleischer

German Air Force Centre of Aerospace Medicine, Koenigsbrueck, Germany

#### (Original Research)

**INTRODUCTION:** Aircrew could undergo hypoxia awareness training either in a hypobaric chamber (hypobaric hypoxia = hh) or by using an ROBD (normobaric hypoxia = nh). In the Aviation Physiology Training Centre of the German Air Force, an ROBD is now integrated in a disorientation trainer. This is a step forward in integrating aeromedical training into flight simulator missions in order to make the training as realistic as possible. The aim of this study was to evaluate hypoxia symptoms and physiological responses of fighter pilots exposed to acute normobaric and hypobaric hypoxia in different training scenarios. **METHODS:** 33 male fighter pilots (age 40 +/- 9 yrs) took part in normobaric hypoxia awareness training by means of a ROBD, which was performed during a simulator flight in a disorientation trainer. The pilots were instructed to meet a tanker aircraft at 25,000 ft for an aerial refueling mission. From the time the demonstration begins the ROBD was delivering about 7% oxygen to the pilots, equal to a physiological altitude of 25,000 ft. The pilots were encouraged to turn on their emergency oxygen when recognizing their individual hypoxia symptoms. They all had undergone previous hypoxia training in a hypobaric chamber at least 4 years ago. The heart frequency, oxygen saturation, hypoxia recognition time (hrt) and hypoxia symptoms were recorded. **RESULTS:** The most frequent first symptom was the sensation of heat, followed by dizziness. This applied to both hypoxia conditions (hh and nh). Most pilots (82%) had similar hypoxia symptoms under nh as compared to hh. 18% of the pilots had different symptoms. Under hypobaric conditions, pilots reported more hypoxia symptoms than for normobaric exposure. The hypoxia recognition time was about 124 sec for hh and 130 sec for nh. The pilots reconnected to 100% oxygen at an average oxygen saturation of 80% for hh and of 73% for nh. **DISCUSSION:** Aeromedical training of flight personnel should ideally be performed in a full mission simulator integrating all physiological effects (hypoxia, spatial disorientation, night vision, etc.) and human factors. In our disorientation trainer, pilots could train and experience hypoxia, spatial disorientation and night vision effects in one simulator mission. The ROBD is an appropriate hypoxia training and demonstration device with the key benefit of allowing pilots to experience hypoxia during flight simulation.

#### Learning Objectives

1. The audience will learn about the different methods of Hypoxia Awareness Training.
2. The audience will learn about the physiological response to normobaric and hypobaric hypoxia.

### [282] UNIQUE HEART RATE RESPONSE: INDIVIDUAL VARIATION WITH ACUTE PROFOUND HYPOXIA?

Riley Ferguson<sup>1</sup>, Philip Bickler<sup>2</sup>, John Feiner<sup>2</sup>, Koa Gudelunas<sup>2</sup>

<sup>1</sup>University of Cincinnati College of Medicine, Cincinnati, OH, United States;

<sup>2</sup>University of California San Francisco, San Francisco, CA, United States

#### (Original Research)

**INTRODUCTION:** Depressurization events can lead to acute profound hypoxia of pilots and passengers. Recognizing profound hypoxia is a hallmark of pilot training. The hypoxic heart rate (HR) response increases cardiac output to compensate for falling blood oxygenation levels, although individual variation to this response has not been quantified. We aim to better delineate how the physiologic response to acute profound hypoxemia differs between individuals. **METHODS:** We evaluated the hypoxic HR response to acute profound hypoxemia in 44 sequences of

healthy adult volunteers. Fourteen subjects participated in more than one study date. Stable SaO<sub>2</sub> plateaus between 70 and 100% (70%, 75%, 80%, 85%, 90%, 95% and 100%) were targeted by adjusting inspired oxygen. At each level, arterial blood was sampled. HR, Perfusion Index (PI), and SaO<sub>2</sub> value were recorded throughout the desaturation of each subject using a Masimo pulse oximeter and ABL 90 blood gas analyzer. The average and standard deviation of these values were determined during the final 30 seconds of the plateau, representing the new steady-state and greatest stability. A mixed-effects multivariable linear model was used to analyze the slope and relationship between HR, SaO<sub>2</sub>, and other variables. This study was IRB approved and all subjects provided informed consent.

**RESULTS:** Visual inspection of the data suggests that the relationship between SaO<sub>2</sub> and HR appears linear. Individual subjects' change in HR response varied from as low as -0.3 bpm/%SaO<sub>2</sub> to as high as -1.5 bpm/%SaO<sub>2</sub>. This corresponds to an increase of 8 to over 40 bpm during desaturation from room air to 75% SaO<sub>2</sub>. For the analysis of all individuals combined, the slope of HR vs. SaO<sub>2</sub> was -0.82 (95% CI: -0.86 to -0.78). Between-subject variation in slope was greater than within-subject variation ( $p=0.02$ ). Age, sex, and ethnicity were not significantly related to the HR response. **DISCUSSION:** We demonstrate a significant variability of the HR response to profound (<75% SaO<sub>2</sub>) hypoxia between individuals. Subjects with repeat sequences had similar HR responses, appearing to be intrinsic individual responses. Demographic criteria such as sex, age, ethnicity, and skin pigment were not related to the HR response. No significant correlation between individuals and PI was found. Ultimately, a better understanding of individualized physiologic response to hypoxemia can lead to better algorithmic selection and training of aerospace crew members.

#### Learning Objectives

1. The audience will learn about individualized responses between individuals to acute profound hypoxia.
2. The audience will be exposed to experimental design for inducing acute profound hypoxia including data analysis methods.

### [283] THE INFLUENCE OF NEED FOR COGNITION ON MULTIPLE EXECUTIVE FUNCTIONS

Nicole Beasley<sup>1</sup>, Dustin Huber<sup>2</sup>, J. Lynn Caldwell<sup>3</sup>

<sup>1</sup>ORISE, Wright-Patterson AFB, OH, United States; <sup>2</sup>Retired, Pensacola, FL, United States; <sup>3</sup>Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, United States

(Original Research)

**INTRODUCTION:** The study of pilot personality has a rich history of identifying adaptive and maladaptive traits. This current research investigates the relation between Need for Cognition (NFC) and a variety of executive functions. NFC is a personality trait that describes the motivation (rather than ability) to seek out and engage in effortful cognitive activity. NFC is usually studied in the realm of intelligence, personality, and academic performance. In basic executive function, NFC has been correlated with willingness to invest effort and self-control. This study hypothesized that individuals higher in NFC would score significantly better on cognitive tasks than those lower in NFC. **METHODS:** This study was part of a larger study on strategic napping and cognitive performance approved by the Naval Medical Research Unit Dayton's Institutional Review Board. Twenty-four military personnel stationed at Wright-Patterson Air Force Base completed the 18-item NFC questionnaire and 11 cognitive tasks representing various components of cognition (e.g., attention). The 11 cognitive tasks were completed every 3 hours starting at 2300 and ending at 2000 the next day for 8 total iterations. NFC scores were divided into high and low using a median split. Responses from the last test session were used to extrapolate the influence of NFC. A one-way ANOVA was used with NFC as a fixed factor. **RESULTS:** There was a significant effect of NFC on cognitive performance for 2 (out of the 11 included) tasks: Choice Reaction Time (RTC) [ $F(1,21) = 5.26, p = .032$ ] and Novascan Continuous Memory (NCM) [ $F(1,21) = 6.173, p = .021$ ]. Pairwise comparisons indicated that those in the high NFC group performed significantly better than those in the low NFC group on both the RTC task ( $M = 62.73, SD = 0.55; M = 61.08,$

$SD = 0.57$ , respectively) and the NCM ( $M = 38.82, SD = 1.74; M = 32.83, SD = 1.67$ , respectively). **DISCUSSION:** These results provide evidence for a relationship between NFC and three executive functions that are relevant to a pilot population: simple discrimination (RTC), response selection functions (RTC), and working memory (NCM). Additional research is needed to further explore and validate this construct as part of the larger study on pilot personality traits and their relationship to complex task performance (e.g., problem solving), selection, training, and system design initiatives.

#### Learning Objectives

1. The audience will better understand the role of Need for Cognition in cognitive activity.
2. The audience will better understand how Need for Cognition relates to basic executive functions.

### [284] FATIGUE AND SLEEPINESS IN HELICOPTER EMERGENCY MEDICAL SERVICES PILOTS

Hiba Dhanani<sup>1</sup>, Jason Cohen<sup>2</sup>, Tovy Kamine<sup>1</sup>, Susan Wilcox<sup>2</sup>, Edward Kelly<sup>1</sup>, Gabriel Ryb<sup>1</sup>

<sup>1</sup>Baystate Medical Center, Springfield, MA, United States; <sup>2</sup>Boston MedFlight, Bedford, MA, United States

(Original Research)

**INTRODUCTION:** Previous studies on helicopter emergency medical services (HEMS) pilots note correlation among fatigue, nodding off in flight, and accidents. However, despite recent studies detailing risks of fatigue in commercial pilots and healthcare workers; HEMS fatigue data are outdated. Though the Epworth Sleepiness Scale (ESS) is used to quantify fatigue in medical professionals, it has not yet been used in HEMS pilots. Our survey determines ESS scores of HEMS pilots and updates previous literature on fatigue. **METHODS:** IRB approval was obtained from the Mass General and Brigham IRB. An anonymous electronic survey of 32 questions was sent via the National EMS Pilots Association (NEMSPA) EMS listserv. Questions included demographics, the ESS and subjective effects of fatigue on flying. Investigators did not have access to the listserv, responses were collected via REDCap and statistical analysis were performed using TTest and ANOVA. **RESULTS:** 31 pilots responded to the survey with 65% reporting an ESS  $\geq 10$ , indicating excessive daytime sleepiness. 39% endorsed nodding off in flight, and 65% endorsed that they should have refused a flight though in practice only 45% had turned down a flight ( $p=0.08$ ). En route was the most likely phase of flight to be affected by fatigue (74%) while takeoff (7%) and landing (7%) were the least likely to be affected ( $p<0.01$ ).

**DISCUSSION:** Our study indicates that significant numbers of HEMS pilots report excessive daytime sleepiness. These findings demonstrate greater fatigue than seen in medical residents. While this primarily affects en route performance, most respondents stated that they should have turned down a flight due to fatigue and close to half of participants endorsed nodding off in flight. Given the size of our study, more research is necessary to quantify the burden of fatigue among HEMS pilots and its impact on flight safety.

#### Learning Objectives

1. The audience will learn about the prevalence of fatigue amongst HEMS pilots and barriers to fatigue mitigation. This will be relevant in addressing safety concerns and culture change amongst HEMS pilots.
2. The participant will be able to apply the understand the utility in applying the Epworth Sleepiness Scale to healthcare workers. This is significant as the ESS has been used to measure fatigue in residents, however as our paper shows, HEMS pilots have higher scores highlighting excessive sleepiness.

### [285] TRANSCRANIAL ELECTRICAL STIMULATION TO SUSTAIN AVIATOR PERFORMANCE: THE EFFECTS OF TIMING OF STIMULATION AND INDIVIDUAL DIFFERENCES

Jordayne Wilkins, Kathryn Feltman

United States Army Aeromedical Research Laboratory, Fort Rucker, Alabama, United States



*(Original Research)*

**INTRODUCTION:** The U.S. Army Future Vertical Lift (FVL) program will yield advanced aircraft. These systems will likely include increased automation and be able to fly longer duration missions which means that aircrew will need to have longer durations of sustained attention. Due to automated features, aviators' level of system reliance will likely impact their performance and workload level, which puts them at risk of missing manual cues. Transcranial Direct Current Stimulation (tDCS) can aid aviator's attention by delivering a low intensity current (1 to 2 milliamps) to the brain through electrodes lasting up to one hour (Brunoni et al., 2012; Dedoncker et al., 2016). The electrodes are placed on the scalp at the location of the brain that manages the targeted behavior (or function). The main objective of this study was to test if tDCS can sustain aviators' performance due to its effects on alertness and attention.

**METHODS:** The study was a single-blinded, randomized, sham-controlled, mixed design to evaluate the main effects of stimulation and the time of delivery (prior to the flight and during the flight) on flight performance. Participants were randomly assigned to groups, with 10 participants in the preflight stimulation group, and 12 participants in the during flight stimulation group. A total of 18 questionnaires and cognitive tasks were used to assess individual differences that could impact performance outcomes and the duration of the simulation effects.

**RESULTS:** Significant differences were found between for approach performance in sham and active conditions. Those who received active stimulation during flight had a more precise approach compared to those who received active stimulation preflight. Inattentiveness and hyperactivity subscales and flight experience all limited the effect of tDCS on different areas of performance. **DISCUSSION:** The findings suggest that tDCS improves aviator's performance outcomes during attentional tasks and with stimulation applied during flight. This was important to determine whether tDCS can be used prescriptively during long duration flight missions that can decrease attention in a high-performance operation.

**Learning Objectives**

1. Participants will recognize the potential applicability of transcranial electrical stimulation in aviation operations.
2. Participants will understand the individual differences impacting the enhancement utility of transcranial electrical stimulation.

## **[286] A LITERATURE REVIEW OF THE ASSESSMENT OF QIGONG PRACTICES AND SUITABILITY FOR IMPLEMENTATION IN THE FATIGUE MANAGEMENT SERVICE**

Jessica Tedford<sup>1</sup>, Pamela Baskin<sup>2</sup>, Charles Dukes<sup>3</sup>

<sup>1</sup>Naval Aerospace Medical Institute, Pensacola, FL, United States;

<sup>2</sup>KBR, Houston, TX, United States; <sup>3</sup>UTMB, Galveston, TX, United States

*(Education - Tutorial/Review)*

**INTRODUCTION:** NASA operations has a far-reaching and ever-changing, real-time schedule. Many methods currently exist to increase mission effectiveness for astronauts and ground personnel alike. The Behavioral Health and Performance (BHP) group at NASA has recently been evaluating suitability for implementation of practices such as Qigong as part of their Fatigue Management Service (FMS) countermeasures for ISS crewmembers. The China National Space Administration and NASA both report sleep disturbances and chronic fatigue in current missions. The CNSA openly uses Traditional Chinese Medicine as an adjunct for sleep improvement and fatigue management. **TOPIC:** In this presentation, we review the history of Qigong in Traditional Chinese Medicine, previous medical research concerning its implementation, commonly used techniques, and suitability of available practices for incorporation into the Fatigue Management Service at NASA, International Space Station, long-range flights, and beyond. **METHODS:** Scientific papers (N=40) were reviewed and rated for applicability and suitability for the NASA FMS. An Overall Suitability rating from 1 (low) to 5 (high) was given for each paper with criteria of peer-review, randomization, and clear outlines of Qigong practices utilized with possible ability to recreate the activities in a zero-G

environment. **RESULTS:** Given the available information, four separate types of Qigong were recognized to have possible benefit for implementation: Baduanjin, Wu Qin Xi, Liu Zi Jue, and Waitankung. All have shown benefit for cardiovascular, pulmonary, sleep, and cognitive function in the studies reviewed. **APPLICATION:** With NASA's increasing focus on longer duration spaceflight missions on the ISS and long-range spaceflight both astronauts and ground crew will need greater adaptability and a full spectrum of available fatigue management strategies to improve performance. Chinese taikonauts have already begun to utilize this ancient and integrative practice. These forms of deep breathing, meditation, and body movement could be added to the FMS to enhance focus in body and breathing as well as mindfulness, which could mitigate chronic fatigue.

**Learning Objectives**

1. Participants will be introduced to the history of Qigong for the past 4,000 years and some of the practice of the technique.
2. Participants will understand the current medical evidence for use of Qigong practices in specific patient populations and the proven health benefits.
3. Participants will understand the likelihood of implementation of Qigong practice in the NASA FMS and how it might impact future studies.

## **[287] A STUDY ON THE EFFECT OF SURYANAMASKAR ON ORTHOSTATIC TOLERANCE AND NEUROVESTIBULAR FUNCTIONING UPON EXPOSURE TO SIMULATED MICROGRAVITY CONDITION**

Gaurab Ghosh, Rahul Pipraiya, Biswajit Sinha

Institute of Aerospace Medicine, Indian Air Force, Bangalore, India

*(Original Research)*

**INTRODUCTION:** Yoga has been widely accepted as a practice to modulate human physiology in varied professions. One of the fields of modern medicine where there is an adaptive physiological response is in the microgravity environment of space. Two important changes due to space adaptation are orthostatic intolerance and neurovestibular desynchronization. The study aimed to find out whether effective practice of *Suryanamaskar* was able to allay the cardiovascular and neurovestibular deconditioning that take place upon exposure to simulated microgravity. **METHODS:** Ten age-matched, healthy participants voluntarily took part in the study. Initial baseline readings of their responses to Head-up tilt and a disorientation run on Barany's chair to calculate the Coriolis Time Interval were taken. The responses were re-evaluated after exposure to 4 hours of simulated microgravity by Head-down tilt, before and after practice of *Suryanamaskar* for 21 days. The findings were then compared using repeated measures ANOVA and paired t-tests. **RESULTS:** Mean age of the participants was  $34.2 \pm 3.9$  years. The findings suggested that there were significant reductions in heart rate ( $-5.8$  beats/min), systolic blood pressure ( $-3.1$  mm Hg), mean arterial pressure ( $-2.8$  mm Hg) after yogic intervention on exposure to microgravity. The comparisons of diastolic blood pressure, Coriolis time interval and motion sickness rating scale evaluation pre and post *Suryanamaskar* practice did not yield statistically significant results. **DISCUSSION:** Yoga is an easy, economic, less space occupying, and effective way to mitigate the cardiovascular changes that take place in space and the outcome of this study gravitates its usefulness. However, repeated trials, both on ground and during short duration space missions, are necessary to validate the outcome and implement use of *Suryanamaskar*, both pre-flight and in-flight, as a countermeasure to microgravity induced physiological deconditioning.

**Learning Objectives**

1. To examine orthostatic tolerance and neurovestibular function after exposure to simulated microgravity before and after yogic intervention.
2. To compare the responses to explore the effects of selected yoga postures on cardiovascular and neurovestibular deconditioning in space.

**Wednesday, 05/25/2022**  
**Tuscany C,D,E**

**4:00 PM**

**[S-55]: PANEL: 12TH ANNUAL RAM BOWL**  
*Sponsored by the American Society of Aerospace  
 Medicine Specialists*

**Chair: Jan Stepanek**  
**Co-Chair: Allen Parmet**

**Panel Overview:** The 12th Annual RAM Bowl features teams from the Air Force, Navy/Army, Mayo Clinic, Wright State, UTMB 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.

**[288] THE 12TH ANNUAL RAM BOWL**

Allen Parmet<sup>1</sup>, Jan Stepanek<sup>2</sup>, Rebecca Blue<sup>2</sup>, Rahul Suresh<sup>2</sup>, Roy Allen Hoffman<sup>3</sup>, Joanna Nelms Nelms<sup>4</sup>, Walter III Dalitsch<sup>5</sup>, Mary Cimrmancic<sup>6</sup>

<sup>1</sup>University of Southern California, Kansas City, MO, United States; <sup>2</sup>Mayo Clinic, Scottsdale, AZ, United States; <sup>3</sup>U.S. Navy, Pensacola, FL, United States; <sup>4</sup>U.S. Air Force, Dayton, OH, United States; <sup>5</sup>U.S. Navy, Dayton, OH, United States; <sup>6</sup>Marquette University, Milwaukee, WI, United States

*(Education - Tutorial/Review)*

**OVERVIEW:** The 12th Annual RAM Bowl features teams from the Air Force, Army, Navy, Mayo Clinic, 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 competencies including the flight environment (atmosphere, radiation, vibration, acceleration), clinical aerospace medicine, aircraft and space vehicle systems/operations, accident investigation, historical events, 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 and bonus questions. Multiple rounds of competition will lead to the selection of this year's victor and awarding of team and individual trophies, 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.

**Wednesday, 05/25/2022**  
**Tuscany A**

**4:00 PM**

**[S-56]: SLIDES: VISION TOPICS**

**Chair: Benisse Lester**

**[289] THE HISTORY OF USAF VISION STANDARDS:  
 BACK TO THE FUTURE? – PART V**

Douglas Ivan<sup>1</sup>, Adrien Ivan<sup>2</sup>, Tomas Tredici<sup>3</sup>

<sup>1</sup>ADI Consultants, San Antonio, TX, United States; <sup>2</sup>Vernon College, Wichita Falls, TX, United States; <sup>3</sup>UTMB Health Sciences Center, San Antonio, TX, United States

*(Education - Tutorial/Review)*

**INTRODUCTION:** The fifth and final installment in this series tracing the historical origins of USAF aircrew vision standards will build on the aeromedical lessons learned from all previous military conflicts previously presented and address new challenges and requirements that impacted aeromedical standards after 1980. **TOPIC:** Among the topics to be discussed will be: the mid-1970s liberalization of U.S. Air Force Academy entry requirements that impacted myopia selection criteria and spawned the practice of *orthokeratology*; development of an *improved aircrew spectacle* (IAS) frame program to address safety deficiencies of the DoD's triservice aircrew frame (HGU-4/p); lessons learned from the *1995 Aircrew Operational Vision Survey*, the largest and most successful DoD aircrew survey ever accomplished; the USAF's *Medical Flight Screening* program, including its comprehensive color vision testing paradigms and generation of two new *USAF Surgeon General Study Groups* involving the *topographical pattern suggestive of early keratoconus (TPSK)* and defective stereopsis/microtropia/monofixation; and development of the *Rabin Cone Contrast Test (CCT)* color vision screening test. **APPLICATION:** This presentation will highlight the key aeromedical vision standard and policy developments related to the above issues. It will span the period from 1980 up through 2011, when the *Base Realignment and Closure (BRAC)* process closed USAFSAM facilities at Brooks Air Force Base, Texas and moved them to new facilities at Wright-Patterson Air Force Base, Ohio.

**Learning Objectives**

1. The audience will learn about: The historical foundation of USAF aeromedical flying selection policies and standards.
2. The audience will learn about: The technological developments that influenced USAF flying standards during the period under discussion.

**[290] OPERATIONAL NVG FLYING: TIME TO VISUAL  
 ADAPTATION UNDER VARIOUS ILLUMINATION CONDITIONS  
 POST DE-GOGGLING**

Binu Sekhar Miraj, Vijay V. Joshi, Neeraj Kumar Tripathy  
*Institute of Aerospace Medicine, Bangalore, Karnataka, India*

*(Original Research)*

**INTRODUCTION:** NVG display brightness, being at upper mesopic to lower photopic range, is the cause for impairment in visual adaptation to ambient light levels. The duration for visual adaptation with respect to ambient illumination levels during night flying has not been well quantified. The information, if available, would provide the aviator with further guidance to achieve optimum vision as per the operational scenario. This study was planned to estimate the duration for visual adaptation following post-de-goggling during NVG flying. **METHOD:** 14 subjects (11 males and 3 females) with normal visual acuity and color perception participated in the study. ANVIS Gen 2++ NVG was used for aided night vision and USAF 1951 Tribar chart was used to measure visual acuity. Baseline unaided visual acuity was recorded for a full moon, half-moon, and quarter moonlight levels. Duration to achieve the baseline visual acuity of respective moonlight conditions after 10 minutes of NVG use at the same light scenario was measured as visual adaptation time for that light scenario. **RESULTS:** The recorded mean unaided visual acuity was 20/266, 20/96, and 20/74 for the quarter, half, and full moon respectively. The aided visual acuity was 20/41, 20/37, and 20/34 for the quarter, half, and full moon respectively. The post-de-goggling visual adaptation times were 5 min 55 sec ( $\pm 1$  min 02 sec), 2 min 20 sec ( $\pm 1$  min 22 sec), and 1 min 23 sec ( $\pm 32$  sec) respectively for the quarter, half, and full moon ambient light conditions. The adaptation time to quarter moonlight was found significantly different from half and full moonlight while the difference in adaptation time between half and full moonlight was found insignificant. **DISCUSSION:** The duration for visual adaptation after de-goggling of NVGs in different light scenarios of night flying has been quantified in this study. The adaptation time to ambient light post-de-goggling was inversely proportional to moonlight intensity

levels. The findings of this study would provide guidance to aviators on taking requisite cautionary measures post-de-goggling following NVG flying.

#### Learning Objectives

1. The audience will learn about the importance of dark adaptation in night flying and the flight safety implications related to Physiological limitations pertaining to visual adaptation.
2. The audience will learn about the methodology adopted for a realistic assessment of dark adaptation by simulating different moonlight intensities as encountered during NVG flying.
3. The audience will learn about the varied durations of visual adaptation after discontinuation of NVG use and the same information can be disseminated to aircrew to improve flight safety related to NVG flying.

### [291] COMPARISON OF CONE CONTRAST TEST (CCT) TEST-RETEST RELIABILITY

Marc Winterbottom<sup>1</sup>, James Gaska<sup>1</sup>, Eleanor O'Keefe<sup>2</sup>, Elizabeth Shoda<sup>2</sup>, Eric Seemiller<sup>2</sup>, Jonelle Knapp<sup>1</sup>, Steven Hadley<sup>1</sup>

<sup>1</sup>Air Force Research Laboratory, Airman Systems Directorate, Wright-Patterson AFB, OH, United States; <sup>2</sup>KBR, Beavercreek, OH, United States

#### (Original Research)

**INTRODUCTION:** Good test-retest reliability is essential to predict relevant performance (e.g. flying performance) and maintain sensitivity/specificity. The cone contrast test (CCT) has been used since 2011 for aircrew color vision screening. However, there are very little test-retest reliability data. This research compares test-retest reliability of four versions of the CCT: 1) Innova Systems, v18 (New Innova), 2) Innova Systems, v13.11 (Old Innova), 3) NCI Vision Systems, v14 (NCI), and 4) Konan Medical CCT-HD, v1.0.0.1 (Konan). **METHODS:** Monocular CCT scores were measured for L-, M-, and S-cones for 67 subjects. Each subject repeated each test 4 times: 1) right eye (OD) day 1; 2) left eye (OS) day 1; 3) OD day 2; and 4) OS day 2. We used a Bland-Altman analysis to compare the 95% limits of agreement (LOA) for Test 1 and Test 2 for each of the 4 tests and for each eye. A reliable test will result in a narrower LOA. **RESULTS:** Averaged across OD and OS, the LOAs for the Konan, New Innova, Old Innova, and NCI were, respectively, 19.1, 21.1, 29.3, and 30.3 for the L-cone; 21.4, 23.6, 28.9, and 30.8 for the M-cone, and 35.6, 20.1, 21.2, and 13.4 for the S-cone. Thus, LOAs were lowest (i.e. best test-retest reliability) for the Konan L- and M-cone tests. For the S-cone, the Konan had the largest LOAs. However, there was a large ceiling effect for the S-cone test for both the Innova and NCI tests, with approximately 50% of subjects scoring at the maximum value of 100 for both Innova CCTs, and 84% of subjects scoring at the maximum value of 100 on the NCI CCT. **DISCUSSION:** All of the CCTs have been shown to reliably screen for color deficiency (for pass/fail criterion of 75). However, only the Konan CCT-HD provides high test-retest reliability for L- and M-cones and can fully characterize both color deficient and color normal individuals to support Air Force Medical Service objectives to develop better, more diagnostic, threshold-level aeromedical tests. The results of this research suggest that additional research is needed to examine the utility of S-cone testing.

#### Learning Objectives

1. The audience will learn about the importance of test-retest reliability for clinical/laboratory tests.
2. Understand differences between commercially available color vision screening tests used for occupational/aeromedical screening.

### [292] TEMPORALLY LOCAL EFFECTS OF ACUTE HYPOXIA EXPOSURE ON STEREOACUITY

Eric Seemiller<sup>1</sup>, Bonnie Posselt<sup>2</sup>, Marc Winterbottom<sup>2</sup>, Kara Blacker<sup>3</sup>, Kyle Pettijohn<sup>3</sup>, Steve Hadley<sup>2</sup>

<sup>1</sup>KBR, Inc., Dayton, OH, United States; <sup>2</sup>711th Human Performance Wing, U.S. Air Force, Wright-Patterson AFB, OH, United States; <sup>3</sup>U.S. Navy, Wright-Patterson AFB, OH, United States

#### (Original Research)

**INTRODUCTION:** Though a number of experiments have suggested a coarse relationship between acute hypoxia exposure and measurements of early visual function, including spatial and color vision, few have investigated temporally local, event-related effects. While peripheral oxygen saturation (SpO<sub>2</sub>) decreases monotonically with hypoxia, the decay may be inconsistent and punctuated by local peaks and troughs. Do these small, rapid changes relate to corresponding changes in visual function? To answer this, we investigated the temporally local effects of changing SpO<sub>2</sub> on stereoacuity thresholds. **METHODS:** Hypoxia was induced in 12 participants using a Reduced Oxygen Breathing Environment with 9.7% oxygen mix for 15 minutes (equivalent to approx. 20,000 ft). This led to an unsteady and noisy decay in SpO<sub>2</sub>, during which they were continuously presented with discrete disparity discrimination trials to assess binocular vision function. Participants were asked to identify which of 4 circle targets appeared in front of the plane of the display. This allowed for continuous estimation of stereoacuity threshold over time by fitting a log-Weibull function to a moving window of psychophysical results. **RESULTS:** After converting the time series vectors of SpO<sub>2</sub> decay and stereoacuity threshold into normalized local velocity, we computed the global cross-correlation between the two. This generates a correlation vector as a function of temporal lag between the two measures. 75% of participants experienced a measurable change in stereoacuity between 10 and 45 seconds after a change in SpO<sub>2</sub>, more than would be predicted through chance. The change was always in the opposite direction of the change in SpO<sub>2</sub>; as peripheral oxygen saturation levels decreased, stereoacuity thresholds degraded. **DISCUSSION:** This experiment demonstrates a novel technique for quantifying event-related changes in visual function specifically related to changing atmospheric conditions. We show that beyond sustained exposure to hypoxia, even small changes in SpO<sub>2</sub> can lead to quantifiable, event-related changes in stereoacuity threshold. This methodology can be used cross-modally to investigate rapid changes in brain function related to external events and could provide a new method for understanding the effect of rapid changes in the aviation environment on human performance.

#### Learning Objectives

1. Understand the temporal relationship between binocular visual function and hypoxia.
2. Consider a novel analysis method comparing two time series, one sensory and one ecological.

### [293] HUMAN PERFORMANCE USING STEREO SYMBOLOGY IN A HELMET MOUNTED DISPLAY AND ASSOCIATION WITH INDIVIDUAL STEREOACUITY

Bonnie Posselt<sup>1</sup>, Eric Seemiller<sup>2</sup>, Geno Imel<sup>2</sup>, Marc Winterbottom<sup>1</sup>, Steve Hadley<sup>1</sup>

<sup>1</sup>711th Human Performance Wing, U.S. Air Force, Dayton, OH, United States; <sup>2</sup>KBR, Dayton, OH, United States

#### (Original Research)

**INTRODUCTION:** Binocular Helmet Mounted Displays (HMDs) are a critical part of the aircraft system, allowing information to be presented to the aviator with stereoscopic 3D (S3D) depth, potentially enhancing situational awareness and improving performance. The utility of S3D in an HMD may be linked to an individual's ability to perceive changes in binocular disparity (stereoacuity). Though minimum stereoacuity standards exist for most military aviators, current test methods may be unable to characterize this relationship. **METHODS:** 43 participants performed a simulated flying task while differentiating between two warning alerts appearing in their HMD. Warning alerts were presented in four different conditions of stereo depth: 2D (flashing at 2 Hz), intermittent S3D (flashing on/off at depth), persistent S3D (alternating between 2 depth planes), and dynamic S3D (oscillating sinusoidally in depth). Both physiological measurements (peripheral skin temperature and heart rate) and subjective



questionnaires were used to assess workload. Stereoacuity was tested with two novel digital disparity discrimination tests along with the analog TNO test, which is currently used by the British military to select aircrew. **RESULTS:** No significant difference in throughput (accuracy divided by response time) was found between the four conditions. Though peripheral skin temperature decreased in all conditions, suggesting an increase in cognitive load, there was no specific relationship to S3D presentation. Interestingly, despite no significant relationships between performance and individual stereoacuity, those with poorer stereoacuity exhibited significantly greater increases in heart rate and reported greater levels of workload. In addition, computer-based test were able to measure stereoacuity to threshold and eliminated a number of limitations seen with the TNO test.

**DISCUSSION:** The addition of S3D to warning alert symbology does not improve performance but may be associated with an increase in workload in those with poorer stereoacuity. These results do not necessarily support incorporating stereo symbology in an HMD for a warning alert or altering current stereoacuity standards. Without precise and repeatable vision screening tests, the relationship, or equally important, lack of relationship, between vision and operational performance cannot be determined. Thus, improved stereoacuity testing with computer-based threshold measures is still endorsed.

#### Learning Objectives

1. Use of Helmet Mounted Displays in military Aviation and different applications.
2. The limitations of current military stereoacuity test methods and selection standards.

**Wednesday, 05/25/2022**  
**Tuscany B**

**4:00 PM**

## [S-57]: SLIDES: SWEET & SALTY: TOPICS IN DIABETES AND AGING

**Chair: Joyce Pastore**

### [294] EXPERIENCE AND RESEARCH ADDRESSES CONCERNS ABOUT PILOTS WITH INSULIN TREATED DIABETES FLYING

Ewan Hutchison

United Kingdom Civil Aviation Authority, Gatwick Airport, United Kingdom

(Education - Tutorial/Review)

**INTRODUCTION:** When the UK proposed a research protocol through which medical certificates could be issued to pilots with insulin treated diabetes, other National Aviation Authorities were concerned about the risks to flight safety. Entry into the protocol is tightly controlled and those pilots who are issued with certificates are regularly monitored. Ireland and Austria joined the protocol and we are reviewing and publishing data. **TOPIC:** Measuring capillary blood glucose can be done efficiently by pilots who are used to monitoring their diabetes this way. It may be more convenient to use continuous monitoring systems and this is currently permitted in the USA. Studies are underway in our protocol to assess the effectiveness and accuracy of CGMS in our cohort of pilots, many of whom already use CGMS alongside the capillary measurements required by the protocol. Pilots' logbooks and glucometer data are regularly reviewed and no pilot has thus far recorded a blood glucose measurement in the hypoglycaemic range. The protocol includes a buffer zone ("low red") for acting before blood glucose drops sufficiently to be classed as hypoglycaemic. Of the 38,621 readings reported so far, only 48 were in the low red range and the 14 of those that occurred in-flight all corrected to the normal "green" range by the time of next measurement. Following up pilots within the protocol for a mean duration of 4.3 years there was no significant change in glycaemic control when comparing their HbA1C at the point they joined against their most recent measurement. Of the 9,189 flights recorded in the protocol thus far, none have been delayed, cancelled or rerouted because of a pilot's blood glucose. Further developments in the

management of diabetes offer better management and monitoring of diabetes which will lower residual risks further. **APPLICATION:** The UK, Ireland and Austria's diabetes protocol enables the safe issuance of medical certificates to pilots with insulin treated diabetes.

#### Learning Objectives

1. The audience will learn about how in-flight hypoglycaemia is avoided in pilots with insulin treated diabetes.
2. The audience will learn about the impact of strict adherence to diabetes protocols for flying on overall glycaemic control in pilots with insulin treated diabetes.

### [295] RISK MANAGEMENT OF INSULIN TREATED DIABETICS IN CANADA

Rani Tolton<sup>1</sup>, Edward Brook<sup>2</sup>

<sup>1</sup>Transport Canada, Vancouver, British Columbia, Canada;

<sup>2</sup>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.

### [296] CHARACTERIZATION OF PILOTS APPLYING FOR FIRST/SECOND CLASS MEDICAL CERTIFICATION THROUGH THE FAA INSULIN TREATED DIABETES MELLITUS (ITDM) PROTOCOL

Lynn Stanwyck<sup>1</sup>, James DeVoll<sup>2</sup>, Joyce Pastore<sup>2</sup>, Anna Poe<sup>2</sup>, Gabrielle Gui<sup>2</sup>, Zykevis Gamble<sup>2</sup>

<sup>1</sup>Office of Aerospace Medicine, Federal Aviation Administration, and Virginia Tech Carilion School of Medicine, Washington, DC, United States; <sup>2</sup>Federal Aviation Administration, Washington, DC, United States

(Original Research)

**INTRODUCTION:** Insulin treated diabetes mellitus (ITDM) provides a challenge to medical certification due to variability in pathogenesis, clinical presentation, treatment, side-effects, complications and concerns for hypoglycemia. Since 1996, the Federal Aviation Administration (FAA) has certificated third class pilots with ITDM. In November 2019, the FAA announced a new protocol to evaluate pilots with ITDM for special issuance (SI) medical certification for first-/second-class pilots. The program aim is

improved assessment of ITDM control and risk for hypoglycemia. Criteria includes clinical stability for at least 6 months on the current treatment regimen, based in part on continuous glucose monitoring (CGM) data. This study compares the characteristics of pilots with ITDM and certification outcome (issued or denied a first-/second-class medical certificate) under the program. **METHODS:** Data was collected retrospectively from the FAA Document Imaging Workflow System (DIWS) for pilots considered for a first-/second-class SI under the ITDM program between November 2019 and October 2021. Inclusion criteria required submission information specified under the program (including CGM data) leading to a certification decision (SI vs. denial). We extracted de-identified data on demographics and CGM parameters including mean glucose, standard deviation, coefficient of variance (CoV), time in range (%), time > 250mg/dl (%), time less than 70-80 mg/dl (%) and device wear (%). We compared these parameters between pilots issued a SI vs. denial with t-tests and chi-squared tests using R. **RESULTS:** Of 200 pilots with ITDM identified in DIWS, 77 met inclusion criteria. 55 received SIs and 22 were denied. Pilots issued SI were older (45 versus 33 years old,  $p = 0.001$ ), had a lower hemoglobin A1c (6.41% versus 7.09%,  $p < 0.001$ ), lower average glucose (138 mg/dl versus 158 mg/dl,  $p < 0.001$ ), and lower CoV (25.9 versus 33.2,  $p < 0.001$ ), and spent less time with low (1.6% versus 3.0%,  $p = 0.008$ ) glucose levels.

**DISCUSSION:** The FAA program has successfully medically certificated pilots with ITDM for first-/second-class. Pilots granted an ITDM SI reflect significantly better diabetes control, including less time at glucose levels concerning for hypoglycemia. The risk assessment process identifies pilots with good control considered acceptable for medical certification. As this program continues and evolves, it will potentially allow many previously disqualified pilots to fly safely.

#### Learning Objectives

1. The audience will learn about the FAA's new ITDM protocol used to assess the level of risk for pilots seeking first/second class medical certification.
2. The audience will be able to describe clinical characteristics of a successful applicant for a first or second class medical certificate under the ITDM protocol.

### [297] MENOPAUSE IN AVIATION: SUPPORTING THE CLIMACTERIC TRANSITION AS A NORMAL PART OF WOMEN'S FLYING CAREER

Catherine Wilkinson<sup>1</sup>, Elaine Rutland<sup>2</sup>, Jemma Austin<sup>3</sup>

<sup>1</sup>Royal Air Force College, Cranwell, United Kingdom; <sup>2</sup>Royal Air Force Centre of Aviation Medicine, Henlow, United Kingdom; <sup>3</sup>Royal Air Force Centre for Air and Space Power Studies, Shrivenham, United Kingdom

(Education - Tutorial/Review)

**INTRODUCTION:** Women over the age of 45 are the fastest growing demographic in the UK workforce. ICAO predict a doubling of aircrew requirement by 2047. The RAF are seeking a 20% female workforce by 2030. However, current data from the CAA medical certificate holder database demonstrates that whilst there has been a three-fold increase in female AT medical certificate holders since the year 2000, these women are not being retained into their senior years, compounding pilot shortages.

**TOPIC:** CAA data demonstrates a pattern of retirement 10 years earlier than male certificate holders, a stable phenomenon for the past 20 years. Women are not being retained in significant proportions into the second half of their flying careers, undoing efforts to improve female diversity through recruitment strategies. Study findings from UK doctors may provide some explanation, identifying that women are leaving the medical workforce early due to anxiety around the impact of menopausal symptoms on their role and stigma in seeking help and support during this period. Menopause is a normal transition period for all aircrew who have had ovaries and some of the common symptoms are of aerospace-medical relevance. AMEs have an essential role in informing and supporting aircrew through the climacteric period and in shaping aligned fitness-to-fly policies within military and civilian flying. However, a literature review would suggest that this topic is at present largely absent within aerospace medical literature, research and guidance. **APPLICATION:** The tutorial will

focus on the role of the AME in providing aeromedical interpretation of clinical advice around the menopause to their aircrew and in shaping policy around the menopause within aerospace workplaces. With the average age of menopause occurring age 51 with a range of 45-55, women have a potential 20-year career window where menopausal awareness is advantageous to the AME. A combination of workplace, lifestyle and medical treatments are available to support women so they can continue successfully flying well past the menopause.

#### Learning Objectives

1. Prepare AMEs to actively support female aircrew throughout their menopausal transition through review and analysis of clinical literature relevant to aerospace medicine.
2. Understand treatment modalities relevant to the menopause including their safety and applicability in aerospace medicine.
3. Consider the application of existing workplace-based menopausal policies and guidance into military and civilian aerospace workplaces.

### [298] STUDY ON THE HEALTH STATUS AND OUTCOME OF AGING PILOTS OF A JAPANESE MAJOR AIR CARRIER DURING THE 5 YEARS FROM 60 YEARS OF AGE

Kazunori Takazoe, Hideho Gomi

Japan Aeromedical Research Center, Tokyo, Japan

(Original Research)

**INTRODUCTION:** It is a critical issue whether or not aging pilots over 60 can continue flying maintaining their health. In Japan, pilots wishing to be engaged in flight operation beyond age 60 must undergo medical examination in addition to regular aviation medical examination (additional aviation medical examination, AAME) and fulfil the criteria. The purpose of the study is to clarify health status and outcome of aging pilots. **METHODS:** Data from aging pilots from a Japanese major air carrier who had an initial AAME at age 59 or 60 at Japan Aeromedical Research Center during the 6 years from 2008 to 2013 were analyzed for 5 years from age 60 regarding occurrence of disqualifying diseases, application for and decision by Aviation Medical Review Board (AMRB), and dropouts due to medical reasons after the initial AAME. **RESULTS:** Two hundred and sixty-two aging pilots were included. There were 17 cases disqualified at the initial AAME (8 in cardiology, 8 in central nervous system (CNS), 1 in ophthalmology, 1 in otorhinolaryngology). All of them applied for AMRB for decision and 16 cases obtained conditional qualification (special issuance) with pass rate of 94.1%. The disqualified case was due to suspected spinocerebellar degeneration. Sixty-one cases including 28 in cardiology, 15 in gastroenterology and 14 in ophthalmology had already been conditionally qualified by AMRB before becoming aging pilots, all of whom were again conditionally qualified at the time of initial AAME. Forty-four cases developed disqualifying conditions (including 25 in cardiology, 6 in CNS, and 6 in ophthalmology) during the 5-year period after the initial AAME. Among them, 39 cases obtained conditional qualification by AMRB (pass rate 88.6%). Disqualified cases consisted of 3 heart and 2 lung diseases. Furthermore, 29 cases gave up flying duties halfway for medical reasons including 10 in cardiology and 4 in CNS without application for AMRB. Aging pilots not able to complete the 5 years for medical reasons comprised 34 cases (13.0%). **Discussion:** In this study, nearly 90% of aging pilots above 60 maintained their health or returned to work even if they developed some illness during their career.

#### Learning Objectives

1. The participant will be able to understand the health status of Japanese aging pilots for the 5 years from 60 years of age from a major air carrier.
2. The participant will learn about disease characteristics in Japanese aging pilots and their outcome during the 5 years.

### [299] TAKOTSUBO CARDIOMYOPATHY/SYNDROME IN A PRIVATE PILOT: A CASE REPORT

Ganesh Anbalagan

Civil Aviation Safety Authority, Australia, Canberra, Australia

*(Education - Case Study)*

**INTRODUCTION:** This case report describes a private pilot with Takotsubo Cardiomyopathy/Syndrome (TTS), the aeromedical implications and the approach to medical certification. **BACKGROUND:** TTS is a syndrome characterized by transient regional systolic dysfunction of the left ventricle, mimicking acute coronary syndrome, but in the absence of angiographic evidence of obstructive coronary artery disease or acute plaque rupture.

**CASE PRESENTATION:** A 70-year-old male private pilot experienced chest discomfort while he was trying to open the aircraft hangar doors. They were not associated with any other symptoms or exertion. His ECG showed an inferolateral ST elevation and left axis deviation. His Troponin was elevated. His ECGs did not evolve. His coronary angiogram showed mild to moderate coronary artery disease with no flow-limiting lesion. The left ventriculogram showed mild segmental systolic dysfunction with apical hypokinesis and ballooning and preservation of basal and lateral function. Echocardiogram findings were similar to what was noted on the ventriculogram. A follow-up resting echocardiogram and stress echocardiogram performed 3 weeks later, showed restoration of normal left ventricular systolic function with no evidence of inducible myocardial ischaemia. The findings were consistent with TTS. **DISCUSSION:** Symptoms of TTS can cause subtle or overt incapacitation. Aeromedical concerns include the risk of recurrence of TTC, increased risk of major adverse cardiac events, and in some patients prolonged impairment reflecting impaired myocardial energetics, ongoing inflammation, and variable fibrosis. Current literature reports a recurrence rate of 1.8%, with no significant relationship between presenting features and the subsequent recurrence. Long term follow-up of patients with TTS revealed a rate of death from any cause of 5.6% per patient-year and a rate of major adverse cardiac and cerebrovascular events (MACCE) of 9.9% per patient year, with men at higher risk than women. Most recurrences and adverse outcomes were documented in the early years after the index TTS episode. The case was discussed in the CASA's Complex Case Management panel, and he was issued with a restricted medical certificate with surveillance requirements and to fly with safety pilot only. After 12 months period of stability, safety pilot restriction on his medical certificate was removed.

**Learning Objectives**

1. The audience will learn about the pathophysiology and aeromedical concerns of Takotsubo Cardiomyopathy/Syndrome.
2. The audience will learn about the approach to assessment of fitness for a Civil Aviation Medical Certificate for a pilot diagnosed with Takotsubo Cardiomyopathy/Syndrome.

**Wednesday, 05/25/2022****4:00 PM****Tuscany F****[S-58]: SLIDES: "SANS SARS": COMING BACK POST COVID****Chair: Sarita Dara****Co-Chair: Carol Ramsey****[300] DEVELOPMENT AND EVALUATION OF AN EVIDENCE-BASED POLICY FOR RETURN-TO-FLIGHT POST-COVID-19 IN THE ROYAL CANADIAN AIR FORCE (RCAF)**Victoria Tucci<sup>1</sup>, Melissa Gear<sup>2</sup>, Phil Laird<sup>3</sup>, Erin Smith<sup>4</sup>, Joan Saary<sup>5</sup>

<sup>1</sup>McMaster University, Hamilton, Ontario, Canada; <sup>2</sup>Canadian Armed Forces, Winnipeg, Canada; <sup>3</sup>Canadian Field Hospital and Queen's University, Kingston, Canada; <sup>4</sup>Canadian Forces Environmental Medicine Establishment (CFEME), Toronto, Canada; <sup>5</sup>University of Toronto and Canadian Forces Environmental Medicine Establishment (CFEME), Toronto, Canada

*(Education - Tutorial/Review)*

**INTRODUCTION:** A recent review (Tucci, Saary, in-press) highlighted persistent and emergent sequelae among mild COVID-19 (C-19) cases. Given the multiple organ systems affected, and sequelae that may be unrecognized without additional testing, development of an evidence-based policy for return-to-flight post-C-19 was paramount for risk

mitigation. However, policy development alone is insufficient; it is also critical to review the effectiveness of a screening program to identify high-risk cases, false-positive investigations, and the clinical and operational resource implications of enhanced post-disease screening. This enables quality improvement through amended surveillance strategies. **TOPIC:** Health effects of C-19 beyond the post-acute recovery period may go unrecognized, especially in mild cases and physically fit individuals. This demographic aligns with safety-sensitive occupational populations, including RCAF aircrew. Consequently, fitness for flight duty decisions necessitated consideration of possible multi-system sequelae informed by screening and surveillance protocols to maintain predictably low risk for causes of subtle or sudden incapacitation. Participants will learn the process of translating evidence into policy development and subsequent quality improvement measures as we describe the Canadian Armed Forces (CAF) experience developing a Flight Surgeon Guideline (FSG) for return-to-flight decisions among post-C-19 RCAF aircrew and measuring its post-implementation effectiveness. This session will outline the Canadian clinical policy strategy including diagnostic factors and clinical evaluations for promoting the health and performance of RCAF aircrew related to C-19 infection. **APPLICATION:** By discussing how the evidence was applied, audience appreciation and understanding of evidence-based clinical policy implementation on post-acute C-19 infection sequelae patterns and effectiveness of screening and ongoing surveillance will be achieved by describing (1) development and modification of the FSG-100-05 for return-to-flight decisions post-C-19 infection for the CAF, (2) quality improvement review and measures to determine effectiveness.

**RESOURCES:** (1) Tucci V, Saary J. Persistent and Emergent Clinical Sequelae of Mild COVID-19. *Aerospace Med Hum Perform*. 2021; 92(11):1-8. (2) FSG 100-05 AIRCREW MEDICAL FITNESS POST COVID-19. Canadian Armed Forces, Aerospace Medicine Authority; 2020. Available at <https://www.aerospacemedicine.ca/FSG100-05.pdf>.

**Learning Objectives**

1. Participants will gain insight into and understanding of how to translate clinical COVID-19 sequelae findings into post-COVID-19 infection return-to-work screening and surveillance policies for safety-sensitive occupations to mitigate the risk of sudden and/or subtle incapacitation.
2. Participants will develop an awareness and applied understanding of the relevant diagnostic factors and clinical evaluation(s) for post-COVID-19 infection return-to-work screening and surveillance policies.
3. Participants will learn how an evidence-based decision-making process was applied to modify, and update, the FSG 100-05 to account for potential persistent and emergent COVID-19 sequelae when making return-to-work and fitness-to-fly decisions.

**[301] THE RAPID DEVELOPMENT OF A RETURN TO FLYING AND CONTROLLING POLICY FOR UK MILITARY AIRCREW FOLLOWING COVID-19 INFECTION**

Elaine Rutland

RAF Centre of Aviation Medicine, RAF Henlow, United Kingdom

*(Education - Program/Process Review)*

**BACKGROUND:** The impact of COVID-19 on aircrew fitness to fly necessitated rapid research and review of the aviation medical risk of the disease and the vaccination programme. The approach to this research and rapid development of the process for returning aircrew to flying holds valuable lessons for the development of other fitness to fly policies and potential lessons for any other novel diseases that may occur in future.

**OVERVIEW:** The novel nature of COVID 19 presented a significant risk in terms of assessing aircrew fitness to fly along with the rapidly developed and emergency approved vaccinations and the unknown recovery timelines. In order to ensure that COVID-19 had the minimal possible impact on operational effectiveness of UK military aviation a review of the following was undertaken to better understand and quantify the risk: ongoing and updated scientific and medical literature on the disease; evolving disease experience from the UK Defence COVID Recovery Service; submissions for emergency licensing for the COVID vaccinations; benchmarking from International civilian and military aviation



organisations and the experiences within the UK military aviation in general. The RAF Command Flight Medical Officer individually managed the return of over 300 aircrew to flying continually reviewing the safety and effect of the policy approach incrementally reducing the time off flying following COVID recovery. There were no adverse sequelae from the return of any of the aircrew (or controllers) to flight status. **DISCUSSION:** This individualised approach permitted a rapid return of aircrew to flying duties as soon as they were individually fit enough to do so and facilitated the rapid development of a policy that was both safe and minimised adverse operational effect. Whilst this approach is demanding in resource requirements, it demonstrates the value of ongoing review of rapidly developed policy in order to optimise safety and how the central management of such a novel approach in the initial stages can mitigate risk whilst optimising operational effect.

#### Learning Objectives

1. To understand the process followed that facilitated rapid policy development of a novel disease in order to be able to better appreciate the pros and cons of this and be able to apply elements of this to further process or policy development.
2. To understand the balance between resource intensive individualised approach to aircrew fitness to fly by a subject matter expert and the more generalised policy approach of returning aircrew to flying designed to be followed by a more generalist Av Med practitioner and the benefits and drawbacks of both approaches.
3. To understand the development and approach of UK military aviation to returning aircrew to flying post COVID-19 infection.

### [302] LOSS OF MISSION READINESS: FALSE POSITIVE COVID TESTS

Walter Dalitsch

Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, United States

(Original Research)

**INTRODUCTION:** During the height of the COVID-19 pandemic, the military introduced the concept of Operational Risk Reduction (ORR) in order to meet mission requirements in the face of quarantine requirements. If a commander deemed an individual essential to a specific mission objective, that individual could be released from an otherwise mandatory quarantine early if completing a negative (i.e., non-detectable) polymerase chain reaction (PCR) test. **CASE DESCRIPTION:** Command-directed ORR was conducted on two individuals required for a flying mission who were in quarantine in Italy after having recently traveled from the U.S. They were both asymptomatic and other than travel had no other specific risk factors for COVID. To be released from quarantine, both individuals underwent PCR testing. However, both resulted in a positive test, adding an additional two weeks of isolation to their quarantine. As part of the public health epidemiologic investigation, a thorough two-week history was conducted, and serial COVID serum immunoglobulins were collected. Based on the history and test results, the conclusion was that the first individual was a post infection non-infectious viral particle "shedder," and the second individual was a false positive due to environmental contamination. As neither test was a true positive, neither individual should have required additional isolation, which had an obvious negative impact on mission execution. **DISCUSSION:** The shortfall of PCR is that it can result in a false positive from detection of an incomplete, i.e., non-viable, viral genome. The emergency use authorization (EUA) for PCR was specifically intended for clinical use, not the asymptomatic population at large, resulting in a potentially significant drop in positive predictive value of the test. Although this case report consists of only two individuals, this interesting epidemiologic consideration brings into question the accuracy of the actual number of positive COVID "cases" worldwide.

#### Learning Objectives

1. The audience will learn how the polymerase chain reaction (PCR) detects viral genome but not living virus.
2. The audience will learn how use of equipment intended for clinical use can have a negative impact on mission accomplishment when used for purposes other than authorized uses.

3. The audience will learn how positive predictive value falls when clinical equipment is applied to the asymptomatic general population.

### [303] DIVING AFTER SARS-COV-2 INFECTION: A SURVEY

Brian Pinkston, Cheryl Lowry

Kinetic Adventure Medical Education/Kinetic Consultants, St. Petersburg, FL, United States

(Original Research)

**INTRODUCTION:** As the COVID-19 pandemic evolves, many recreational and professional scuba divers are questioning the safety of returning to scuba diving after SARS-CoV-2 infection. This presentation will consist of the results of survey of 12 recreational scuba divers, some of whom had experienced mild to moderate symptoms based upon the UCSD operational diving classification. The long-term sequelae of SARS-CoV-2 infection are still not fully understood, making it difficult to determine when divers can safely return to diving. The pulmonary, cardiac and thromboembolic pathophysiologic effects of this disease are relevant to scuba divers. A survey was performed to determine any disparity in diving outcomes between military veteran divers who had been diagnosed with COVID and those who had not. **METHODS:** Divers completed a 20-question survey regarding SARS-CoV-2 prior infection and symptoms associated with diving post-COVID. This survey was not used as a screening criteria for participation. The questions categorized the severity of disease based upon criteria developed by UCSD. **RESULTS:** This presentation will discuss a small cohort of divers who participated in a veterans' challenge. 75% of the participants in the survey had experienced COVID infection with one experiencing moderate symptoms in the year prior to the event. All completed the challenge with multiple dives up to 60 feet without sequelae. Therefore, within this population, there was no statistically significant diving outcome difference between divers who had COVID infection and those who had not. **DISCUSSION:** A literature review revealed no consensus opinion about returning to diving following COVID-19. The presentation will review important focus areas for this post-COVID-19 scuba diving medical examination, including recommended imaging and additional testing. While it could be argued that recreational divers never "need" to dive, it is reasonable to expect that these divers are anxious to return to the water. Additionally, scientific and occupational divers have ongoing missions where their work is required. UCSD proposed criteria that were theoretically reasonable in 2020. Ongoing studies seek to test the validity of this methodology for returning to dive after SARS-CoV-2 infection. While this was a small sample, these results suggest that it is possible to safely return to scuba diving after mild (and potentially moderate) COVID infection.

#### Learning Objectives

1. The audience will learn about the methodologies for assessing fitness for diving after SARS-CoV-2 infection.
2. Attendees will be able to describe COVID-19 health concerns related to scuba diving.

### [304] SPREAD OF B.1.617.2 MUTATION OF NOVEL CORONA VIRUS SARS-COV-2 AMONG PERSONEL OF MIXED VACCINATION STATUS DURING OUTBREAK ON TEMPORARY DUTY TRAVEL

Cameron Conard

325th Medical Group, Tyndall AFB, FL, United States

(Original Research)

**INTRODUCTION:** This case study describes an outbreak of SARS-CoV-2 strain B.1.617.2 among 246 personnel during temporary duty travel (TDY) in Summer, 2021. **BACKGROUND:** Emergence of the novel coronavirus, SARS-CoV-2, as a global pandemic has caused major impacts to Uniformed Services operations and missions. Initially, the hierarchy of controls served as the best prevention against the spread of COVID-19. Development of COVID-19 vaccines brought added protection but relaxation of prior initial measures. **CASE PRESENTATION:** On 10 Jul 2021, 246 individuals from two installations went TDY to a third installation to

complete a squadron's formal training syllabus. On 14 July 2021, a member presented to the embedded Flight Surgeon with SARS-COV-2 symptoms and was tested. Initial interview quickly identified 4 individuals meeting close contact criteria. By 20 July 2021, symptomatic numbers increased to 14 cases later confirmed positive with testing. Early termination of the TDY occurred on 21 July 2021. Personnel were cohorted for return travel by vehicles based on illness or exposure status. Home Station Public Health Emergency Officers recommended Restriction of Movement (ROM) to the Installation Commanders. Rapid testing upon arrival at home station was arranged for all non-positive returning personnel, identifying positive asymptomatic and fully vaccinated cases. On 24 July 2021, busses of returning non-close contacts revealed 35 positives, rendering the balance as bus riders as new close contacts. Subsequent ROM and quarantine impacted military operations at two installations, shutting down operations for two fighter squadrons and significantly impacting maintenance, logistics, air crew equipment, and flight medicine personnel. Unit leadership negotiated an Exception to Policy (ETP) with the Installation Commanders for early return to operations on 03 Aug 2021 (10 days from initial testing) with repeat testing on 1 week after initial. Retesting netted another 25 COVID-19 positives. In summary, 74 individuals tested positive (30.7% case rate); fully vaccinated COVID-19 case breakthrough rate was 12%; and unvaccinated COVID-19 case rate was 43% with 2 hospitalizations and one death. **DISCUSSION:** This case stresses the importance of adhering to hierarchy of control precautions to prevent SARS-COV-2 spread and to avoid mission impact. Furthermore, it demonstrates the importance of vaccination in protecting individuals from severe disease outcomes.

#### Learning Objectives

1. Examine the impact to mission caused by exponential spread of Delta variant of SARS-COV-2 from one individual to an entire squadron over a 2 week period.
2. Demonstrate the importance of secondary and primary prevention measures in minimizing spread and mission impact.
3. Examine the incidence of asymptomatic infection and infection rates among fully vaccinated individuals with delta variant of SARS-COV-2.

#### [305] EFFECT OF COVID-19 PANDEMIC ON AIRCRAFT ACCIDENTS

Francesca Izzo, Adin Tyler Putnam, Kristina Kramer, Aixa Perez-Coulter, Edward Kelly, Tovy Haber Kamine  
Baystate Medical Center, Springfield, MA, United States

(Original Research)

**INTRODUCTION:** The COVID-19 pandemic has resulted in lockdown measures that have decreased movement of people in the United States. Multiple prior studies have documented a decrease in motor vehicle collisions corresponding to the lockdown measures. We investigated whether there was a concomitant decrease in aircraft accidents.

**METHODS:** The NTSB and FAA ATADS database, number of total flights, general aviation (GA) flights, as well as total and GA accidents in the US were queried from February, 2016 to January of 2021. A Poisson regression analysis was performed to determine if there was a difference in rates of aircraft accidents during the time of the COVID-19 pandemic. **RESULTS:** When compared with the same months from 2016-2020, total flights decreased significantly each month from March, 2020 to January, 2021. GA flights decreased significantly from March to June 2021. Total and GA accidents decreased significantly from March to May of 2020. There was a significant increase in overall accident rate per million flights in April 2020, compared to the prior 4 years, but not in the GA accident rate. There was no significant change in overall or GA accident rate in any other month.

**DISCUSSION:** There was a significant decrease in overall aircraft accidents and GA accidents from March to May of 2020. Despite this, however there was no significant change in accident rate except in April, 2020 where there was a significant increase in overall accident rate. Since the majority of accidents are GA and there was no increase in the GA accident rate, this increase in overall accident rate may be an artifact of the steep drop in overall flights.

#### Learning Objectives

1. The audience will learn about the impact of a global pandemic on the aircraft flight volume.
2. The audience will learn about the impact of a global pandemic on the rate of aircraft accidents.

Wednesday, 05/25/2022  
Tuscany 3

4:00 PM

#### [S-59]: SLIDES: THE SPIN ZONE: BLADES & BRAINS

Chair: Thomas Smith

Co-Chair: Amanda Lippert

#### [306] BLADES OF GLORY: HEMS PAST, PRESENT, AND FUTURE

Woodrow Sams

Mayo Clinic, Rochester, MN, United States

(Education - Tutorial/Review)

**INTRODUCTION:** Helicopter Emergency Medical Services (HEMS) provide emergency and critical care transportation to more than 400,000 patients annually in the United States. This presentation will discuss the origins of HEMS and how it was able to significantly reduce mortality during World War II and the Korean War, and how it has continued to do so in the US after its adaptation to the civilian population. There are many different airframe and crew configurations throughout HEMS based on the team's intended environment and mission, and this presentation will also cover the most common aircraft, airframe configurations, and crew make-ups while discussing some of the pros and cons of each. We will also examine past legislation that led to an abundance of varied HEMS organizations and assets, as well as current lawmaking that is attempting to moderate this expansion and standardize the abilities and equipment available to crews. Intertwined with legislation is a review of HEMS utilization and a discussion of prehospital/interfacility provider levels. The lecture ends with an overview of some of the leading professional organizations within HEMS and their accrediting body.

#### Learning Objectives

1. The audience will learn about the origins of HEMS and how it was able to significantly reduce mortality during World War II and the Korean War, and how it has continued to do so in the US after its adaptation to civilian populations.
2. The audience will learn about past legislation that led to an abundance of varied HEMS organizations and assets, as well as current lawmaking that is attempting to moderate this expansion and standardize the abilities and equipment available to crews.
3. The audience will review HEMS utilization and prehospital/interfacility provider levels.

#### [307] CHARACTERIZATION OF FORCES ON SUPINE PATIENTS DURING LOADING AND UNLOADING ONTO ARMY MEDICAL EVACUATION HELICOPTERS

Laura Kroening<sup>1</sup>, Kerri Caruso<sup>1</sup>, Amy Lloyd<sup>1</sup>, Rachel Kinsler<sup>2</sup>, Jeffrey Molles<sup>1</sup>, Khalid Barazanji<sup>3</sup>, Eric Frick<sup>3</sup>, Varun Chalasani<sup>3</sup>  
<sup>1</sup>Golbelt Frontier, LLC, in support of U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, United States; <sup>2</sup>U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, United States; <sup>3</sup>ActiBioMotion, LLC, Coralville, IA, United States

(Original Research)

**INTRODUCTION:** The exposure to vibration and repeated shocks associated with medical evacuation (MEDEVAC) may contribute to exacerbation of casualty injuries. The purpose of this study is to characterize the biodynamic response of a supine human during loading and unloading procedures. **METHODS:** The Basic Medical Interior on the

HH-60M MEDEVAC helicopter and the Interim MEDEVAC Mission Support System on the UH-60 helicopter were used for testing. Other parameters that varied included litter pan height, patient orientation, and litter pole sensor placement. An instrumented manikin with accelerometers and gyroscopic sensors was loaded and unloaded 20 times under different combinations of parameters. The metrics used for data analysis included metrics based on International Organization for Standardization 2631-1 (Vibration Dose Value (VDV) and root mean square (RMS)), maximum acceleration, and Jolt Exposure (JE). The latter is an acceleration-based calculated metric developed for this study to better characterize the unique motions recorded. Video data was also synchronized with the inertial data to link the measurements with the actions of the litter bearers, litter, and manikin. **RESULTS:** Results showed that loading the litter imparted significantly more vibrational exposure to the manikin than walking the litter – between 3 and 11 times as much according to JE. There were no significant differences in exposure between the MEDEVAC platforms, the litter pan heights, or patient orientation. The outboard side of the platform showed a higher JE by a factor of 1.75 when compared to the inboard side. Finally, JE for loading was 2.4 times higher than unloading JE. **DISCUSSION:** The head of the simulated patient received the most vibration and shocks during the entire procedure, suggesting the need for better immobilization systems, particularly for patients with head and neck injuries. Adding a shock absorbing material to the outboard side or redesigning the platform may help to reduce shocks during loading. The standard deviations of these metrics were large, suggesting that the litter team may be capable of exacerbating or mitigating the exposure to vibrations and shocks. Experience, training and anthropometry of the litter bearers should be factors in future studies.

#### Learning Objectives

1. The audience will be able to understand that loading and unloading patients into aeromedical evacuation platforms subjects them to dangerous shock and vibration.
2. The audience will learn about factors which may mitigate the shock and vibration patients are subjected to during loading, such as standard training of litter bearers and the optimization of aeromedical platform cabin designs.

### [308] A STATISTICAL ANALYSIS OF ARMY AVIATOR CERVICAL SPINE RANGE OF MOTION FROM AH-64 MAINTENANCE DATA RECORDER HEAD POSITION MEASUREMENTS

Steven Williams, Adrienne Madison, Fred Brozoski, Valeta Chancey  
U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, United States

#### (Original Research)

**INTRODUCTION:** Flight surgeons have inadequate guidance to make an informed decision on military aviator flight fitness related to cervical spine range of motion (CROM); they currently use civilian physiological limits to determine ability to resume flight operations. Based on this need, we previously developed a method for estimating in flight CROM requirements using head position data obtained from the AH-64 integrated helmet and display sight system (IHAADS). Determining the required CROM during flight can provide an operationally relevant reference for military flight surgeons. This work summarizes aviator CROM based on analysis of over 17,000 flight hours of IHAADS pilot and co-pilot head position data. **METHODS:** Analyses were conducted under an approved non-human subject research protocol. Three-dimensional head position IHAADS data provided by Apache Attack Helicopter Project Management Office were used to calculate aviator tri-axial neck angles which were categorized as neutral, mild, or severe for flexion/extension (chin to chest/ceiling), lateral bending (chin to ear), and twist rotation (chin to shoulder). The percentage of time in mild and severe postures for pilots and co-pilots was calculated for each flight. A paired t-test was performed on the pilot and co-pilot posture percentages and a two-way ANOVA was performed over day and night flights. **RESULTS:** Pilots spent 35.8%, 26.7%, and 66.5% of their flight time in mild flexion, lateral bending, and twist rotation,

respectively, and 1.0%, 6.7%, and 23.2% in severe flexion, lateral bending, and twist rotation, respectively. Co-pilots spent 39.2%, 31.8%, and 67.2% in mild flexion, lateral bending, and twist rotation, respectively, and 1.7%, 8.4%, and 18.4% in severe flexion, lateral bending, and twist rotation, respectively. The t-test showed statistical significance for all postures with the exception of severe twist ( $p < 0.05$ ). The ANOVA showed statistical significance for all postures except day and night severe bending and mild twisting and severe twisting interaction ( $p < 0.05$ ). **DISCUSSION:** Majority of AH-64 flight time is spent in mild and severe twist rotation for both pilots and co-pilots; however, co-pilots exhibit greater neck range of motion than pilots. The limitations of this analysis (flight maneuvers performed, conditions, as well as demographic and anthropometric information) are being addressed in ongoing human subject research at USAARL involving UH-60M aviators.

#### Learning Objectives

1. The audience will learn about cervical spine range of motion requirements for AH-64 aviators during routine flight.
2. The audience will learn about the postural categories used to analyze head position data.

### [309] UNDERSTANDING THE FACTORS CONTRIBUTING TO SPATIAL DISORIENTATION IN UK MILITARY AVIATION: ANALYSIS OF INCIDENTS 2018-21

Tracy Grimshaw<sup>1</sup>, Jonathan Boyd<sup>1</sup>, Alastair Bushby<sup>2</sup>

<sup>1</sup>QinetiQ Ltd, Farnborough, United Kingdom; <sup>2</sup>Royal Air Force Centre for Aviation Medicine, Henlow, United Kingdom

#### (Original Research)

**INTRODUCTION:** Accident data shows that spatial disorientation (SD) continues to present a risk to flight safety for UK military aircrew. To understand the factors that contribute to disorientation and develop mitigation strategies, the Disorientation Incident Survey (DIS) has collected anonymous military aircrew reports of SD since 2004. The aim of the latest work was to collect incidents occurring 2018-2021. This paper presents results from this latest survey plus analysis of the factors involved in over 600 SD incidents collected throughout the lifetime of the DIS programme.

**METHODS:** The DIS asks aircrew to describe occasions in flight when they either became confused about their aircraft attitude or position or they suddenly realised that the attitude or position of their aircraft had changed. Aircrew also rated the risk to flight safety of each incident. Independently, SD experts analysed the incident descriptions to establish the factors that contributed to the incident and whether the SD was recognised or unrecognised (i.e. the aircraft had significantly departed from its intended attitude or position). Evidence for association between incident factors with SD recognition and risk to flight safety in the whole dataset (over 600 incidents) was explored using logistic regression. **RESULTS:** Sixty-eight SD incidents were reported from 2018 to March 2021. Incidents reflected changes in operational focus, new aircraft and new aircraft systems compared to the last survey period. Based on logistic regression analysis of the whole dataset, unrecognised SD was associated with in-cockpit distraction, poor crew coordination, and lack of pilot experience for both fast jet (FJ) and rotary wing (RW) incidents and, additionally, with combat manoeuvres and external distraction for FJ and drift in RW ( $p < 0.05$ ). Increased risk to flight safety was associated with combat and bombing for FJ and poor crew coordination, take-off, deck take-off and blackhole approaches for RW ( $p < 0.05$ ). **DISCUSSION:** Many incidents involved visual misperceptions, and certain manoeuvres were more likely to lead to disorientation, for example air-to-air refuelling for FJ, and landing (including deck landing) for RW. Analysis of all disorientation incidents collected since 2004 found that distraction, either in-cockpit or external to the aircraft, increased the likelihood of the aircraft departing significantly from its intended attitude or position during a disorientation incident.

#### Learning Objectives

1. The audience will learn about factors that contribute to spatial disorientation in UK military aircrew.
2. The audience will understand the survey technique developed to capture aircrew experiences of disorientation.



### [310] EDUCATIONAL TOOL DEMONSTRATES SPATIAL DISORIENTATION IN DEGRADED VISUAL ENVIRONMENTS

Eric Groen<sup>1</sup>, James Keller<sup>2</sup>, Mark Houben<sup>1</sup>, Richard Den Hollander<sup>3</sup>

<sup>1</sup>TNO, Soesterberg, Netherlands; <sup>2</sup>The Boeing Company, Philadelphia, PA, United States; <sup>3</sup>TNO, Delft, Netherlands

(Education - Tutorial/Review)

**INTRODUCTION:** Helicopter pilots operating in degraded visual environments (DVE) can experience spatial disorientation (SD) because, on the one hand, outside visual references are lost, or the visual environment contains confounding cues which induce visual illusions, on the other hand. An example of the latter is a sloping cloud deck, which may be perceived as a (false) horizon. According to safety reviews, helicopter accidents are often associated with DVEs, indicating a need for tools to increase the pilots' awareness of SD in DVEs. Here we present a "DVE support tool" that computes and visualizes how SD develops in different DVE conditions. **METHOD:** The tool is based on a mathematical perception model, consisting of transfer functions which describe the dynamics of the human vestibular system (i.e., the semicircular canals and otolith organs). In a previous research effort, the model was used to predict vestibular SD illusions in the absence of outside visual references. In the current project, the model was extended with a functionality to predict visual illusions based on visual cues in the outside view. These cues involve the (true or false) horizon and optic flow, which are detected by means of automatic pattern recognition. The detected cues are processed by a visual path in the perception model, where they are combined with vestibular cues derived from recordings of the helicopter motion. The mismatch between the model-predicted and actual helicopter motion is depicted as illustration of SD. **APPLICATION:** Currently the tool successfully predicts the following DVE effects: 1) underestimation of ground speed when flying over featureless terrain, due to lacking optic flow; 2) illusion of bank when flying over a sloping cloud deck, due to a false horizon; 3) illusion of backwards and downwards motion due to the optic flow induced by the movement of a dust cloud during a Brownout landing. In particular the animation capability makes the DVE support tool suitable for educational purposes, adding to textbook knowledge about SD.

#### Learning Objectives

1. The audience will learn vestibular-visual interactions that lead to spatial disorientation in-flight.
2. The audience will be able to differentiate between "degraded" visual environments and "false" visual environments.

### [311] EFFECTS OF SPATIAL ORIENTATION IN A CENTRIFUGE ON THE ABILITY OF FIGHTER PILOTS TO PERCEIVE THE BANK ANGLE DURING FLIGHT WITHOUT VISUAL REFERENCES

Andreas Brink, Michailis Keramidias, Arne Tribukait, Eddie Bergsten, Ola Eiken

Royal Institute of Technology, KTH, Stockholm, Sweden

(Original Research)

**INTRODUCTION:** When a fixed-wing pilot lacking external visual references, performs a coordinated flight turn, he/she typically underestimates the bank angle, because the two sensory systems in the balance organs are providing discordant information of the roll-angle displacement; the otoliths consistently signal upright (vertical) position, whereas the semicircular canals detect the roll displacement. Our aim was to investigate to what extent the ability to perceive the bank angle can be improved by spatial orientation training in a centrifuge. **METHODS:** Sixteen fighter pilots/pilot students were investigated during flights in a Saab SK60 jet trainer, as regards their capacity to, in complete darkness, detect the roll angle during coordinate turns to the left and right. Each

turn lasted 2 min, and was performed at Gz loads of 1.15 or 2.0 G, corresponding to bank angles of 30° and 60°, respectively. The experiments were repeated after a 4-wk period during which half of the cohort (training group, n=8) performed nine 30-40-min training sessions in a centrifuge; these comprised feedback training on roll angle and G load, and on setting a given roll angle with a visual indicator as well as theory lectures on G load vs bank angle. **RESULTS:** Before training, the pilots perceived a 45±15° roll angle during the initial and a 32±23° angle during final period of the 60° turns. During the 30° turns before training, the initial perceived angle was 22±14°, whereas the final angle was 15±17°. Training improved the capacity to perceive the roll angle during the 60° turns (to initial perception: 60±8°, final perception 55±15°; p=0.04), but not during the 30° turns (initial perception 24±11°, final perception 12±15°; p=0.25). Roll-angle estimates did not change in the untrained control group (60° trial, initial perception: 45±18°, final perception: 34±20°, 30° trial, initial perception: 20±16°, final perception: 12±17).

**DISCUSSION:** The results suggest that it is possible to, in a centrifuge, train a pilot's ability to perceive large, but not discrete roll-angle displacements. The training effect is attributable to improved capacity to translate perceived G load into roll angle rather than to increased reliance on semicircular-canal signals.

#### Learning Objectives

1. Pilots can be trained to be aware of increased G-load and translate it into corresponding bank angle in an assumed level turn without visual clues. Flight hours, novel or experienced pilots, did not in this study reveal any differences.
2. A human gondola centrifuge can be used to simulate a coordinated turn in a flight like manner although stimuli pattern in yaw, pitch and roll differs from real flight due to the smaller radius. Results can be quantified and reproduced.
3. Improve spatial disorientation training and demonstration by for an example include better theoretical knowledge about the G and bank angle formula in order to increase overall situational awareness.

Wednesday, 05/25/2022  
Tuscany 4

4:00 PM

### [S-60]: PANEL: OPTIMIZING TREATMENT PLANS IN AVIATORS AND ASTRONAUTS UTILIZING HEALTHY LIFESTYLE INTERVENTIONS – PART 2

Chair: Terry Correll

**PANEL OVERVIEW: INTRODUCTION:** What if we could optimize every treatment plan we prescribe, decide it more collaboratively with patients, get more buy in, empower and energize our patients, and get better and more sustainable results? We can, if we regularly incorporate healthy lifestyle interventions in our treatment planning. **TOPIC:** The literature supports the robust efficacy of healthy lifestyle interventions, even compared to psychotherapy and pharmacotherapy in mental health. Neurology finds healthy lifestyle to be important in its disorders. NASA emphasizes healthy lifestyle in its astronaut corp. All of medicine has outstanding literature support in this area. There typically is a synergistic effect when healthy lifestyle interventions are utilized in a multifaceted treatment plan. At the United States Air Force School of Aerospace Medicine's Aeromedical Consultation Service, we have surveyed our aviators regarding the effectiveness of psychiatric medications, psychotherapy, and healthy lifestyle interventions and all interventions are rated as equally efficacious, even when healthy lifestyle interventions are not typically prescribed as principal treatments. How helpful could healthy lifestyle interventions be if we prescribed them more as first line and augmentation strategies in our treatment plans? **APPLICATION:** This panel will review the helpfulness of healthy lifestyle interventions when incorporated in the treatment plan and culture. We will review our data on USAF flyers, review the relevant literature, describe how NASA utilizes these principles, and invite

discussion/ideas on how to improve medical treatment planning utilizing healthy lifestyle interventions.

### [312] EXAMINING THE EFFECTIVENESS OF PSYCHOTHERAPY FOR MENTAL HEALTH CONDITIONS IN THE AVIATOR

Monica Malcein

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

**INTRODUCTION:** All mental health disorders are disqualifying for flying duties and a waiver for a mental health diagnosis can be considered only after symptoms have resolved. Psychotherapy is an important component of treatment for mental health diagnoses, with some psychotherapeutic approaches showing greater efficacy than others in reducing symptoms and functional impact. **TOPIC:** Aviation, and particularly military aviation, is a high stress occupation that can contribute to the development of mental health symptoms. These mental health symptoms, if not adequately treated, can compromise the performance of aviation personnel and affect their ability to safely perform aviation-related duties. Aviation personnel who are diagnosed with a mental health problem are disqualified from flying until the problem is treated and symptoms resolve. Therefore, timely and effective treatment of mental health disorders is essential for the reduction of symptoms in aviation personnel, allowing them to return to flying duty without unnecessary delay. Psychotherapy can be an effective tool in addressing mental health symptoms quickly, and there are evidence-based therapies available for symptoms and mental health diagnoses most commonly seen in the aviation population, including sleep disturbance, depression, and anxiety. An overview of these evidence-based approaches and their effectiveness in treating symptoms will be presented. Review of cases seen at the ACS will explore the aviators' perception of the effectiveness of psychotherapy that they received to address mental health symptoms. **APPLICATION:** Examination of the effectiveness of different psychotherapeutic approaches for mental health conditions that are most frequently diagnosed in aviators will allow for better understanding of available treatments and inform clinical decision-making in this population. Additionally, this information should increase recognition of the effectiveness of psychotherapy compared to other treatment approaches including medication management and healthy lifestyle interventions.

#### Learning Objectives

1. The audience will learn about evidence-based psychotherapeutic approaches to the treatment of mental health symptoms in the aviator.
2. The participant will be able to describe psychotherapeutic approaches and their effectiveness for managing mental health symptoms.

### [313] LIFESTYLE INTERVENTIONS FOR HEADACHE DISORDERS

Aven Ford

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

**INTRODUCTION:** Recurrent headaches can be more than a nuisance and in many cases can prove disabling to an aviator. Unfortunately, many of the available headache medications are not aeromedically-appropriate for chronic or frequent use. Thankfully, there is mounting evidence that shows that there are lifestyle interventions such as diet change, sleep hygiene counseling, mindfulness, and movement practices/physical exercises that can effectively decrease the impact of headaches. **TOPIC:** A recent study of Air Force aviators found that more than half of the aviators studied found modification of behavioral and dietary factors effective for reducing the impact of migraines. Dietary interventions for headache including trigger avoidance, elimination diets, and macronutrient-based diets, can effectively decrease the disability

related to migraines. Sleep disorders are common in patients with headaches. Sleep hygiene counseling is the first step towards improving sleep in patients with insomnia and if this is ineffective or another sleep disorder is suspected, the patient should be referred for a formal sleep evaluation. Mindfulness and related practices have long been suggested as beneficial for headache patients. Much of the recent research in this area has focused on the use of the 8-week Mindfulness Based Stress Reduction program in migraine and tension-type headache patients. Physical exercise is controversial in headache medicine, as some headache patients feel that exercise worsens their headaches. However, there is growing evidence that the type and frequency of movement practices and exercise regimen may be important factors in reducing the impact of headaches. These lifestyle interventions are often time and energy intensive, both for the patient and for the provider, and the evidence for their use is often based on small studies with imperfect control groups. However, these interventions are very safe and may provide benefits to a patient's general health and wellbeing. They are aeromedically-acceptable for use in aircrew and should be considered first-line for treatment of migraine and related disorders. **APPLICATION:** This presentation will review the available literature supporting lifestyle interventions for headache disorders. It aims to increase awareness of the effectiveness of these tools and suggest practical ways to implement these strategies into a busy clinical practice in order to minimize the impact that headaches have on our aviators.

#### Learning Objectives

1. Discuss the available research on the treatment of headache disorders using diet interventions, mindfulness and related practices, and movement practices and exercise.
2. Discuss the limitations of the existing research into these areas.
3. Discuss strategies for implementation of these interventions.

### [314] OPTIMIZING FLYER PERFORMANCE UTILIZING MINDFULNESS, MEDICATION, AND RELAXATION

Kevin Heacock

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

**INTRODUCTION:** The mind of the flyer is the most important aspect to human performance in aviation. Optimizing brain function through self-directed processes such as mindfulness, meditation, and relaxation is a great way to enhance and maintain flyer performance. **TOPIC:** Mindfulness is an easily accessible state of mind that has been available to humans for thousands of years. Recent interest in this area has shown benefits to performance optimization and quality of life utilizing techniques ranging from simple relaxation to full on meditation. Relaxation can improve the physical performance needed to operate some of the most complex man-made machines, like those piloted and maintained by United States Air Force Airmen. Mindfulness can improve management of the cognitive processes and interpersonal relationships needed to be successful in military operations and aerospace endeavors. Meditation can provide an overall sense of being allowing for access to both internal and external stimuli leading to better decision making processes. Overall, these healthy lifestyle interventions can be easily taught, implemented into normal routines, and made available at any time of need, with mindfulness and relaxation available even in the cockpit. **APPLICATION:** This presentation will review the helpfulness of mindfulness, meditation, and relaxation techniques as a way to optimize human performance. It will invite discussion on ways to utilize these techniques in everyday life to improve quality of living in all spheres and environments to include aerospace.

#### Learning Objectives

1. The participant will be able to understand the positive benefits of mindfulness in enhancing flyer performance.
2. The audience will learn about different techniques and methods to optimize flyer performance through mindfulness, medication, and relaxation.

**[315] EXERCISE! EXERCISE! EXERCISE!**

Ryan Peirson

U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, United States

*(Education - Tutorial/Review)*

**INTRODUCTION:** Physical exercise is emphasized and valued both in the military and in popular culture. Although traditional practice is for physicians merely to recommend exercise, seeing it as a core tool one can "prescribe" is inconsistently endorsed. **TOPIC:** Exercise as a therapeutic tool will be discussed and supporting and critical literature will be presented. Possible biological mechanisms for provider/patient discussion will be reviewed including inflammatory and neurotrophic mediators as well as neurotransmitter modulation and the involvement of specific cytokines. The experience of the ACS will be shared, particularly in the general enthusiasm for and benefit from exercise as reported by evaluated aircrew. Two case examples will be presented illustrating the use of exercise as a treatment modality. **APPLICATION:** Since military culture and requirements value physical fitness and keeping one's body in shape is an aspect of readiness, a healthcare provider may find it unnecessary to monitor or even mention it. Emphasizing exercise specifically as a resiliency tool and emphasizing it as a therapeutic intervention when a member experiences the symptoms of a mental disorder is supported in the literature and endorsed by aircrew.

**RESOURCES:** 1) Meyer JD, Stenger AJ, Kim JS, and Cook DB. Influence of exercise intensity for improving depressed mood in depression: a dose-response study. *Behavior Therapy*: 47 (2016) 527-537. 2) Kvam S, Kleppe CL, Nordhus IG, Hovland A. Exercise as a treatment for depression: A meta-analysis. *Journal of Affective Disorders* 202 (2016) 67-86.

**Learning Objectives**

1. The participant will be able to describe at least one proposed mechanism for how exercise can improve mental health.
2. The participant will be able to identify one strategy to use with patients to motivate them to exercise.

**Wednesday, 05/25/2022****4:00 PM****Tuscany 12****[S-61]: PANEL: AEROSPACE MEDICINE IN GERMANY****Chair: Jochen Hinkelbein****Co-Chair: Torsten Pippig**

**Panel Overview:** This session is provided by the German Society of Aerospace Medicine (DGLRM) and given in German language with English slides. The session summarizes current topics in Aerospace Medicine in Germany.

**[316] THE SPINE IN THE MILITARY AEROMEDICAL ASSESSMENT. AEROMEDICAL WAIVER FOR APPLICANTS**Torsten Pippig

Centre of Aerospace Medicine of the German Air Force (GAF), Fuerstenfeldbruck, Germany

*(Original Research)*

**INTRODUCTION:** Military aircraft pilots and crew member are exposed to high physical stress. Neck and back pain of pilots are common and can limit or exclude flight operations. The highest loads occur when using the rescue systems (ejection seat, parachute) and in flight accidents, severe injuries and death are possible. Therefore, a detailed examination of the muscular-skeletal system of all applicants and in particular of the spine is necessary. **METHODS:** Conventional X-ray imaging of the whole spine was carried out until 1999, and since 2000 pilots have been selected using MRI imaging of the whole spine (cervical, thoracic and lumbar spine). The MRI findings of the spine from January 1, 2011 to December 31, 2020 are evaluated. The focus of this presentation is on the frequency and reasons

for unfitness for military flying duty and the conditions and frequency of an aeromedical waiver for applicants. **RESULTS:** In the 10-year period, 4564 young and asymptomatic men and women in the orthopaedic section of the Centre of Aerospace Medicine of the German Air Force (GAF) were examined for the first time for military flying duty (Air Force, Army and Navy; fighter aircraft, helicopter, other transport aircraft). For 268 applicants (5.9%), no complete orthopaedic assessment was carried out. 4296 applicants (94.1%) were fully examined and evaluated, 3901 (90.8%) as "fit" (age 20.4 years) and 395 (9.2%) as "unfit" (age 21.8 years). 159 applicants (40.2%) were granted an aeromedical waiver. The spinal column diagnoses, reasons and conditions (restrictions) for the granting or rejection of an aeromedical waiver are explained. **CONCLUSION:** For military flying duty, health requirements must be met. On the one hand, service regulations must be observed, on the other hand, we must protect the applicants or pilots from dangers, injuries and death (care and prevention). It is possible to issue an aeromedical waiver. The aeronautical requirements and the prognosis of changes in the spinal column must be observed. An aeromedical waiver for applicants is always an individual decision.

**Learning Objectives**

1. Examination of the muscular-skeletal system, including MRI examination of the whole spinal column as part of the aeromedical fitness for applicants.
2. Asymptomatic pathological changes and condition of the whole spine (cervical, thoracic, lumbar).
3. Aeromedical waiver procedure for asymptomatic applicants, what is justifiable.

**[317] NUCLEAR MEDICAL DIAGNOSTICS IN AVIATION MEDICINE – IMPORTANCE AND PERSPECTIVES**Christian Loessel, Hans-Juergen Noble, Sven-Erik Soenksen, Heinz Knopf

German Air Force Center of Aerospace Medicine, Fuerstenfeldbruck, Germany

*(Education - Tutorial/Review)*

**INTRODUCTION:** Early detection of relevant dysfunctions can prevent fulminant courses of disease and fatal complications in aerospace due to heart attacks. It is important to minimize the risk by targeted functional diagnostic. Likewise, the prognosis after cardiovascular events is crucial for regaining fitness to fly. **TOPIC:** Every year over 200,000 people die from cardiovascular diseases in Germany. Cardiovascular diseases are rarely responsible for a sudden incapacitation in aircrew, but in about 50% of cases they lead to rejection or withdrawal of aviation license. Since it can be assumed that the number of unrecognized coronary heart disease is comparable to the normal collective of the population, it is highly relevant to detect these pathologies in advance. This applies especially to first time applicants for flight duty and to active pilots or astronauts before a longtime space mission, both for safety reasons to avoid disastrous aircraft accidents and from an economic and preventive point of view. After a cardiovascular event, therapy monitoring and prognosis are also essential to enable pilots to return to the cockpit. **APPLICATION:** In the German Air Force Center of Aerospace Medicine Department of Imaging Diagnostics, we strive to expand nuclear medical diagnostics from an aeromedical perspective. First, we have to determine the possibilities and added value of nuclear medicine procedures for the issues of aviation medicine. We must balance between medical assessment, clinical aviation medicine, prevention and radiation protection. With nuclear medical techniques we easily can produce a robust non-invasive functional diagnostic. Myocardial scintigraphy has a firm place in clinical medicine and is particularly valued for its prognostic significance. In contrast to other cardiac imaging, myocardial scintigraphy can be physiologically stressed. This enables mapping under almost natural conditions. Other techniques like low-dose computer tomography and magnetic resonance imaging are also necessary to investigate non-invasive coronary heart disease. The combination of functional and morphological method like hybrid imaging (SPECT/CT, PET/CT, PET/MRI) opens new possibilities in cardiovascular diagnostics for aviation medicine. Furthermore, this may also affect



manned spaceflight considerably, especially since an increased vulnerability of cardiovascular pathologies cannot be excluded.

#### Learning Objectives

1. Learning about nuclear medical diagnostics in relation to aviation medicine.
2. Learning about possible methods for visualizing relevant pathologies at early stages, which may lead to sudden incapacitation.

### [318] DEATH IN SPACE - TWO NEW METHODS FOR CPR IN SPACE

Jan Schmitz

University Hospital of Cologne, Cologne, Germany

(Original Research)

**BACKGROUND:** The risk of severe medical events during long-duration spaceflight is a major concern. These critical events can endanger both the crew as well as the mission and include cardiac arrest, which would require cardiopulmonary resuscitation (CPR). So far, five methods to perform CPR in microgravity have been proposed. However, those methods seem to be in some extent insufficient and not applicable at any spot of spacecraft. The aim of the present study is to describe and gather data for two new CPR methods in microgravity.

**MATERIAL AND METHODS:** A double-randomized cross-over trial (RCT) comparing two new methods for CPR in a free-floating underwater setting. Paramedics performed chest compressions on a manikin (Ambu Man, Ambu, Germany) using two new methods for a free-floating position. The first method (Schmitz-Hinkelbein-Hand-Method) is similar to conventional CPR, with the patient in a supine position, lying on the operator's knees for stabilization. The second method (Schmitz-Hinkelbein-Elbow-Method) is similar to the first, but chest compressions are conducted with one elbow and the other hand stabilized the head. The main outcome parameters were total number of chest compressions (n) during 1 min of CPR (compression rate), the rate of correct chest compressions (%), the no-flow-time (s), and the self-satisfaction-score of participants. The study was registered on clinicaltrials.gov (NCT04354883). **RESULTS:** 15 volunteers (age 31.0±8.8 years, height 180.3±7.5 cm, weight 84.1±13.2 kg) participated in this study. Compared to the Schmitz-Hinkelbein-Elbow-Method, the Schmitz-Hinkelbein-Hand-Method showed superiority in the compression rate (100.5±14.4 compressions/min), correct compression depth (65±23%) and overall high rates of correct thorax release after compression (66% high, 20% moderate, 13% low). The Schmitz-Hinkelbein-Elbow-Method showed correct depth rates (28±27%) but was associated with a lower mean compression rate (73.9±25.5/min) and with low rates of correct thorax release (20% high, 7% moderate, 73% low). **CONCLUSIONS:** Both methods are feasible without any equipment and could enable immediate CPR after cardiac arrest in microgravity, even in a single-helper scenario. The Schmitz-Hinkelbein-Hand-Method appears superior and could allow the delivery of high-quality CPR immediately after cardiac arrest with sufficient quality.

#### Learning Objectives

1. The audience will learn about existing methods of CPR in space, including potential limitations of each method.
2. The audience will learn about two new methods for CPR in space, data was conducted in a submerged setting.

### [319] USING SUPRAGLOTTIC AIRWAYS BY PARAMEDICS FOR AIRWAY MANAGEMENT IN ANALOGUE MICROGRAVITY

Jochen Hinkelbein<sup>1</sup>, Anton Ahlbäck<sup>2</sup>, Christine Antwerber<sup>3</sup>, Lisa Dauth<sup>4</sup>, James DuCanto<sup>5</sup>, Elisabeth Fleischhammer<sup>3</sup>, Carlos Glatz<sup>6</sup>, Steffen Kerkhoff<sup>3</sup>, Alexander Mathes<sup>3</sup>, Thais Russomano<sup>7</sup>, Jan Schmitz<sup>3</sup>

<sup>1</sup>University Hospital and Medical Faculty of Cologne, Köln, Germany; <sup>2</sup>Department of Anaesthesiology and Intensive Care, Örebro University Hospital, Örebro, Sweden; <sup>3</sup>UK Köln, Köln, Germany; <sup>4</sup>St. Elisabeth Hospital, Cologne, Germany; <sup>5</sup>Department of Anaesthesiology, Medical College of Wisconsin,

Aurora St. Luke's Medical Center, Milwaukee, WI, United States; <sup>6</sup>Department of Medicine, Goethe University Frankfurt am Main, Frankfurt, Germany; <sup>7</sup>Centre for Human and Applied Physiological Sciences, School of Basic and Medical Biosciences, Faculty of Life Sciences and Medicine, Kings College London, London, United Kingdom)

(Original Research)

**BACKGROUND:** In the next few years, the number of long-term space missions will significantly increase. Providing safe concepts for emergencies including airway management will be a highly challenging task. The aim of the present trial is to compare different airway management devices in simulated microgravity using a free-floating underwater scenario. Five different devices for airway management [laryngeal mask (LM), laryngeal tube (LT), I-GEL, direct laryngoscopy (DL), and video laryngoscopy (VL)] were compared by n = 20 paramedics holding a diving certificate in a randomized cross-over setting both under free-floating conditions in a submerged setting (pool, microgravity) and on ground (normogravity). The primary endpoint was the successful placement of the airway device. The secondary endpoints were the number of attempts and the time to ventilation. A total of 20 paramedics (3 female, 17 male) participated in this study. Success rate was highest for LM and LT and was 100% both during simulated microgravity and normogravity followed by the I-GEL (90% during microgravity and 95% during normogravity). However, the success rate was less for both DL (60% vs. 95%) and VL (20% vs. 60%). Fastest ventilation was performed with the LT both in normogravity (13.7 ± 5.3 s; n = 20) and microgravity (19.5 ± 6.1 s; n = 20). For the comparison of normogravity and microgravity, time to ventilation was shorter for all devices on the ground (normogravity) as compared underwater (microgravity). In the present study, airway management with supraglottic airways and laryngoscopy was shown to be feasible. Concerning the success rate and time to ventilation, the optimum were supraglottic airways (LT, LM, I-GEL) as their placement was faster and associated with a higher success rate. For future space missions, the use of supraglottic airways for airway management seems to be more promising as compared to tracheal intubation by DL or VL.

#### Learning Objectives

1. How airway management is performed in microgravity by paramedics in an underwater setting.
2. Using SGA instead of ETI is faster and provides more safety.

### [320] GRAVITY-RESPONSIVE CHROMOSOMAL REGIONS IN HUMAN T CELLS

Oliver Ullrich, Cora Sandra Thiel

University of Zurich (UZH), Zurich, Switzerland

(Original Research)

**BACKGROUND:** The detection and characterization of the underlying cellular mechanisms responsible for the reactions of cells to microgravity is an open question, which has been addressed with our previous and current work conducted on cells of the human immune system. We were able to demonstrate that profound alterations of the transcriptome taking place as early as 20s – 5min after the onset of altered gravitational force in various cell models and independent experiment campaigns on parabolic flights, suborbital rockets and the ISS. Based on these results, we aim at investigating now whether the gravitational force on Earth stabilize and maintains chromatin architecture, DNA accessibility and homeostasis of gene expression and used an integrated approach with a combination of genome-wide analysis of transcriptional activity and detection of three-dimensional (3D) chromosomal conformational changes. The investigations are not be limited to the identification of single cellular and molecular events, but to understand cellular response to altered gravity in an integrative context. In human Jurkat T cells, we found an association of differential gene expression in gravity-responsive chromosomal regions, but not differentially regulated single genes. These coupled gene expression effects in chromosomal regions could be explained by underlying chromatin structures, analyzed by high-throughput chromatin conformation capture (Hi-C) analysis, where we detected a nonrandom overlap

between Hi-C-identified chromosomal interacting regions and gravity-responsive chromosomal regions (GRCRs). We therefore demonstrate the first evidence that gravitational force-induced 3D chromosomal conformational changes are associated with rapid transcriptional response in human T cells.

#### Learning Objectives

1. The participant will be able to understand that human cells respond and adapt rapidly to altered gravitational forces.
2. The participant will be able to understand that gene expression responses to altered gravitational forces is associated with chromatin conformation changes.

**THURSDAY MAY 26, 2022**

**Thursday, 05/26/2022**

**8:30 AM**

**Tuscany C,D,E,**

### 56<sup>TH</sup> HARRY G. ARMSTRONG LECTURE

**Melchor Antuñano, M.D., M.S.**

#### “Medical & Human Factors Challenges of New Aerospace Transportation Systems”

**Thursday, 05/26/2022**

**10:00 AM**

**Tuscany C,D,E**

### [S-62]: PANEL: THE NUTS AND BOLTS OF BEING A CHIEF MEDICAL OFFICER FOR PRIVATE SPACE COMPANIES

*Sponsored by the Space Medicine Association*

**Chair: James Vanderploeg**

**Co-Chair: Richard Jennings**

**Panel Overview: BACKGROUND:** Commercial space companies have begun flying paying customers on private human space flights. In preparation, these companies have established medical teams to evaluate and care for these space flight participants. **DESCRIPTION:** This panel consists of reports from the Chief Medical Officers (CMO) of Axiom Space, Space Adventures, SpaceX, and Virgin Galactic on the development and implementation of medical programs in each of their respective companies. They will discuss what is involved in being the CMO, what some of the challenges are, how those challenges are solved, and what they see developing in the future for the Space Medicine practitioner. **DISCUSSION:** Initiating, developing, and implementing a medical program for a new space flight company is a daunting task. While there are many lessons learned upon which to draw from past efforts of NASA and the ISS partners, many factors are new. The pace of development is very rapid. The CMO may be called upon for input into a wide variety of space craft features such as seat design, restraint systems, life support systems, emergency egress, and SFP training. Responsibilities also include the provision of emergency response capabilities on the ground, preflight and post landing medical support, SFP training and more. Further differences from historical space medicine practice revolve around the breadth of medical status of the private SFPs. Advanced age, the existence of a broad range of medical conditions, language and cultural barriers, and limited time for preparation and training add to the complexity of the commercial company CMO's job. The panel will address the challenges encountered and the solutions implemented in the variety of settings in which Space Medicine is practiced in the private sector. The panel will also discuss what future developments and changes may be appropriate for the Space Medicine practitioner in the continued growth of the private human spaceflight market.

### [321] THE NUTS AND BOLTS OF BEING A CHIEF MEDICAL OFFICER FOR PRIVATE SPACE COMPANIES

**James Vanderploeg**

*Self, Granby, CO, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** Commercial space companies have begun flying paying customers on private human space flights. In preparation, these companies have established medical teams to evaluate and care for these space flight participants. **DESCRIPTION:** This panel consists of reports from the Chief Medical Officers (CMO) of Axiom Space, Space Adventures, SpaceX, and Virgin Galactic on the development and implementation of medical programs in each of their respective companies. They will discuss what is involved in being the CMO, what some of the challenges are, how those challenges are solved, and what they see developing in the future for the Space Medicine practitioner. **DISCUSSION:** Initiating, developing, and implementing a medical program for a new space flight company is a daunting task. While there are many lessons learned upon which to draw from past efforts of NASA and the ISS partners, many factors are new. The pace of development is very rapid. The CMO may be called upon for input into a wide variety of space craft features such as seat design, restraint systems, life support systems, emergency egress, and SFP training. Responsibilities also include the provision of emergency response capabilities on the ground, preflight and post landing medical support, SFP training and more. Further differences from historical space medicine practice revolve around the breadth of medical status of the private SFPs. Advanced age, the existence of a broad range of medical conditions, language and cultural barriers, and limited time for preparation and training add to the complexity of the commercial company CMO's job. The panel will address the challenges encountered and the solutions implemented in the variety of settings in which Space Medicine is practiced in the private sector. The panel will also discuss what future developments and changes may be appropriate for the Space Medicine practitioner in the continued growth of the private human spaceflight market.

#### Learning Objectives

1. The participant will gain an understanding of the complexity of factors involved in the job of Chief Medical Officer for private human spaceflight companies.
2. The participant will learn about challenges encountered and solutions implemented to assure safe space flights for private space flight participants.
3. The participant will gain an understanding of what the future roles of a space medicine practitioner may include in support of private human spaceflight.

### [322] THE NUTS AND BOLTS OF BEING A CHIEF MEDICAL OFFICER FOR PRIVATE SPACE COMPANIES

**Tarah Castleberry**

*UTMB, Virgin Galactic, Las Cruces, NM, United States*

*(Education - Program/Process Review)*

**BACKGROUND:** The commercial spaceflight industry has begun offering spaceflights to customers who would otherwise not have opportunities to reach space. Medical program leadership for these companies must develop and implement plans for medical risk management and support of the company across a broad range of technical and clinical tasks. **OVERVIEW:** Virgin Galactic (VG) will offer suborbital flights to customers onboard its SpaceShip, an air launch system which lands back on the runway from which it departed. The Chief Medical Officer (CMO) and medical team for VG are engaged in work across all spaceflight related tasks, including spaceship design, pilot and passenger screening, training, support of flight operations, and emergency response. **DISCUSSION:** Challenges for the CMO and medical team include translation of historical and current orbital spaceflight data, requirements, standards, and support for traditionally highly screened