during a launch contingency. Egressing spaceflight crew members wearing the NASA Orion Crew Survival System (OCSS) exposed to hypergolic propellants will be decontaminated with a water spray to reduce the toxic hazards of off-gassing. Nevertheless, off-gassing effects from propellant impregnated fabric could pose a risk to rescue crews. **METHODS:** The NASA Advanced Crew Escape System II (ACES II) used during Space Shuttle Program is similar to the OCSS and was utilized in this test. A 20 cm^2 section of ACES II bilayer fabric (Nomex/Gore-Tex) was placed and sealed inside 5 cm permeation cells equipped with exposure and detection ports. The fabric's exterior surface was exposed to concentrated N_2O_4 (1000 ppm) or MMH (100 ppm and 500 ppm) vapor for 1 h to saturate the suit material at a constant airflow of 28.3 L/h inside the permeation cell. A 30 s water rinse to simulate decontamination with a water deluge spray was followed by 120 min off-gassing detection in the test cell. The fabric dimensions and air flow parameters were extrapolated to simulate a 2 m^2 suit surface area, and transportation inside an enclosed helicopter cabin (12,472.6 L) without ventilation. **RESULTS:** During the 120 min detection period, NO_2 off-gassing peaked at 0.5 ppm for a duration of 6 min, a value which does not exceed EPA acute exposure guideline level (AEGL-1) 8 h level limits. For the first hour, MMH off-gassing levels did not exceed 0.09 ppm, which is below AEGL-2 limits of 0.11 ppm. As the fabric dried out, an MMH off-gassing burst of 2.7 ppm was observed, a value that exceeds AEGL-2 30 min level limits of 1.8 ppm.

Learning Objectives

1. The audience will learn about the off-gassing of hypergolic propellants from space suits.
2. The audience will learn about the health risks and mitigation in regards of off-gassing of hypergolic propellants from space suits.

[98] DEVELOPMENT OF COMMERCIAL SPACE OCCUPATIONAL MEDICINE HEALTH STANDARDS

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

(Original Research)

INTRODUCTION: Medical standards for spaceflight have been established by government space agencies. Commercial space companies will soon fly personnel who are not selected by these agencies. Selectees may have known disease for which no monitoring standards currently exist. The study reviews occupational standards for various populations working in environments analogous to spaceflight, develops occupational medicine standards for space workers and develops or determines the appropriate medical tests and medical monitoring required. Wearable medical monitoring technology is analyzed and tested in extreme conditions analogous to spaceflight. **METHODS:** Current literature regarding medical standards for populations analogous to spaceflight is reviewed. Human factors that would jeopardize participant health or mission completion /are identified and a review of appropriate monitoring and testing hardware is done. Based on the review, appropriate tests and monitoring technologies such as wearable monitors established. Monitoring procedures are established and tested under extreme conditions such as high G and hypobaric atmospheres. Collaboration with industry for portions of assessing human factors and electronic device usability includes use of the ETC/NASTAR centrifuge, sensor hardware and software assistance from Danish Aerospace Company, and a testing environment platform from Axiom Space, Inc. **RESULTS:** Data from current commercial space companies along with environments analogous to spaceflight suggests that eight to ten medical conditions are suitable for monitoring in the spaceflight environment. Monitoring technology for those specific conditions is tested under extreme conditions analogous to spaceflight including hyper G, hypobaric and microgravity conditions. **DISCUSSION:** Occupational medical standards for the population of future space workers does not exist. The results of this 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. Analysis of wearable medical monitoring technology will establish a new standard for commercial spaceflight. Future work includes applying wearable technologies to astronauts or commercial space travelers when they embark on a space journey in order to further evaluate medical monitoring capability in the space environment.

Learning Objectives

1. The participant will be able to understand the importance of establishing new health standards for the spaceflight environment based on acceptance of known disease.
2. The participant will know which known diseases can be monitored in the spaceflight environment and how monitoring technology is utilized.

TUESDAY, AUGUST 31, 2021

Tuesday, 08/31/2021 ***8:30 AM***

Grand Ballroom

7TH ANNUAL REINARTZ LECTURE

Dr. Anthony Wagstaff

"The Feedback Loop of Aerospace Medicine and Human Performance"

Tuesday, 08/31/2021 ***10:30 AM***

Governor's Square 14

[S-21]: PANEL: LESSONS LEARNED AND INNOVATIONS FOR ENHANCING HUMAN SYSTEMS INTEGRATION

Sponsored by Life Sciences and Biomedical Engineering Branch of AsMA

Chair: Dwight Holland
Co-Chair: Carlos Salicrup
Co-Chair: Estrella Forster

PANEL OVERVIEW: *This educational panel explores different approaches, lessons learned or not learned (?), and innovative approaches for enhancing human performance through better Human Systems Integration (HSI) while exploring the earth, skies, and space. The emphasis will be on some classic major areas in Human Performance and Human Systems Integration such as example the challenges, strengths and weaknesses of subjective Flying Quality and Mental Workload Assessment, etc. scales used widely in Aerospace Systems evaluation. And, a presentation on the recent 737Max mishap talk given by a 737Max pilot-physician and team. In this diverse session, we also have presentations of newer technologies and opportunities in wearable computers, Virtual/Augmented Reality for better HSI integration and Situation Awareness, and a look at new cutting-edge technologies in Life Sciences to see how changes in metabolomics might occur with longer space flights. Of course, the problem of Fatigue seems to always to appear sooner or later in sustained operations, and we examine so aspects of that as well in the context of optimal overall systems design. This panel is dedicated to the memory of Virginia Tech Norton Professor Emeritus and Transportation Institute Associate Director Walter W. Wierwille, Ph.D. who passed away in late October 2020 as this panel was being developed and relating to areas he made direct major contributions to with regard to Human Factors in Aerospace Systems as a researcher, professor, and mentor.*

[99] COOPER-HARPER HANDLING QUALITIES AND OTHER KEY SUBJECTIVE RATING SCALES

David Mitchell[1], Christopher Cotting[1], Dwight Holland[2]
[1]*US Air Force Test Pilot School, Edwards, CA, USA;* [2]*Human Systems Integration Associates, Roanoke, VA, USA*

(Education - Program / Process Review)

BACKGROUND: Handling qualities are "those qualities or characteristics of an aircraft that govern the ease and precision with which a pilot is able to perform the tasks required in support of an aircraft role" (Ref. Cooper & Harper, 1969). They encompass aspects of every element of the aircraft design and response, from pilot-vehicle interface to dynamic response, and can be influenced by complicating factors such as outside

visibility and winds. This scale and others mentioned here may also be used to assess control characteristics for spacecraft handling. **OVERVIEW:** Over 50 years ago, the Cooper-Harper Rating (CHR) scale was developed by George Cooper of NASA Ames Research Center and Bob Harper of Cornell Aeronautical Labs (CAL), CHR is a 10-point scale to be used by test pilots in assessing handling qualities of aircraft. **DISCUSSION:** The CHR Scale has been criticized because of its attempt to collect three unique contributors to aircraft handling into a single number: task performance or the ability to complete primary and ssecondary tasks; overall task workload, both physical and mental; and pilot compensation, or the extra effort required of the pilot to achieve suitable task performance with suitable workload. Despite this criticism, the scale has become ubiquitous in research, evaluation, and acceptance testing of all types of vehicles. Issues with application of the scale often can be traced to the over-reliance on a numerical value, when comments and opinions of the pilot should be weighed just as heavily; interpretation of an ordinal scale as if it were an interval scale; and, especially, a distinct lack of education and training in the scale's proper usage, strengths, and weaknesses. These scales and others that owe their lineage to the CHR scale, such as the Modified Cooper-Harper Scale (developed by Dr. Walt Wierwille, who worked on the CHR scale with Bob Harper at Cornell Labs), the Cranfield Aircraft Handling Qualities Rating Scale (developed at Cranfield University in England), and the Bedford Workload Scale (developed at RAE Bedford in England) will be briefly reviewed, compared, and contrasted as well. Significant past close calls and mishaps will be highlighted as lessons learned where appropriate. Notions on how Situational Awareness is related to developing optimal workload in tasks will also be touched upon. Current challenges with application of the scales to highly automated systems, such as unmanned aircraft, will be discussed.

Learning Objectives

1. The audience will learn about the challenges to assessing human-system interactions through examination of aircraft handling qualities and rating scales.
2. The audience will gain an appreciation of existing ordinal rating scales for evaluation of aircraft handling qualities and mental and physical workload.
3. The audience will understand the need for proper education and training in the use of qualitative rating methods.

[100] EVALUATION OF AN AUGMENTED REALITY INTERFACE TO CONTROL TELEOPERATED SATELLITES

Andrew Liu[1], Jessica Todd[1], Leia Stirling[2]
[1]Massachusetts Institute of Technology, Cambridge, MA, USA; [2]University of Michigan, Ann Arbor, MI, USA

(Education - Case Study)

INTRODUCTION: In future long-duration missions, free-flying teleoperated and autonomous satellites will replace astronaut extravehicular operations (EVA) for inspection or maintenance tasks. The satellite control interface will have to provide sufficient spatial and temporal awareness if astronaut operators are to safely complete their tasks. We present a pilot evaluation of an Augmented Reality (AR) interface for conducting an inspection of a spacecraft exterior and its impact on task performance and operator strategies. **METHODS:** Twelve subjects performed a simulated inspection task by flying a small satellite around the spacecraft exterior and identifying potential anomalies. They wore a Microsoft HoloLens and controlled their viewpoint and the satellite through a gesture-based interface. Four control modes were tested: (1) Manual control in a satellite-referenced frame, (2) manual control in a station-referenced frame, (3) waypoint navigation and (4) flexible mode control. Performance measures included percentage of station inspected, number of collisions, anomaly detection, and subjective workload. Interactions with the interface were recorded to characterize subject strategies. The experiment protocol was approved by MIT COUHES. **RESULTS:** Manual control in the global and local frames maximized the inspected area, but waypoint navigation resulted in fewer collisions. No significant difference in accuracy of anomaly detection was found across the command modes. With free choice of command mode, subjects generally preferred to remain in one of the manual control modes. Subjects reported that the global and local modes required less workload and were more usable than waypoint navigation. **DISCUSSION:** Although manual control modes were preferred, the higher risk of collisions could outweigh the benefits of improved coverage. Improving the usability of waypoint navigation is needed to realize the benefits of both control modes. Future studies should also compare task performance and usability against current interfaces (e.g., ISS Robotic Workstation).

Learning Objectives

1. The participant will learn how virtual and augmented reality techniques can be used for telerobotic applications.
2. The participant will learn how human performance affected by the use of VR/AR technologies.

[101] ENHANCING HUMAN PERFORMANCE INFLIGHT WITH WEARABLE, IMPLANTABLE AND INGESTIBLE TECHNOLOGY

Danielle Carroll[1], Dwight Holland[2]
[1]University of Colorado Boulder, Boulder, CO, USA; [2]Principal, Human Systems Integration Associates, Roanoke, VA, USA

(Education - Program / Process Review)

BACKGROUND: Over the last two decades, the landscape of modern medicine has changed tremendously due to the progressive digitization of healthcare. The field of Aerospace Medicine, among others, has reaped benefits from these advancements, but further optimization of astronaut health can be achieved by refining the role of wearable, implantable, and ingestible (WII) technologies in the inflight setting. **OVERVIEW:** The aerospace environment impacts nearly every organ system in the body; many of these effects have terrestrial parallels that become exaggerated in the context of spaceflight-induced physiologic stress. Judicious use of WII technologies will allow for enhancement of preventative capabilities and identification of opportunities to intervene early, ultimately intercepting conditions while intervention is still a possibility. **DISCUSSION:** Early detection of harmful trends is especially useful in austere, remote settings. The human body is a rich, yet largely untapped source of biometric, biomechanical, and physiologic data; strategic use of WII devices will facilitate the long-anticipated shift toward precision medicine in the aerospace environment. Aviation Environment: High-performance jet and aerobatic pilots are often faced with inflight conditions that test the body in unique ways, to include high G-loading, altered ambient levels of O2 and CO2, muscular and cognitive strain resulting in fatigue, and other factors. Feedback from wearable technologies can improve awareness of human performance parameters in this setting and permit early detection of problems before they are amplified through continued stress. Spaceflight Environment: Many of the unique physiologic changes seen in spaceflight can be targeted with WII sensors, permitting a shift toward prevention and early intervention. In particular, critical issues such as sleep, fatigue, hydration, nutrition, and overall performance can be trended and targeted for personalized therapeutic interventions. **SUMMARY:** The quality, capabilities, and availability of WII devices have boomed in recent years, thanks to the investment of greater attention and resources in the global health technology sector. Optimization and personalization of health care in the aeromedical setting can be achieved with strategic use of such technologies, which provide opportunities for prevention and early detection through longitudinal, noninvasive monitoring.

Learning Objectives

1. Understand the trends in data-based healthcare processes over the last twenty years.
2. Understand the ways in which health data may be collected in order to permit personalized medical interventions.
3. Recognize the critical areas within Aerospace Medicine that wearable technologies can target.

[102] THE NASA TWINS STUDY: ELEVATION OF P-CRESOL AND CYP450 2E1 DURING SPACEFLIGHT, AND ITS IMPLICATIONS FOR DRUG METABOLISM AND ASTRONAUT PERFORMANCE

Michael Schmidt[1], Christopher Mason[2], Caleb Schmidt[1], Cem Meydan[2]
[1]Sovaris Aerospace, Boulder, CO, USA; [2]Weill Cornell Medicine, New York, NY, USA

(Education - Program / Process Review)

BACKGROUND: p-Cresol is a metabolite that is produced when gut bacteria act upon dietary tyrosine. p-Cresol is absorbed into circulation and must be processed in the liver. Once in the liver, p-cresol requires sulfur groups for its metabolism and ultimate removal as a safe excretion product. Drugs, such as acetaminophen, also require sulfur groups for their metabolism. When p-cresol is produced by gut bacteria, it competes for the liver's sulfur pool that is needed to safely metabolize drugs, such as acetaminophen. This can lead to formation of drug intermediates (e.g. NAPQI) that produce hepatic damage and potential degradation in astronaut performance. CYP450 2E1 is the enzyme that governs the formation of NAPQI from acetaminophen. The present work explores the production of p-cresol and the expression of CYP450 2E1 genes (RNA) in spaceflight. Over a period of one year, two identical twins (one in space and one on earth as control) followed the same longitudinal protocol of multi-scale omics, clinical, and performance measures. Multi-scale omics measures included genome, epigenome, transcriptome, metabolome, and microbiome. The p-cresol glucuronide and p-cresol sulfate features were extracted from the high dimensional metabolome data, during pre-flight, in-flight, and post-flight periods. RNA data for CYP450 2E1 were also extracted. **OVERVIEW**: A significant elevation in p-cresol glucuronide and p-cresol sulfate was observed in space. p-Cresol glucuronide and p-cresol sulfate returned to baseline levels, upon return to Earth. In addition, a time-specific two-fold elevation in gene expression of CYP450 2E1 was observed in space in relation to the ground control. **DISCUSSION**: This appears to be the first evidence that p-cresol sulfate and p-cresol glucuronide are elevated during spaceflight and return to baseline upon return to Earth. This suggests changes in the gut metagenome involving species, such as clostridia. Second, CYP450 2E1 is the cytochrome responsible for metabolizing about 15% of acetaminophen, which results in the formation of the toxic intermediate NAPQI. Normally, a rich sulfur pool protects against NAPQI via conjugation with glutathione (GSH) and safe excretion of the NAPQI-GSH conjugate. The increase in p-cresol and the upregulation of CYP450 2E1 in space may pose a previously unidentified risk to the ingestion of specific drugs that impact astronaut safety and performance, which warrants further investigation.

Learning Objectives

1. To understand the role of gut bacteria in the production of p-cresol (para-cresol).
2. To understand the role of p-cresol and sulfur compounds in drug metabolism.
3. To understand the role of CYP450 2E1 in drug metabolism.

[103] SYSTEM DESIGN FOR HUMAN PERFORMANCE VARIABILITY: FATIGUE

Gregg Bendrick[1]
[1]*Federal Aviation Administration, Oklahoma City, OK, USA*

(Education - Tutorial / Review)

INTRODUCTION: Aerospace Systems are often tested and validated by operators who are well-rested and performing optimally. However, In the operational setting systems must inevitably be operated by operators who experience some degree of fatigue. Fatigue consists of acute sleep deprivation, chronic sleep restriction, and/or circadian desynchrony. While there is some difference among individuals in how exactly they respond when fatigued, in almost all cases fatigue degrades overall performance to some degree; in some cases the performance is significantly degraded. Research has shown (Durmer & Dinges, 2005) that the neurocognitive effects of fatigue to be (among other things): Increased errors of omission & commission, neurocognitive slowing (with delayed response times), decline of both short-term and working memory, reduced ability to acquire incoming information, deterioration of divergent thinking (i.e. multi-tasking), response perseveration on ineffective solutions (i.e. keep trying to do the wrong thing), and growing neglect of activities judged to be non-essential. Together, these lead directly to the loss of ability to form and maintain situational awareness. Similarly, decision-making and response execution are degraded. Fatigue has been demonstrated as a cause or contributing factor in many aviation accidents. Moreover, even though humans are not in the vehicle in Unmanned Aerial Systems (UAS), humans are nonetheless still a part of the system, and thereby induce the potential risk of fatigue. **TOPIC:** To ensure robustness of design, systems should be tested using operators who are deliberately fatigued. Furthermore, design solutions that could potentially mitigate the risk of operator fatigue on overall system performance include wrist actigraphy and predictive performance modelling, as well as real-time physiological monitoring of the operator. **APPLICATION:** These methodologies can then be combined with artificial intelligence algorithms to leverage adaptive automation as a method to reduce workload on the operator, to a degree commensurate with that operator's fatigue.

Learning Objectives

1. The learner will be able to identify the three physiologic aspects of fatigue that, alone or combination, affect performance.
2. The learner will be able to list at least three neurocognitive elements that are affected by fatigue.
3. The participant will understand how artificial intelligence can utilize adaptive automation to minimize the risk of operator fatigue on system performance.

[104] AUTOMATION ON THE RAMPAGE: THE BOEING 737MAX CASE STUDY

Carlos Salicrup[1], Diego Garcia[2], Dwight Holland[3]
[1]*Aeromexico / IFALPA, Mexico City, Mexico;* [2]*Embry Riddle Aeronautical University, Daytona Beach, FL, USA;* [3]*Principal, Human Systems Integration Associates, Roanoke, VA, USA*

(Education - Case Study)

INTRODUCTION: There is nothing more terrifying than trying to take manual control of an airplane during a critical situation with a non-responsive automated system overruling commands. It took 2 accidents, 346 dead, and enormous consequences to ground B737MAX. Civil aviation authorities banned the MAX shortly after the second accident, when preliminary investigations appointed to a B737MAX native system: The Maneuvering Characteristics Augmentation System (MCAS). This review covers different Human Systems Integration (HSI) perspectives: Level of Automation (LoA), Training, Human Cognitive Performance and Situation Awareness (SA). **BACKGROUND:** The aerospace industry promotes more automation as one of the solutions for overcoming more complex digital jet systems as part of the answer to enhanced operational capacity. Automation helps to shed workload in complex systems saving cognitive resources, to enhance peak-performance. LoA is defi ned by the amount of human involvement to complete such tasks. The conundrum of automation lies in choosing the right amount of LoA depending on the task, but also in collateral, deleterious eff ects on human skills, SA, and decision making. Even so, pilots must be trained in detail about how the various LoA assist the tasks at hand, and all the intervention protocols in various failure modes. **CASE PRESENTATION:** The initial Boeing 737 (1967) model transitioned through 3 generations of modifications. The B737MAX introduced MCAS: an augmented protection for excessive angle of attack (AoA) stalls, which compensates for the pitch-up momentum resulting from the thrust of new engine configuration, especially during high-power and low-speed situations (take-off and initial climb). This case presentation addresses operative details of the MCAS system, the applied automation philosophy, and the training process for pilots. **DISCUSSION:** Human-centered automation should allow pilots to regain full control of the airplane in manual mode at any moment, avoiding deterrent process for overriding system's control. Automation has solved many human performance limitations linked to all types of mishaps. Indeed, safety numbers are at their best today in great part due to technology. But it has also taken the burden of costly events related to reduced situational awareness, automation overreliance, and impaired psychomotor skills related to automated processes. Automation should always be a tool to enhance human performance, not to reduce it.

Learning Objectives

1. The attendee will learn about the human systems automation and it risks.
2. The attendee will learn about the importance of training in all the new system automation failure modes.

Tuesday, 08/31/2021 ***10:30 AM***
Governor's Square 15

[S-22]: PANEL: AUTOMATION IN AEROSPACE AND HEALTHCARE: CHALLENGES AND OPPORTUNITIES

Sponsored by Aerospace Human Factors Association

Chair: Brian Musselman
Co-Chair: Diego Garcia

PANEL OVERVIEW: *Improving the capabilities of machines has increased productivity and safety, and enabled the development of complex systems. Despite these advances, human behaviors and cognitive limitations outputs are the main drivers for mishaps. Automation has become a successful countermeasure against human error in safety-critical operations; the automated human-machine interface poses challenges that can decrease overall safety. Unexpected failures that require a human to take control of a system, automation surprises, and the need to maintain vigilance for long periods of time are examples of how human performance can impact safety. Aviation and healthcare are two industries in which automated systems have become part of routine operations. Unmanned aerial vehicles are being developed for delivery, surveillance, and teamed operations with manned aircraft. Urban air mobility (UAM) vehicles that will transport people with little or no human control are being tested, and may be introduced to the commercial transportation system. Commercial aviation and space operations use highly automated systems that require a decreasing amount of human intervention. In fact, single pilot (and even pilotless) operations in commercial aviation are being proposed as safer and, of course, more profitable alternatives. Healthcare decision support systems and robotic surgery are becoming more prevalent. Aerospace and healthcare are two examples of industries in which the introduction of automation and other leading-edge technology has improved productivity while raising questions about safety. Human limitations and a loss of trust in technology are barriers to their implementation. This panel discusses barriers and opportunities for implementation of highly automated systems, and provides suggestions for research and education.*

[105] QUALITATIVE ANALYSIS OF COMMERCIAL AVIATION COMMUNICATIONS BREAKDOWN AS A REQUIREMENTS INPUT TO SINGLE PILOT OPERATIONS

Brian Musselman[1]
[1]*US Air Force, San Antonio, TX, USA*

(Original Research)

INTRODUCTION: Single pilot operations are an emerging development in commercial aviation. Effective communications are a challenge of single pilot operations. Understanding current communications challenges between aircrew and ground-based operators can inform requirements for single pilot operations development. The purpose of this study is to identify factors associated with poor human-machine interaction through qualitative analysis of Aviation Safety Reporting System (ASRS) reports submitted by personnel operating under Part 121. **METHODS:** The data for this research was obtained from the ASRS database. The search parameters included reports from January to December 2018 from Part 121 operations where human factors were the primary problem and communications breakdown was a reported human factor. Qualitative research was conducted using NVivo Plus version 12 for exploration, coding and analysis. **RESULTS:** More communication breakdowns were reported in descent, approach (initial and final), and cruise than other phases of flight. Majority of the communications breakdowns during descent and initial approach is with TRACON, during final approach is with tower, and during cruise is with center. There are potentially different factors contributing to communication breakdown with TRACON during descent than with other phases of flight. The coded occurrence of communication breakdown in February, September, and December is higher than other months. **DISCUSSION:** This quantitative study provides several remarkable results in the phase of flight and month of the year. Future research could involve targeted audits for increased granularity as to the types of communication breakdown during descent, approach (initial and final), and cruise, and factors contributing to the month

Learning Objectives

1. The audience will learn about cause of communication breakdowns between pilots and ground-based controllers.
2. The audience will learn about communication breakdowns by phase of flight.
3. The audience will learn about communication breakdowns by control function.

[106] AI IN SPACE HEALTHCARE: HOW, WHEN AND WHY

Ilaria Cinelli[1]
[1]*InnovaSpace, London, United Kingdom*

(Education - Program / Process Review)

INTRODUCTION: Medical monitoring and health maintenance on the International Space Station (ISS) are carried by a system made of a series of individual components, not integrated for redundancy. Here, the ground control oversees and provides remote assistant to astronauts in space throughout the mission. In incoming missions beyond low Earth Orbit, the crew shall become Earth-independent or autonomous from the ground. The system providing healthcare and onboard medical capabilities shall be re-engineered when accounting of a different end-user, such as commercial astronauts (CAs) and space tourists (STs). **METHODS:** Onboard machines may replace part of the tasks executing by the ground if provided with intelligence. Here, the requirements for having a robust artificial intelligence (AI) are identified to highlight the existing gaps with current AI developed for Terrestrial applications when looking at the specific case of healthcare. Large discrepancies arise when considering the type of data, ethics and risk of medical conditions. Against this backdrop of limitations, an approach is proposed for generating data by running classified analogue missions (CAMs). Such classification aims at controlling operational stressors and stresses of adaptation to isolation in extreme environments. So, the deriving medical risk model of CAMs aims at giving insights into a possible medical scenario when CAs and STs will be onboard. Then, guidelines are suggested for including AI in already existing devices and for confining the impact of AI in decision making. **RESULTS:** The implementation of CAMs is shown for a short-duration mission run in the Utah desert. Then, an example of AI integration is shown in neuromodulation where an intelligent brain-stimulating device is designed to function as a brain countermeasure. **DISCUSSION:** The medical risk model, on which AI and ethics build on, shall include CAs and STs. Then, AI in space healthcare is going to be reliable if the system supporting the development of AI and the collection of data is robust. More research is needed for preserving health in commercial activities.

Learning Objectives

1. Understanding the importance of artificial intelligence (AI) in space healthcare.
2. The medical risk model of commercial astronauts and space tourists may be established by running classified analogue missions.
3. AI developed for terrest rial applications is not t ransferable to healthcare in space.

[107] HUMAN PERFORMANCE FACTORS ASSOCIATED WITH MEDICAL AUTOMATION: A LITERATURE REVIEW

Keith Ruskin[1]
[1]*University of Chicago, Chicago, IL, USA*

(Education - Tutorial / Review)

INTRODUCTION: Automation has become an integral part of medical practice. Systems such as monitors, anesthesia gas machines, and ventilators are controlled by software, which is in turn managed by the clinician. **METHODS:** A comprehensive literature review was conducted that included the keywords "automation," "medical equipment," "ergonomics," and "human performance." Articles were reviewed for relevance to the

topic. **RESULTS:** A total of 39 articles were relevant to the topic of automation in the operating room. These articles discussed advanced technology, alarm fatigue, automated checkouts, and malfunctions. Boredom and complacency were also associated with increasing levels of automation. **DISCUSSION:** Medical devices have become increasingly complex and can fail in unexpected ways. Increasing levels of automation in the clinical environment poses challenges that have been confronted in industries such as transportation and nuclear power. Reliance on automated systems can cause disuse of human skills, impairing a physician's ability to cope with system failures. Automation surprises can present confusing and sometimes contradictory information, making it difficult for the human operator to regain control of the system. This presentation will discuss medical automation and explain how to apply human performance principles from aviation to the clinical environment.

Learning Objectives

1. The participant will learn how automated medical technology can impact human performance.
2. The participant will be able to use lessons learned from the aerospace industry to better manage devices that use advanced medical technology.
3. The audience will understand how alarms, alerts, and warnings (collectively called signals) can affect our understanding of what automated devices are doing.

[108] OPTIMIZING HUMAN PERFORMANCE VIA CLINICIAN'S SELECTION OF REASONS FOR COGNITIVE AID NON-USE: A STEP TOWARDS USEABLE AUTOMATED COGNITIVE AIDS

Anna Clebone[1], Keith Ruskin[1]
[1]*University of Chicago, Chicago, IL, USA*

(Original Research)

INTRODUCTION: Despite the established benefits of following the advanced cardiac life support (ACLS) guideline during cardiac arrest situations, it is not always accessed. Automating the appearance of a critical event cognitive aid during cardiac arrest and other critical events could lead to increased use of the aid if the reason for non-access was unavailability. Conversely, if the reason for non-access was that the clinician perceived that the aid was not needed, or that the clinician disagreed with the protocol, automating the appearance of the aid might not be as useful. We hypothesized that the rate of unavailability of the cognitive aid as a reason for cognitive aid non-use could be found with a self-reported survey. **METHODS:** After IRB exempt designation (UChicago IRB16-0718-AM001), incidences of and reasons for cognitive aid use and non-use during actual perioperative critical events were collected pre- and post implementation training. All anesthesia clinicians at a single academic medical center were surveyed, including 70 clinical faculty and certified registered nurse anesthetists, and 76 residents and fellows. The Chi Square test was used to compare data before and after implementation. **RESULTS:** The response rate was 64.5%. Over 80% of respondents encountered at least one critical event. Participants reported guideline non-use in 93% of reported events. Reasons for cognitive aid non-use were collected for both the control arm (before aid implementation) and the study arm (after aid implementation), with 334 reasons reported total. Reasons for non-use fell into six categories. Incidence in each category (control/study, category % of total) was: A = 'not available' (50/17, 50%), N = 'not needed' (60/57, 35%), T = 'no time' (14/19, 9%), P = 'another person running crisis' (25/13, 11%), H = 'used in another way' (15/16, 9%), O = no reason given (21/27, 14%). A difference between the control (before implementation) and study (after implementation) arms was found for reason A = 'not available,' Chi-Square, 12.55, $p<0.001$. **DISCUSSION:** Increased use of emergency guidelines during and perioperative critical events may improve patient care. The reason for cognitive aid non-use was unavailability in over 50% of cases. This finding supports the possibility that making cognitive aids automatically available may be found useful by clinicians. The authors would like to thank Barbara K. Burian, Ellen Choi, Allan Klock, and Avery Tung for their integral roles

Learning Objectives

1) Understand the reasons for critical event cognitive aid non-use in one study in the peri-operative setting.
2) Gain additional insight into one way that looking at human factors can inform the creation of future automation.

Tuesday, 08/31/2021 ***10:30 AM***
Plaza A/B

[S-23]: PANEL: THE HISTORIC NASA/SPACEX DEMO-2 COMMERICAL CREW TEST-FLIGHT MISSION: PART 1

Sponsored by Space Medicine Association

Chair: Joseph Dervay

PANEL OVERVIEW: BACKGROUND: *Crew Dragon Demo-2 (DM2) was the historic first crewed test-flight of the SpaceX (SpX) Crew Dragon spacecraft. It represented years of collaborative work between NASA and SpX (as the first commercial crew provider) to deliver astronauts into low-earth orbit and dock with the International Space Station (ISS). OVERVIEW: Demo-2 launched on May 30, 2020 from the Kennedy Space Center with NASA Astronauts Doug Hurley and Bob Behnken. It was the first crewed flight in 9 years from US soil since STS-135 in 2011. The 63-day mission concluded on Aug 2nd with a water recovery in the Gulf of Mexico, the first US splashdown in 45 years since Apollo-Soyuz. The test flight validated the hardware and operations necessary for subsequent crewed missions. This mission was executed in light of challenges with the global COVID-19 pandemic.* ***DISCUSSION:*** *This first of two panels will discuss a wide range of topics addressing operational, technical, training, health, medical, and safety issues. Development of Operational (Ops) Concepts and integration between NASA and the provider was critical. Flight Rule development and evaluation of occupant protection will be explained. Ops training evolutions included; recovery vessel orientation and capsule retrieval, medical simulations of landing crew with potential MEDEVAC, and integration with DOD forces for contingencies. Kennedy Space Center launch pad modifications were completed for Falcon and Dragon ops. KSC Crew Quarters and medical facility refurbishment were addressed to serve the health and safety of crew and support staff. The Launch and Landing evolutions demonstrated close integration between NASA and SpaceX.*

[109] NASA COMMERCIAL CREW MEDICAL CONOPS DEVELOPMENT AND INTEGRATION

James Pattarini[1], Joseph Dervay[1], Stephen Hart[1], Tara Williams[2], Rhonda Haralson[2], Lawrence Baitland[2], Benjamin Johansen[1], Anil Menon[3]
[1]*NASA-JSC, Houston, TX, USA;* [2]*KBR, Houston, TX, USA;* [3]*SpaceX, Hawthorne, CA, USA*

(Education - Program / Process Review)

BACKGROUND: The transition from Shuttle operations to capsule-based launches and landings via the Commercial Crew Program's (CCP) vehicle development process required broad reassessment and adaptation of NASA medical support to the new paradigm. The public-commercial partnership with SpaceX for the Crew Dragon Demo 2 launch and subsequent recovery was a first for human spaceflight, and the first water recovery of a capsule since 1974. Its success relied on an integrated NASA-SpaceX medical team. **OVERVIEW:** In the years prior to launch, physicians and biomedical engineers from NASA describe their approach to flight rules development, contingency planning, crew support, and end-to-end communications concept of operations (ConOps) development in tandem with SpaceX medical leadership, and with the NASA Flight Operations Directorate. Joint team staffing ConOps and surgeon roles are discussed from the prelaunch period through safe crew return to Johnson Space Center. **DISCUSSION:** The joint public-private medical team approach to crew support and ops products development was effective, giving all medical providers the tools and skills needed to execute their roles. The clear delineation of crew care handoffs between team members removed opportunities for medical error, and staffing ConOps developed for CCP provide a useful framework for future exploration programs.

Learning Objectives
1. Learning Objective 1: Describe the medical authority philosophy adopted by the joint NASA-SpaceX team to ensure seamless transitions of patient care.
2. Learning Objective 2: Describe the risk trades involved in a decision to deorbit in response to vehicle or crew health contingency.

[110] RETURN OF KSC OPERATIONS TO SUPPORT THE COMMERCIAL CREW PROGRAM

Philip Scarpa[1], Catherine DiBiase[1], Joseph Dervay[2]
[1]NASA-Kennedy Space Center, NASA-KSC, FL, USA; [2]NASA-Johnson Space Center, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: The Commercial Crew Program will allow human-rated commercial provider vehicles to launch from the Kennedy Space Center (KSC). Significant restoration and improvements have been made at KSC of operations and facilities since the last space shuttle crewed launch in 2011. The Demo-2 (DM2) was the historic first crewed test-flight of the SpaceX (SpX) Crew Dragon spacecraft, with KSC playing a critical role in pre-launch support. **OVERVIEW:** Significant launch pad modifications by SpX helped prepare for DM2, including installation of an emergency egress system and direct egress to triage medical care via armored personnel vehicles acquired by NASA. Major improvements to the KSC Emergency Medical Services were made and important revisions to KSC facilities, operations, and personnel in support of implementing the Health Stabilization Plan (HSP) at KSC occurred. **DISCUSSION:** In preparation for commercial crew missions such as DM2, a review of the new SpX pad egress system and revisions of the Triage and Emergency Medical Services provided to support any pre-launch and early launch contingencies will be discussed. Discussion will also include the important role of establishing an Emergency Response Working Group (ERWG) in conducting exercises and operating in new control centers, and integrating roles with commercial providers. Significant modifications to the KSC Astronaut Crew Quarters, the Crew Examination Facility, and the creation of a Primary Contact Exam Facility will also be highlighted. Close integration with Johnson Space Center Flight Surgeons ensured the medical needs of crew and support staff quarantined at KSC in the final phase toward launch would be met at the highest levels. Unique challenges related to providing HSP, protecting critical ground mission personnel, and providing VIP visitor support at KSC during a worldwide pandemic will also be presented.

Learning Objectives
1. Understand the restoration and modification activities at KSC since the end of the shuttle program to prepare for commercial crew flights.
2. Review the quarantine and health stabilization factors at Astronaut Crew Quarters to ensure medical readiness prior to launch.

[111] NASA/SpX DM-2 PRE-LAUNCH PREPARATION AND LAUNCH EVOLUTION

Stephen Hart[1], Joseph Dervay[1]
[1]NASA Johnson Space Center, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: The liftoff of SpaceX's (SpX) Crew Dragon capsule atop their Falcon 9 booster represented the first crewed launch from US soil since the final shuttle of STS-135, 9 years previously. While many of the conventions developed over almost 60 years of spaceflight from the Cape Canaveral area were preserved, a number of novel operational approaches were developed to modernize our approach and ensure effective integration of NASA and SpX operations and hardware. **OVERVIEW**: With 9 years since the last launch of a vehicle from US soil, and 45 years since the last splashdown, revisions to our approach to launching crew required significant focus and development in most every detail. Where possible, efforts were made to standardize across present (Soyuz and SpX) as well as future platforms (Boeing and Orion), including; templates for Initial & Final Medical Operations Readiness Reviews (MORRs), debriefs, mission Checklists, Space Operations Medical Support Training Course (SOMSTC). Likewise, the actual flow in the runup to launch, was developed using the shuttle experience as a starting point, but folding in lessons learned in 20 years of Soyuz launches and landings to refine elements such as the Health Stabilization Program and Contingency response.

DISCUSSION: The presentation will cover the period from un-crewed DM1 flight to DM2 launch and docking, and into the Dragon specific portions of the in-flight period. Crew Surgeon perspectives will be shared on activities including: travel to Kennedy Space Center, quarantine, Static Fire viewing, Dry Dress (launch rehearsal), interaction with NASA and SpX medical team and suit techs, and electric car use to pad. The implications or uncertain launch dates and mission durations, as well as impacts of quarantine and travel restrictions due to COVID-19 on crewmembers and support staff will be noted in light of a new vehicle.

Learning Objectives
1. The audience will be presented the elements of mission planning and preparation leading up to the launch and docking of DM2 including vehicle preparation and insights on the launch and docking experience.
2. Crew Surgeon perspectives will be shared as they supported the DM2 crew for launch of a new manned vehicle.

[112] ON-ORBIT & RECOVERY ASPECTS OF THE NASA/SpaceX DEMO-2 COMMERCIAL CREW TEST-FLIGHT MISSION

Joseph Dervay[1], Stephen Hart[1]
[1]NASA Johnson Space Center, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: The NASA/SpaceX (SpX) Crew Dragon Demo-2 (DM2) was the historic first crewed test-flight of the SpX Crew Dragon spacecraft. With two NASA Astronauts onboard, the mission represented years of collaborative between NASA and SpX to launch humans into low-earth orbit, dock with the International Space Station (ISS), and return with a capsule splashdown. **OVERVIEW:** Demo-2 launched on May 30, 2020 from the Kennedy Space Center with NASA Astronauts Doug Hurley and Bob Behnken. The crew docked with ISS and increased the ISS crew to six. During their increment, the crew participated in four EVAs (extravehicular activities), performed science, and evaluated the Dragon capsule. The 63-day mission concluded on Aug 2nd with a water recovery in the Gulf of Mexico, the first US splashdown in 45 years since Apollo-Soyuz. After initial evaluation and treatment, the crew was subsequently transported to the Johnson Space Center for post-flight activities. **DISCUSSION:** On-orbit activities during the ISS stay included participation in four critical ISS battery replacement EVAs, station and exercise equipment maintenance, and participation in various science. The crew also completed on-orbit habitability evaluations of the Dragon capsule in preparation for upcoming four crewmember missions. Close integration existed between the NASA Crew Surgeons, Astronaut Office, Vehicle Integration Office Flight Operations Division, DOD, SpX, and SpX Surgeon and medical team to ensure splashdown safety and efficiency. This included support of recovery sites as Hurricane Isaias was impacting Florida. A recovery vessel for capsule and crew was outfitted by SpX, and provided the necessary platform and facilities for a team medical approach to crew evaluation and treatment as needed. This included helicopter MEDEVAC if required. The NASA Astronauts were successfully recovered in the Gulf of Mexico off the coast of Pensacola, FL, and transported to the Johnson Space Center to begin their post-flight medical evaluations and physical reconditioning.

Learning Objectives
1. Understand the challenges faced by the NASA and SpaceX team in performing the first US capsule splashdown in 45 years.
2. Appreciate the close integration needed by NASA Crew Surgeons and SpX Surgeons in ensuring readiness for crew medical care

Tuesday, 08/31/2021 ***10:30 AM***
Plaza D/E

[S-24]: PANEL: NAVY RAM GRAND ROUNDS

Chair: Nathaniel Almond
Co-Chair: Jennifer Hunt

Panel Overview: *This panel is Navy RAM (Resident in Aerospace Medicine) grand rounds to include case reports by the residents. It will be a pre-recorded session since all of these residents have graduated and been reassigned.*

[113] SLEEP DEPRIVATION AND SELF-HARM ASSOCIATED WITH EXCESSIVE INTERNET GAMING, A CASE STUDY

Andrew Doan[1], Stuart Glass[1], William McDonald[1], Nathaniel Almond[1]
[1]*NAMI, Pensacola, FL, USA*

(Education - Case Study)

INTRODUCTION: Personal technology use (PTU) for entertainment and internet gaming have been associated with health problems, particularly with sleep. **BACKGROUND:** We discuss a case of an active duty aviation mechanic instructor who failed to report to work after a 72-hour period of binge gaming with a massive multiplayer online role playing game (MMORPG). **CASE PRESENTATION:** An investigation revealed significant lack of cleanliness in his home, and the service member suffered a pneumothorax from a self-induced knife injury. The service member overslept his alarm due to severe sleep deprivation after playing for most of his 72-hour leave period. He admitted that excessive gaming with the MMORPG resulted in sleep deprivation and fatigue. To devise an excuse for missing work, he induced self-injury and fabricated a story of robbery and assault. **DISCUSSION:** The issue of sleep deprivation associated with PTU and excessive gaming will be discussed in regard to aviation aircrew and ground crew resilience and readiness.

Learning Objectives

1. The participant will be able to understand the proposed diagnostic criteria for internet gaming disorder.
2. The audience will learn about the association of sleep deprivation associated with internet gaming.

[114] RAM INTERESTING CASES PANEL - FLICKER VERTIGO

Daniel Liddell[1], Daniel Monlux[1]
[1]*Naval Aerospace Medicine Institute, Pensacola, FL, USA*

(Education - Case Study)

INTRODUCTION: This is a case report describing a military rotary-wing crew chief with flicker vertigo. **BACKGROUND:** Flicker Vertigo or Flicker-Induced Vertigo is a largely unstudied condition with a limited volume of dedicated literature. Because of this, the underlying pathophysiologic process, risk factors, effective means of diagnosis, and any potential means of treatment or prevention are of limited understanding. Furthermore, the implications for continued flight service by the effected individual is not explicitly addressed, presenting an admittedly rare but noteworthy challenge. **CASE PRESENTATION:** The subject is a 24-year-old Marine Corps Helicopter Crew Chief with approximately 1,200 total flying hours with reported transient episodes of altered mental status associated with uncontrolled diffuse muscular rigidity and loss of vision. Symptoms had reportedly occurred on approximately 5 separate dates over the preceding year, each time being provoked in an identical scenario – during initial turn-up sequence, standing in position beneath the spinning rotor arc of a CH53E at the approximate 2'oclock position off the aircraft nose, Sun high in the sky, upon staring at a blank section of grey aircraft fuselage just aft of the right crew door he would begin to experience a flickering of light as sunlight passed through the spinning rotors and reflected off the aircraft. He experienced an initial period of progressive vision loss, followed by diffuse generalized muscular rigidity and uncontrolled neck extension. He denied falling or losing control of posture and noted that upon complete vision loss all symptoms would spontaneously and instantaneously resolve. **DISCUSSION:** The primary concern regarding spatial disorientation of any kind in the context of aviation is the inability to correctly interpret aircraft position, attitude, and airspeed. Add the component of transient loss of muscular function/control as exemplified in this case, and the possible ramifications in flight are significant and potentially tragic. Due to its clinical rarity – be that due to underreporting, underdiagnosing, or unawareness, this condition may be misdiagnosed or missed entirely. Knowledge of this condition and its presentation may afford accuracy of future diagnosis and further inquiry regarding implications for flight.

Learning Objectives

1. The participant will gain a better understanding of potential history and presentation of symptoms of flicker vertigo.
2. The participant will be able to develop a differential diagnosis for flicker vertigo and correlate the impact on safety of flight.

[115] NAVY FIGHTER PILOT RETURNED TO DUTY WITH RESIDUAL ANTERIOR MEDIASTINAL MASS: A CASE REPORT

Jami Buckley[1], Sadie Henry[1]
[1]*NMOTC NAMI, Pensacola, FL, USA*

(Education - Case Study)

INTRODUCTION: Increasing numbers of aviators are being returned to flight status after successful treatments for cancer. This report details a Navy F/A-18 pilot who was successfully returned to flight status with a residual anterior mediastinal mass following treatment for lymphoma. **CASE DESCRIPTION:** A 30 year old male F/A-18 pilot presented with exertional chest pain and dyspnea. A 6cm anterior mediastinal mass was found on imaging, followed by a biopsy showing a diffuse large B-cell lymphoma (DLBCL). Further staging placed him at stage IIax, bulky disease with an International Prognostic Index (IPI) of low risk. He was treated with dose-adjusted etoposide, prednisone, vincristine, cyclophosphamide, doxorubicin, and rituximab (DA-EPOCH-R), followed by six cycles of chemotherapy. He then met criteria for clinical remission (CR) despite the continued presence of an anterior mediastinal mass. Due to his initial presentation of exercise intolerance, concerns about potential risks of the patient returning to a tactical flight environment remained. Cardiology evaluation, including an echocardiogram, stress test, and holter monitor, were noted to be normal. His pulmonologist reported a normal exam and pulmonary function tests (PFTs). Out of an abundance of caution, the aviator was sent for repeat centrifuge testing to determine if the residual mass might compromise the patient's G-tolerance or cause a cardiac arrhythmia under G-load. He successfully completed a profile up to 7.5 Gs without abnormalities in electrocardiogram (EKG) or visual field deficit. The patient was granted a waiver to return to tactical aviation with appropriate oncological follow up. He remains asymptomatic and has been flying the full spectrum of missions. **DISCUSSION:** This case illustrates a process of risk mitigation of unknown variables. Currently, there are no other known cases of pilots flying high-G aircraft with anterior mediastinal masses. Mediastinal masses are of aeromedical concern due to risk of cardiopulmonary compromise from mass effect, or potential cardiac arrhythmia from tumor infiltration. In a dynamic flight environment, a decrease in G-tolerance or an increased risk of hypoxia or arrhythmia are not trivial concerns. However, with tools such as centrifuge training and cardiopulmonary testing, a reasonable amount of confidence can be ascertained prior to returning an aviator to flight status.

Learning Objectives

1. Currently, there are no other known cases of pilots flying high-G aircraft with anterior mediastinal masses. This case illustrates a process of risk mitigation of unknown variables and the process can be applied to other rare diseases not already outlined in the Aeromedical Guide.
2. Mediastinal masses are of aeromedical concern due to risk of cardiopulmonary compromise from mass effect, or potential cardiac arrhythmia from tumor infiltration. This case is an example of an aviator who remains asymptomatic and returned to duty. This may help guide future decisions specifically about mediastinal masses.

[116] IDIOPATHIC ACUTE EOSINOPHILIC PNEUMONIA

Landon McKinley[1], Ryan Baxter[1]
[1]*NAMI, Pensacola, FL, USA*

(Education - Case Study)

INTRODUCTION: This case presentation outlines the clinical course of a 33 year old male pilot hospitalized with Idiopathic Acute Eosinophilic Pneumonia (AEP) who required mechanical ventilation and ECMO. He was discharged after a total of 13-days of hospitalization and was believed to have recovered. The initial normalization of his lung function, chest x-rays and clinical presentation led to the determination that he was fit for full duty. However, he was later deemed physical disqualified as a Pilot with subsequent grounding after being diagnosed with asthma. **BACKGROUND:** AEP is a rare disease characterized by an otherwise healthy individual experiencing acute illness of less than four weeks manifested by nonproductive cough, dyspnea, and fever. Hypoxemic respiratory insufficiency is often

identified at presentation and may become life-threatening. The disease is typically severe, with 63% of patients requiring mechanical ventilation. It most often occurs between 20-40 years of age and is twice as likely to occur in males as females. It is confirmed with clinical findings, imaging and bronchoalveolar lavage with >25% eosinophils. **CASE PRESENTATION:** A 33 year old male was admitted to the hospital after he failed to respond to outpatient management for pneumonia. He was treated with Levaquin during his admission and was discharged after 3 days. On post discharge day 3 he experienced shortness of breath and a non-productive cough. On post discharge day 4 his symptoms got worse and was admitted to the ICU where he required mechanical ventilation and ECMO. BAL results showed 87% eosinophils and bacterial culture had no growth. The presumptive diagnosis of eosinophilic pneumonia was made and he was started on high dose IV Solumedrol. He was able to be taken off ECMO on hospital day 6, extubated on hospital day 9, and discharged on hospital day 13. **DISCUSSION:** Eosinophilic pneumonia should be on your differential if a patient presents with non-productive cough, dyspnea, fever, rash, and fatigue that has lasted for more than 10 days. Patients that use tobacco products, inhaled chemical exposure, or take certain medications are at higher risk for developing eosinophilic pneumonia. Recognizing and diagnosing the condition early can greatly improve the outcome.

Learning Objectives

1. The participants will be able to understand the clinical presentation of Idiopathic Acute Eosinophilic Pneumonia.
2. The participants will be able to understand how to diagnosis Idiopathic Acute Eosinophilic Pneumonia.

[117] MILITARY FIXED-WING NAVIGATOR WITH GALACTOSE-ALPHA-1,3-GALACTOSE NON-MAMMALIAN MEAT TICK RELATED ALLERGY (ALPHA-GAL)

Daniel De Cecchis[1], Daniel Roberson[1]
[1]*NMOTC, Pensacola, FL, USA*

(Education - Case Study)

INTRODUCTION: This is a case report describing a military fixed-wing navigator with galactose-alpha-1,3-galactose non-mammalian meat tick related allergy (alpha-gal). **BACKGROUND:** The true prevalence of this syndrome is unknown, but it is estimated to be as high as 10% in the U.S.1 In areas with a high prevalence of ticks associated with this syndrome, idiopathic anaphylaxis should raise clinical suspicion of this syndrome. As this condition is now recognized in the Americas, Asia, Europe, and Australia, this syndrome is of rising public health concern. **CASE PRESENTATION:** The subject is a 32-year-old USMC navigator with over 1,600 total flying hours who first presented in anaphylactic shock of unknown etiology in the squadron hangar. The patient was immediately transferred to off base emergency services via personal vehicle with the flight surgeon in attendance. In route decompensation required self-administration of epinephrine resulting in immediate reduction in respiratory compromise. On next day follow-up, the aviator immediately underwent a downing physical. The patient was referred to Naval Medical Center Portsmouth on temporary duty for an allergy workup. With astute clinical suspicion, the allergist uncovered an important environmental exposure leading to the diagnosis of alpha-gal delayed onset anaphylaxis. **DISCUSSION:** The most significant operational concern associated with this allergy is going undiagnosed resulting in an in-flight anaphylactic episode which could easily result in a mishap. For reference, the median time from the onset of symptoms to diagnosis in the U.S. in 2017 was 7.1 years.1 Desensitization can occur in these at-risk individuals which was once not though possible. Personal protective equipment and insect sprays will drastically reduce recurrence in previously sensitized individuals. After an extensive aeromedical evaluation process, the navigator was recommended for a waiver for all duties involving flight.

Learning Objectives

1. The participant will be able to correlate the history and physical surrounding a patient with delayed anaphylaxis with a possible diagnosis of alpha-gal.
2. The participant will be able to provide preventive measure counseling to a patient with possible alpha gal to reduce the risk of future anaphylactic episodes.

[118] NON-AERONAUTICALLY ADAPTED RECOMMENDATION IN AN AIR TRAFFIC CONTROLLER

Christina Stromsness[1]
[1]*NAMI, Pensacola, FL, USA*

(Education - Case Study)

INTRODUCTION: The subject is a 30-year-old U.S. Navy air traffic controller who was referred to NAMI mental health department for evaluation for aeronautical adaptability. **BACKGROUND:** The most significant operational concern associated with non-aeronautically adapted/adaptable (NAA) personality disorders is the safety of flight. If an individual has such significant adverse personality traits or personality disorder, it can interfere with crew resource management and ultimately be a threat to the safety of flight, not only in the cockpit, but within the responsibilities of air traffic controllers as well. **CASE PRESENTATION:** A couple of months prior to presentation at NAMI, the patient was reprimanded by a supervisor for making inappropriate sexual comments in the workplace that a coworker found offensive. During a conversation with the coworker who made the accusation, the patient stated that "the hypocrisy makes me want to shoot myself." The patient was involuntarily admitted to a local hospital for suicidal ideation for three days. During the admission, he did not engage in care. Upon discharge, he refused to continue psychiatric care. His command sent him for a command directed psychiatric evaluation for fitness for duty. The psychiatrist found him fit for full duty and worldwide deployable and diagnosed adjustment disorder with mixed emotions and conduct; unspecified personality disorder. After this evaluation, the patient went to his flight surgeon for an UPCHIT and at that time, his flight surgeon then placed a request to the NAMI mental health department for evaluation for aeronautical adaptability due to the patient's temperament, and the diagnosis of unspecified personality disorder. At NAMI, the patient underwent an extensive psychiatric evaluation. The evaluation lead to a diagnosis of adjustment disorder and unspecified personality disorder with paranoia, obsessive-compulsive, narcissistic traits. He was found not aeronautically adapted due to his clinical personality traits that can negatively impact crew resource management and jeopardize the safety of flight and was not recommended for continued duty as air traffic control. **DISCUSSION:** With extensive neuropsychology and psychiatric evaluation as well as the insight from his command, the finding for NAA was appropriately made in this case. While the disposition of NAA should not be made lightly or easily, this is an essential part of the aeromedical examination.

Learning Objectives

1. Understand the importance of a thorough evaluation for Aeronautical Adaptability.
2. Understand that significant adverse personality traits or personality disorders can interfere with crew resource management and ultimately be a threat to the safety of flight, not only in the cockpit, but within the responsibilities of air traffic controllers as well.

Tuesday, 08/31/2021 ***10:30 AM***
Governor's Square 12

[S-25]: SLIDE: GOING FOR THE JUGULAR: VENOUS PHYSIOLOGY IN SPACEFLIGHT

Chair: Bonnie Posselt
Co-Chair: Rowena Christiansen

[119] ACUTE EFFECTS OF POSTURAL CHANGES AND LOWER BODY POSITIVE AND NEGATIVE PRESSURE ON THE EYE

Michael Van Akin[1], Allison Anderson[1], Olivia Lantz[2], Abigail Fellows[2], Jay Buckey[2]
[1]*University of Colorado Boulder, Boulder, CO, USA;* [2]*Dartmouth College, Lebanon, NH, USA*

(Original Research)

BACKGROUND: Entry into weightlessness results in a fluid shift and a loss of hydrostatic gradients. These factors are believed to affect the

eye and contribute to the ocular changes that occur in space. To assess the effects of a pressure, which change fluid distributions, and posture, which change hydrostatic gradients, we measured eye parameters during a fluid shift (lower body negative pressure (LBNP)) and a change in hydrostatic gradient direction (supine-prone) in normal subjects. **METHODS**: Ocular parameters (intraocular pressure, ocular geometry, and optical coherence tomography measures) were measured in the seated, supine, and prone positions. To create a fluid shift in the supine and prone positions, LBNP and lower body positive pressure (LBPP) were used. A linear mixed-effects model was used to determine the effects of pressure and posture on eye parameters. **RESULTS**: Pressure was positively correlated with both choroidal thickness ($p=0.01$) and IOP ($p<0.001$). The change in posture, however, had a profound positive effect on IOP ($p=0.01$ supine, $p<0.001$ prone) but not on choroidal thickness. IOP changes correlated with axial length ($p<0.001$). **CONCLUSION**: The effects of hydrostatic gradients and fluids shifts on the eye were isolated by inducing a fluid shift in both the supine and prone postures. We confirmed our hypotheses that both posture and pressure affect IOP, only posture affects axial length and aqueous depth. Contrary to our hypotheses, fluid shifts affected choroid thickness instead of posture. Changes in hydrostatic gradients can produce significant changes in both IOP and axial length. Fluid shifts are often cited as important factors in the pathophysiology of SANS, but gravitational loading may also play an important role in these ocular findings.

Learning Objectives

1. The audience will learn how acute postural and pressure effects on the eye can help elucidate the pathophysiology of the Spaceflight Associated Neuro-ocular Syndrome (SANS).
2. The audience will learn the current state of the art in terrestrial acute ocular studies and their relationship to SANS.
3. The audience will learn about our new findings in acute ocular studies that inform the role of microgravity mechanisms on SANS including fluid shifts, hydrostatic gradients and tissue weight.

[120] EFFECT OF MICROGRAVITY ON THE VENOUS SYSTEM AND BLOOD COAGULATION; A SYSTEMATIC REVIEW

David Kim[1], David Green[2], Lucia Mazzolai[3], Lara Roberts[4], James Pavela[5], Manabu Watanabe[6], Guillaume Weerts[7], Sergi Vaquer[2]
[1]The European Space Agency and The University of British Columbia, Vancouver, British Columbia, Canada; [2]European Space Agency, Cologne, Germany; [3]Lausanne University Hospital (CHUV), Lausanne, Switzerland; [4]King's College Hospital NHS Foundation Trust, London, United Kingdom; [5]UTMB, Galveston, , USA; [6]JAXA, Tokyo, Japan; [7]European Space Agency, Cologne, Germany

(Original Research)

INTRODUCTION: The physiology of the human venous system is affected by intrinsic (cardiac function, musculo-venous pump, abdominal-thoracic pump, venous gradient, tone, and integrity) and extrinsic (external compression, ambient pressure, and gravity) factors. In microgravity (μG), several of these factors are known to be affected due to the loss of the hydrostatic gradient and fluid shifts. The pathogenesis of venous thromboembolism is associated with venous stasis, endothelial damage, and hypercoagulability; known as Virchow's triad. This review assessed the current state of knowledge of the impact of μG upon venous and coagulation physiology as it relates to Virchow's triad. **METHODS:** A systematic review following the Cochrane guidelines were initially performed in 6 electronic databases. Search criteria was set for human studies reporting venous system or coagulation parameters in μG or ground-based μG analogues (Bedrest, head down tilt, immersion, and lower body negative pressure). Due to the heterogeneity of data and identification of significant knowledge gaps, a narrative review of the literature was performed. **RESULTS:** Literature search retrieved 705 publications, of which 25 publications were included in the final review. Of these, 20 investigated the venous system and 5 investigated the coagulation system. 8 studies were conducted in spaceflight and 17 on ground-based analogues. None of the studies assessed the venous or the coagulation system as a whole. Results suggest hypercoagulable states may be induced in μG; as increased fibrinogen levels and shortened thrombin time have been reported. Additionally, venous system changes contributing to venous stasis and endothelial damage were observed in μG and its analogues: loss of musculo-venous pump, venous dilation, and decreased blood flow. **DISCUSSION:** There is evidently a paucity of knowledge regarding venous function and coagulation in μG. Taken together, the literature suggests that changes in both vascular and endothelial function may result in a prothrombotic state in μG. However, published studies were underpowered, heterogeneous, and frequently equivocal rendering definitive conclusions impossible. Given the low occurrence probability but potentially catastrophic consequences of venous thromboembolisms in space, it is imperative that knowledge gaps are addressed in venous and coagulation pathophysiology to reduce overall medical mission risk during spaceflight.

Learning Objectives

1. Participants will be informed about the current state of understanding with regards to venous and coagulation physiology in microgravity
2. Audience will learn about knowledge gaps in venous and coagulation physiology understanding in microgravity
3. Audience will be informed about the potential implications in space medicine about the risk of VTEs in space

[121] CASE REPORT: COMPARISON OF INTERNAL JUGULAR VEIN CROSS-SECTION AREA DURING A RUSSIAN TILT-TABLE PROTOCOL AND MICROGRAVITY

Jason David[1], Richard Scheuring[2], Andrew Morgan[2], Cara Olsen[3], Alexey Grishin[2], Ashot Sargsyan[2]
[1]Nellis Air Force Base/University of Nevada Las Vegas, Las Vegas, NV, USA; [2]NASA-Johnson Space Center, Houston, TX, USA; [3]Uniformed Services University of the Health Sciences, Bethesda, MD, USA

(Original Research)

BACKGROUND: To date, there is little US data on the effects of the long-used Russian tilt-table training protocol known as the "Braslet tilt-table protocol" on Internal Jugular Vein Cross Sectional Area (IJV-CSA) in microgravity. **CASE REPORT**: A case study of a single healthy male astronaut volunteer was used for this study. The Right IJV-CSA was measured using real time ultrasound at set times throughout the Roscosmos Braslet tilt-table protocol, a method of physiologic preparation for microgravity using tilt-table training. In microgravity, the subject's RIJV-CSA measured again for comparison. The mean difference from in-flight RIJV-CSA for Pre-Tilt 0° was -0.438 cm^2, for -15° was 0.887 cm^2, for -30° was 0.864 cm^2, for +50° was -1.15 cm^2, and for Post-Tilt 0° the difference was -0.305 cm^2. **DISCUSSION**: The cross-sectional areas of the subject's RIJV-CSA were significantly different between in-flight values and several angles of the "Braslet Protocol", except for the 0° measurement. In summary, this case-study represents the first time IJV-CSA has been compared between various angles of a tilt-table training protocol and microgravity in the same astronaut subject. The findings support prior cohort studies studying the same principles. Further investigation is merited; both to better describe the relationship between the cardiovascular effects of tilt-table simulations of microgravity and their correlating in-flight values, and to evaluate and study the Braslet Protocol effects on cardiovascular physiology from a training and preparation perspective.

Learning Objectives

1. The audience will learn about the effects of microgravity on vascular physiology, specifically internal jugular venous physiology and hemodynamics, which is pertinent to the current Spaceflight Associated Neuro-ocular Syndrome question.
2. The audience will learn about an interesting case report of an astronaut subject who was exposed to the braslet tilt-table protocol and its correlation to microgravity's actual effects on vascular physiology
3. The audience will be exposed to an example of fast and accurate use of a highly-mobile ultrasound device in microgravity.

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

Gaurab Ghosh[1], Rahul Pipraiya[2]
[1]Insititute Of Aerospace Medicine, Indian Air Force, Bengaluru, India; [2]Indian Air Force, Agra, 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 voluntary 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 ± 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. The paper will provide insight into the effective physiological changes that take place in response to regular short-term yogic activity and whether the changes can help allay the deconditioning in human cardiovascular and neurovestibular systems that occur in simulated microgravity condition.
2. The techniques used in this yogic practice are easy to perform and does not require a great deal of space and thus, can be used as an adjunct / alternative to some of the bulky equipment loaded in space stations for human exercise and prevention of physiological degradation.

[123] WHOLE BLOOD VISCOSITY: A MISSING CONSIDERATION IN SPACE PHYSIOLOGY AND MEDICINE

Ashot Sargsyan[1], James Pavela[2], Kadambari Suri[1], Aaron Everson[1], Mansur Ghani[3], Chad Roberts[4], Timothy Carswell[5], Douglas Ebert[1], Christopher Zahner[6], Richard Cole[6]
[1]KBR Government Solutions, Houston, TX, USA; [2]NASA Lyndon B. Johnson Space Center, Houston, TX, USA; [3]University of California San Diego, San Diego, CA, USA; [4]University of Utah, Salt Lake City, UT, USA; [5]TX Tech Health Science Center, El Paso, TX, USA; [6]University of Texas Medical Branch, Houston, TX, USA

(Original Research)

INTRODUCTION: Relative overcapacity of the suprathoracic venous space in microgravity may be a contributor to facial plethora, nasal congestion, neuro-ocular changes, and other phenomena seen in astronauts. We present a physiological construct that highlights contributions of non-Newtonian, shear-thinning properties of whole blood to vascular ultrasound findings in an astronaut. **METHODS:** Upper extremity vascular sonography was performed in an International Space Station (ISS) long-duration crewmember as part of medical surveillance. Standard 2-dimensional and color flow Doppler views were collected bilaterally, with respiratory maneuvers. **RESULTS:** The right internal jugular vein (IJV) showed strong dominance for both cross sectional area (R/L ratio of 5.32) and for peak flow velocity (R/L ratio of 1.8). Valsalva maneuver provoked sustained unilateral loss of flow spontaneity in the non-dominant IJV. The decline in flow velocity was accompanied by a rise in blood echogenicity, achieving a static state of sustained loss of flow despite resumption of normal respiration. Augmentation by impedance breathing (Mueller maneuver) purged the echogenic content of the left IJV and restarted spontaneous flow. **DISCUSSION:** Human blood is a thixotropic fluid, but the topic of spatial and temporal variability of whole blood viscosity (WBV) is rarely mentioned in medical education or practice. Flow patterns in the presented case are consistent with a local rise in WBV provoked by a Valsalva maneuver. This can be explained by further reduction of already low shear rates in the venous system, combined with other pro-viscosity factors, such as relative dehydration with elevated hematocrit, and potentially hyperfibrinogenemia. A non-dominant, distended left IJV, coupled with available anatomic bypass conduits for cerebral venous outflow, represents a vascular site vulnerable to local hyperviscosity in microgravity, with sustained cessation of flow as an extreme manifestation. Further elucidation of WBV-associated phenomena in human space flight appears to be warranted. Circadian patterns of venous overcapacity and whole body hematocrit, effectiveness of impedance breathing in microgravity, and the potential of viscosity-reducing pharmaceuticals in some individuals such as pentoxyfilin are appropriate topics of interest. We propose that our evidence and existing literature support a central role of WBV in circulatory space physiology and medicine.

Learning Objectives

1. The audience will learn about direct relevance of whole blood viscosity considerations to circulatory physiology in microgravity and to human system risks recognized by the aerospace medicine community.
2. The audience will be able to understand concepts and specific mechanisms related to the influence of whole blood composition on venous hemodynamics and to the resultant amplification of human system risks recognized by the aerospace medicine community.
3. Aerospace medicine practitioners will be able to recognize potential risk reduction opportunities based on better understanding of pathophysiology that underlies the risk of venous thromboembolism.

[124] IMPEDANCE THRESHOLD BREATHING FACILITATES JUGULAR VENOUS DRAINAGE IN A PLACEBO-CONTROLLED STUDY

Douglas Ebert[1], Brandon Macias[2], Millennia Young[2], Alan Hargens[3], Smith Johnston[2], Michael Stenger[2], Ashot Sargsyan[1]
[1]KBR/NASA, Houston, TX, USA; [2]NASA JSC, Houston, TX, USA; [3]UCSD, San Diego, CA, USA;

(Original Research)

INTRODUCTION: Jugular venous overcapacity has been observed during sustained microgravity and terrestrial microgravity analogs. This phenomenon may contribute to spaceflight-associated neuro-ocular syndrome (SANS) and has recently been linked with internal jugular vein (IJV) stasis. An impedance threshold device (ITD) was evaluated as an effective, practicable countermeasure to facilitate drainage of IJVs. ITD provides up to 7 cm H_2O resistance to inspiratory airflow, lowering intrathoracic pressure (ITP) and facilitating venous return to the heart during the inspiratory phase, which comprises at least 25% of the respiratory cycle. We hypothesized that use of the ITD in a spaceflight analog (head down tilt, [HDT]) would counteract IJV congestion. **METHODS:** Fifteen test subjects each participated in two trials, one with an ITD and one with a sham ITD (placebo), in seated, supine, 6° HDT, 15° HDT, and 15° HDT-extended (additional 30 minutes) postures. Measures analyzed from each posture included IJV cross-sectional area (CSA), flow patterns, and estimated pressure (VeinPress; direction of flow in the superior ophthalmic vein (SOV; and flow measures in the central retinal artery (CRA) and vein (CRV). Questionnaires were completed at each posture to document subjective status. **RESULTS:** When integrated over a full respiratory cycle, IJV CSA enlarged with increasing HDT ($p \leq .0006$) during both ITD and placebo device trials. IJV CSA was reduced with ITD

as compared to placebo in all posture conditions, reaching significance in the 6° HDT ($p = .015$), 15° HDT ($p = .031$), and 15° HDT-extended ($p = .021$) conditions. When data from all postures were combined, IJV CSA was reduced 19% with ITD breathing, and Doppler demonstrated improved flow patterns. Estimates of IJV pressure at end-expiration also rose with increasing HDT but were partially mitigated by ITD as compared to placebo, reaching significance at 15° HDT ($p = .005$). Significant differences in CRA, CRV, and SOV Doppler flow with posture or ITD use were also documented. **DISCUSSION:** In the context of a posture-based spaceflight analog, we conclude that 1) based on IJV parameters, ITD relieves venous congestion while improving IJV flow, and 2) based on orbit Doppler data, ITD has positive peripheral vascular effects in HDT, returning values toward those in seated posture. ITD may be useful as a countermeasure to both jugular venous stasis and SANS, and therefore should be tested in microgravity.

Learning Objectives

1. Understand the effects of inspiratory impedance breathing on cervico-cranial venous drainage
2. Evaluate the potential of impedance threshold devices as a countermeasure for venous stasis and spaceflight-associated neuro-ocular syndrome

Tuesday, 08/31/2021 ***10:30 AM***
Plaza F

[S-26]: PANEL: WOMEN PIONEERS IN AVIATION AND AEROSPACE MEDICINE: LESSONS ON LEADERSHIP

Sponsored by The Aerospace Nursing and Allied Health Professionals Society

Chair: Nora Johnson
Co-Chair: Marian Sides

Panel Overview: *This panel is the inaugural event of the Mary F. Foley Endowment. The fund was established in her honor to perpetuate her passion and career-long work in profiling women in aviation and aerospace medicine, and to encourage other women to follow in her path. The conceptual framework of the panel will portray the dynamics of leadership of women pioneers who broke barriers in their fields of aviation and aerospace medicine, and distinguished themselves by persevering through adversity, courage and determination. The qualities and virtues that shaped their leadership, will be portrayed by exemplifying the highlights of their careers, throughout their professional journeys. The first presentation will profile the legacy of Mary F. Foley, whose curiosity for air transport of invalids, led to her publication of guidelines for safety in air travel. She is followed by the recognition of retired U.S. Air Force officer Nicole Malachowski, the first female pilot selected to fly with the Thunderbirds, and an advocate on behalf of patients suffering from tick borne illnesses. The panel will highlight the pioneering efforts of Irene Long, a NASA physician and the first Kennedy Space Center Chief Medical Officer, known for extreme compassion and caring, who leaves a legacy that reverberates throughout the spaceport. Presenters will honor the legacy of Bessie Coleman, the first female, African American pilot and the first female to get an international pilot's license. Dr. Irene Trowell-Harris, the first African American Major General in the U.S. National Guard will be honored for her lifetime of enduring service in support of nurses who aspire to be leaders. Similarities and differences in leadership styles and qualities of these women pioneers will be discussed and how they navigated adversity and challenges will be recognized. The event will offer illuminating insights, inspiration and mentoring opportunities in leadership development for the AsMA membership.*

[125] PRINCIPLES AND PRACTICES OF MARY F. FOLEY: LEGACY IN REVIEW ON LEADERSHIP IN AVIATION AND AEROSPACE MEDICINE

Allen J Parmet[1], Mary Cimrmancic[2]
[1]*AsMA Fellow, Kansas City, MO, USA;* [2]*Marquette University, Milwaukee, WI, USA*

(Education - Tutorial / Review)

INTRODUCTION: Women pioneers in aviation & aerospace medicine leave legacies on leadership that are valuable lessons in perpetuating the advancement of knowledge & the development of collaborative solutions for future challenges in aerospace medicine. This paper will highlight the principles & qualities of Mary F. Foley that shaped the landscape of her lifetime achievements & influenced the future development of aviation and aerospace medicine. **TOPIC:** Mary "Bunny" Foley, was a registered nurse, past president & pioneer member of the Aerospace Physiology Society, Fellow of the Aerospace Medical Association (AsMA), with more than 50 consecutive years of active membership. She was among the first class of physiologists to be granted Board certification in Aerospace Physiology. During her career she performed groundbreaking research on the effects of weightlessness, long term acceleration, hypertension, & head cooling. She made advances in occupational medicine, publishing research on pulmonary functions. In 1955 she became interested in air transport of invalids. She spent 3 months traveling to Asia, Europe, & Africa meeting with airline medical directors, surveying their handling of patients, & published "Air Travel for Patients" that established early standards for air travel. In 1958, she joined the Air Force as a flight nurse. In 1966 she began to study the effects of zero gravity on pulmonary function at Ohio State University. As a scientist & a test subject, she flew in zero-gravity parabolas & operated the human centrifuge to understand G-force limits for pilots, effects of weightlessness on lung capacity, physiological effects of prolonged acceleration & stress reduction benefits of cooling helmets for F-16 fighter pilots. The USAF promoted her to Colonel in 1975. Mary was a pilot & a member of the Ninety-Nines, International Assoc. of Women Pilots. **APPLICATION:** This presentation will exemplify the personality attributes, qualities & fundamental principles that compelled Mary Foley to embark on a journey of discovery of new knowledge, with intellectual curiosity, to improve the quality of human health via research, & enhance wellness through compassionate care & empathy. Mary models an additional diverse range of qualities: passion, ambition, resilience, determination, & relentless advocacy for excellence. Presentation of the legacy of Mary Foley will illuminate these leadership qualities & characteristics, to be emulated by others through replication.

Learning Objectives

1. Describe two pioneering contributions of Mary Foley to aviation and aerospace medicine
2. Identify three leadership qualities demonstrated by Mary Foley in her life time achievements
3. Name a leadership quality of Mary Foley, portrayed in this presentation, that adds value to you.

[126] PRINCIPLES AND PRACTICES OF NICOLE MARGARET ELLINGWOOD MALACHOWSKI: LEGACY IN REVIEW ON LEADERSHIP IN AVIATION AND AEROSPACE MEDICINE

J Karen Klingenberger[1]
[1]*USAF, Williamsburg, VA, USA*

(Education - Tutorial / Review)

INTRODUCTION: Women pioneers in aviation and aerospace medicine leave legacies on leadership that are valuable lessons in perpetuating the advancement of knowledge and the development of collaborative solutions for future challenges in aerospace medicine. This paper will highlight the principles and qualities of Nicole Margaret Malachowski that shaped the landscape of her lifetime achievements and which is influencing the future development of aviation and aerospace medicine. **TOPIC:** Nicole "FiFi" Malachowski, was the first female pilot selected to fly as part of the USAF Air Demonstration Squadron, better known as the Thunderbirds. She was compelled to retire from an outstanding Air Force career due to the debilitating effects of tick borne illness and subsequently became a speaker and advocate on behalf of patients suffering from tick borne illnesses. Col Malachowski was a Civil Air Patrol cadet before she entered the U.S. Air Force Academy (USAFA) in 1992. She graduated from USAFA in 1996. Her first public performance with the Thunderbirds was in March 2006, and her aviator call sign was "FiFi". She spent the 2006 and 2007 air show seasons flying the Number 3 (Right Wing) aircraft in the diamond formation. Between September 1, 2008 and August 31, 2009,

Malachowski was on special assignment, participating in the White House Fellows Program for the Class of 2008–2009, assigned to the General Services Administration. In 2011, she took command of the 333d Fighter Squadron at Seymour Johnson Air Force Base, North Carolina. In September 2015, she returned to the White House to become the executive director of its Joining Forces initiative for supporting veterans, service members, and military families. She was medically retired from the Air Force in 2017 after attaining the rank of colonel. In 2019, she was inducted into the National Women's Hall of Fame. **APPLICATION:** This presentation will highlight the life experience, operational experience and medical challenges she personally endured that compelled Col Malachowski to be a national advocate for the diagnosis and treatment of tick borne illnesses. Col Malachowski shares the diverse range of qualities including passion, ambition, resilience, determination, and a relentless advocacy for excellence. Presentation of the history of Col Malachowski will illuminate these leadership qualities and characteristics, that can be emulated by others

Learning Objectives

1. Describe two pioneering contributions of Col Malachowski to aviation and operational medicine
2. Identify three leadership qualities demonstrated by Col Nicole "FiFi" Malachowski
3. Identify the challenges and impact of diagnosing and treating tick borne illnesses for members of the aviation community

[127] IRENE D. LONG, SPACE MEDICINE PHYSICIAN LEADER

Cathy DiBiase[1]
[1]*Inomedic, Kennedy Space Center, FL, USA*

(Education - Tutorial / Review)

INTRODUCTION: Irene Long was an Aerospace Medicine trained physician who graduated from Wright State University. She was an instrumental employee of NASA who worked her way up to a Senior Executive position and also became Kennedy Space Center's first Chief Medical Officer. **TOPIC:** This Presentation will highlight the trailblazer, Irene Long and her contributions to the space program. Why was Dr. Long a trailblazer? She broke many barriers in her carrier as a black female with a disability. She never lost sight of her goals and worked hard to accomplish them in spite of the challenges. A dedicated mentor, she guided younger generations into Science Technology Engineering and Math (STEM) fields. She spent many hours discussing STEM careers and attending educational conferences where she shared her insights. Training program support at the space center was strongly encouraged by her. I even found myself involved in educational and training programs as she encouraged me to also mentor and counsel younger generations. A Fellow of AsMA she encouraged other AsMA members to volunteer their time and apply for Fellowship. Sadly Dr. Long recently passed but she leaves an indelible mark on those who knew her and aspire to be like her. **APPLICATION:** Adversity makes us stronger and pushes us forward. The attendee will receive insights that they can apply to their own journey as they meet their professional and personal challenges.

Learning Objectives

1. The audience will propagate the thought that adversity is a challenge that can be met
2. The audience will be able to highlight the trailblazer events in this leader's life
3. The audience will use at least one key concept in their approach to mentorship

[128] PRINCIPLES AND PRACTICES OF ELIZABETH BESSIE COLEMAN: LEGACY IN REVIEW ON LEADERSHIP IN AVIATION AND AEROSPACE MEDICINE

Leroy P Gross[1], J Karen Klingeberger[2]
[1]*AsMA, Yorktown, VA, USA;* [2]*USAF, Williamsburg, VA, USA*

(Education - Tutorial / Review)

INTRODUCTION: Women pioneers in aviation & aerospace medicine leave legacies on leadership that are valuable lessons in perpetuating the advancement of knowledge & development of collaborative solutions for future challenges in aviation. **Elizabeth Bessie Coleman** persevered through discrimination & danger in order to fly in the earliest days of aviation. **TOPIC:** Bessie Coleman soared across the sky as the first African American, & first Native American woman pilot. Known for performing flying tricks, Coleman's nicknames were: "Brave Bessie" & "Queen Bess." She was born on January 26, 1982 in Atlanta, TX, the 10th of 13 children. She was an excellent student & avid reader, but due to her family's poverty she was able to attend only one college term. As a young adult she moved to Chicago with her brother John who had fought in France during WWI. Through John she learned that females & people of color were being trained as pilots in France. Bessie learned French & raised money to enroll in flight training in France. On 15 Jun 1921 she became the first African/Native American pilot to obtain an international pilot's license. She returned to the United States with a goal of establishing a flying school to train individuals with her heritage. To earn money through flying, she returned to France to train in aerobatics. She was successful & loved flying as a barn stormer, however, she opened a beauty shop (her first career) in Orlando, FL to earn additional money for the flying school during the flying circus off season. Unfortunately, she was killed at age 34 in during the flight of an aircraft she had just purchased. Only after her death did Bessie Coleman receive the attention she deserved. Her pioneering role was an inspiration to early pilots & the African-American & Native-American communities. Her dream of a flying school for African Americans became a reality when William J. Powell established the Bessie Coleman Aero Club in Los Angeles in 1929. As a result of being affiliated, educated or inspired directly or indirectly by the aero club, flyers like the Five Blackbirds, the Flying Hobos, The Tuskegee Airmen & others continued to make Bessie's dream a reality. **APPLICATION:** This presentation will highlight the life experiences that compelled **Bessie Coleman** to become a pilot and illuminate her leadership qualities & characteristics. She was passionate, ambitious, resilient and was a relentless advocate for women & minorities to pursue careers in aviation.

Learning Objectives

1. Describe two pioneering contributions of Elizabeth Bessie Coleman to aviation
2. Identify three leadership qualities demonstrated by Elizabeth Bessie Coleman throughout her career
3. Identify the challenges & impact of Bessie Coleman's trail blazing to further universal access to aviation

[129] IRENE TROWELL-HARRIS: AN ICON IN EXEMPLARY LEADERSHIP IN THE NATIONAL GUARD

Annette Sobel[1]
[1]*TTUHSC, Sandia Park, NM, USA*

(Education - Case Study)

INTRODUCTION: Women leaders in aviation and aerospace medicine have left an indelible mark on history that enables early identification, growth, and mentorship of future leaders. These traits are agnostic to race, culture, socioeconomic group, specialized education/training, rather, defined by the actions performed and opportunities created for future service members. Dr. Irene Trowell-Harris exemplifies the type of nurse leader and life-long educator who has and continues to define her existence through creating diverse opportunities for others aspiring leadership positions, and in particular, those assigned to the National Guard. **TOPIC:** Major General Irene Trowell-Harris was the first African American Major General in the U.S. National Guard. Her childhood was from meager beginnings in Aiken, South Carolina. After receiving a scholarship from her community and church, she attended Columbia College of Nursing. She served as a flight nurse and educator at the Aerospace School of Medicine, San Antonio, Texas. Her lifetime of enduring service culminated in establishing the American Nurses Foundation's "Dr. Irene Trowell-Harris Endowed Leadership Fund" to support nurses who aspire to be leaders. She is a fervent advocate for diversity across the services, working closely with the Defense Advisory Committee on Women in the Services (DACOWITS) and mentoring young servicemen and women throughout her career. **APPLICATION:** Leaders unwittingly establish mentoring networks and template-able styles of behavior that are embedded in organizations and enable the cultivation and emergence of future leaders. This individual exemplified a leadership

style that was synonymous with trust and respect for diversity across the aerospace and aviation medicine communities, while envisioning an empowered workforce and leadership of the future.

Learning Objectives

1. The participant will be able to describe the leadership styles successfully employed by Dr. Irene Trowell-Harris.
2. The participant will be able to describe the template-able styles of behavior that are embedded in organizations and enable the cultivation and emergence of future leaders.
3. The audience will be able to identify at least two essential elements necessary in successful mentorship of future leaders.

Tuesday, 08/31/2021 ***2:00 PM***
Governor's Square 14

[S-27]: PANEL: SHORT-HAUL, MULTI-SEGMENT FLIGHT OPERATIONS

Sponsored by Aerospace Human Factors Association

Chair: Thomas Nesthus

Panel Overview: *Many pilots suggest that short-haul flying constitutes some of the highest fatigue risk flying in the industry. Part 117 Table B provides flight duty period (FDP) limitations for un-augmented flight operations. Depending on the time of day an operation begins and the number of segments flown, FDPs range from 9-13 hours. From these operations, to date, there are little data describing the impact on flight-crew sleep, workload, and performance, even though they comprise a significant share of U.S. airlines' daily operations. Topic: Pilot workload is a significant factor associated with multiple take-offs and landings. Over the course of a long duty day with numerous aircraft changes, short layovers these pairings and sequences often lead to repeated truncated sleep. Regulations provide 10 hrs between FDPs, but time of day or circadian rhythm issues might affect how much quality sleep pilots receive. Unfortunately, again, there are little data quantifying the combined fatigue impact on pilots. Mitigation strategies during short-haul operations are limited due to the nature of the flight operation and the un-augmented crew complement. Also, since there is typically a significant amount of night flying in these operations, rest/napping/sleep opportunities are restricted. U.S. regulations do not allow in-cockpit napping. Public Law 111-216, § 212(B) Fatigue Risk Management Plan (FRMP), provides carriers with a mandate to manage fatigue issues without reporting to the regulator. So, once again, data are sparse or unavailable for identifying best practices and success stories on this topic. Application: This panel session was developed to introduce many of the issues and concerns already expressed, and to discuss some of the regulatory and operational challenges that exist in developing applicable countermeasures and fatigue management strategies.*

[130] SHORT-HAUL, MULTI-SEGMENT FLIGHT OPERATIONS: FATIGUE MANAGEMENT REGULATIONS

Thomas Nesthus[1]
[1]*FAA Civil Aerospace Medical Institute, Oklahoma City, OK, USA*

(Education - Tutorial / Review)

INTRODUCTION: Title 14 of the Code of Federal Regulations (14 CFR) part 117, Flightcrew Member Duty and Rest Requirements contains many interactive elements for the management of fatigue. **TOPIC**: For short-haul, multi-segment flight operations, §117.11, §117.13, and Table B provides flight duty period (FDP) limitations for un-augmented operations. The table outlines pilot duty periods based on the time of day an operation begins and the number of segments flown. The FDPs range from 9-13 hours; with multiple segment flights restricted to fewer hours due to repeated phases of flight with elevated workload conditions. **APPLICATION**: Mitigation strategies during short-haul operations are limited due to the nature of the flight operation and the un-augmented crew complement. There is typically a significant amount of night flying in these operations, so sleep opportunities for many pilots occur during non-optimal times and sleep quality/quantity is affected by circadian rhythms. The regulation section §117.25 describes the rest period requirements and states, the flightcrew member is given a rest period of at least 10 consecutive hours immediately before beginning an FDP. The 10-hour rest period must provide the flightcrew member with a minimum of 8 uninterrupted hours of sleep opportunity. If a pilot experiences excessive fatigue before or during a FDP, regulation section §117.5(c) states that the certificate holder may not permit a flightcrew member to continue an FDP if that flightcrew member has reported him or herself too fatigued to safely continue their assigned duties. Fair and non-punitive company policies must accommodate this potential outcome. Additionally, Public Law 111-216, § 212(B) Fatigue Risk Management Plan (FRMP), provides carriers with a mandate to manage fatigue issues within the limitations of the regulations. If a flight operation or pairing is found to be excessively fatiguing, the certificate holder is responsible for correcting it. **RESOURCES**: Other U.S. federal documents associated with fatigue management include:

- Advisory Circular (AC) 120-100, Basics of Aviation Fatigue
- AC 117-2, Fatigue Education and Awareness Training Program
- AC 117-3, Fitness for Duty
- Part 117 Preamble text, and Clarification of the Flight, Duty, and Rest Requirements (Docket No. FAA-2012-0358)

Learning Objectives

1. The participant will learn about U.S. regulations pertaining to fatigue mitigation for flightcrew members.
2. The participant will learn about how fatigue mitigations for crew members is integrated across several sections of 14 CFR Part 117: Flightcrew Member Duty and Rest Requirements.

[131] FATIGUE IN SHORT-MEDIUM HAUL AIRLINE OPERATIONS

Jim Mangie[1]
[1]*Embry Riddle Aeronautical University, Atlanta, GA, USA*

(Education - Tutorial / Review)

INTRODUCTION: Since 2014 when the implementation of new flight and duty time regulations were implemented in the U.S., significant resources have been dedicated to fatigue mitigation in long haul operations. Much of this activity has occurred due to the introduction of new, expensive aircraft that have greatly increased capabilities from their predecessors. While much of the flying these aircraft do has the potential for increased fatigue risk, they also provide for increased opportunities for fatigue mitigation. Due to the length of flights, the availability of crew rest facilities and staffing of additional crew members sleep opportunities can be created that very effectively help manage fatigue related risk. **TOPIC**: One area that has received little attention has been unaugmented short to medium haul flying. These flights are done with minimum numbers of crew and mostly on aircraft without crew rest facilities which makes the opportunity for fatigue mitigation very limited. Many of these flights operate during times of day that limit the opportunity for normal nighttime sleep. Additionally, these shorter flights operate in a very dynamic environment where multiple segments, weather, complex airports, maintenance problems, passenger situations and many other distractions occur. These workload and hassle factors can significantly contribute to the overall fatigue level of crews. **APPLICATION**: Biomathematical fatigue models are widely used in the industry but these tools are limited in many ways. Mostly, they only evaluate the sleep opportunity of crews and do little to nothing to account for the workload and hassle factors experienced by crew members during day-to-day operation. To effectively manage fatigue throughout short-and medium haul operations, these additional factors must be accounted for. This discussion will cover the major workload and hassle factors as well as possible mitigations.

Learning Objectives

1. The audience will gain a better understanding of the risks involved with short-medium haul flying operations.
2. The audience will gain a better understanding of the gaps in knowledge and research needs associated with short-medium haul flying operations.

[132] SHORT-MEDIUM HAUL AIRLINE OPS AND FATIGUE

Carlos Salicrup[1]
[1]*Aeromexico / IFALPA, Mexico City, Mexico*

(Education - Case Study)

Most of the information related to fatigue in airlines is dedicated to long and ultralong haul flights, but the area that really haves to be continuously surveilled is the short and medium haul sector, where un-augmented crews regularly fly in 2 to 6 sectors (legs) the same hours and duty time that the long haul augmented crews, without an on board rest facility or rest periods, just a "quick nap procedure" in the cockpit that most of the times is hard to get because of the short cruise time, bad weather, procedures, etc. In a cockpit configuration and seats that are not originally designed to have a pilot flying for 9 hours of flight and up to 15 hours of duty. Another aspect is that these crews schedule is very dynamic, including in the same week early awaking, night flights, evening to early morning flights, etc, with a sequence of flights than farther than satisfying the sleep and performance physiological needs and awakening in a logic mode, obeys to the operational needs and law and contract rest times. Are these pilots performance at the optimum for accurately acting during a critical emergency during their 6th sector (after 5 landings), late afternoon, after an early awake time, with 13 hours of duty and 8 hours of flight already over them? Flight operational quality assurance (**FOQA**), also known as flight data monitoring (FDM) or flight data analysis, is a method of capturing, analyzing and/or visualizing the data generated by an aircraft, this safety system mainly looks for exceedances on order to point matters that may need to be corrected and to make the crews aware, we have found more FOQA exceedance events after night flights, after several legs, after long duty times and long flying times and after several duties that may compromise the sleep reservoir and performance of the crew, like a long duty 6 sector flight awaking the crew in early morning after a night flight. Another aspect to point is that normally the crew roster (flight schedule) is published at the beginning of the month under a fair fatigue surveillance, but on the day to day operations the flight crew schedule may be modified as the crew/ops department needs to comply with operational requirements and to cover unexpected leaves or operations, sometimes letting the crew member to a complete different roster combination that the one that was originally made under a fair fatigue surveillance.

Learning Objectives

1. To introduce the attendee to short-medium haul airline crew duties and fatigue.
2. The attendee will learn about the relation of fatigue and FDM/FOQA events.

[133] SHORT-HAUL, MULTI-SEGMENT FLIGHT OPERATIONS: DATA EXAMPLES AND FUTURE DIRECTIONS

Amanda Lamp[1]
[1]*Washington State University, Spokane, WA, USA*

(Education - Tutorial / Review)

INTRODUCTION: Workload (time on task) is an important factor that influences performance along with time awake and time of day. While time awake and time of day and their effects on fatigue and performance are easier to quantify, workload is more difficult to quantify. Consequently, workload has become a major topic in aviation recently, as scientists and airline and union representatives try to better understand how this factor effects fatigue and performance in real time scenarios. Current biomathematical models do not include a workload component. In aviation, the primary method to quantify workload is the NASA Task Load Index (TLX), which has a high correlation to performance. Scientists and airline management personnel are working on developing a workload component for the modeling based on TLX data, but this work is preliminary. **METHODS/TOPIC:** The current literature on workload and short-haul operations will be discussed. Data will be presented from our lab comparing short-haul multiple-segment operations and ultra long range (ULR) operations on Safety Performance Indicators (SPIs). We also look at our preliminary TLX workload results on a unique multi-segment flight. **RESULTS:** SPIs for ULR operations are equal to or better than SPIs from short-haul multiple-segment operations. Our TLX workload data demonstrates that, as number of segments increases, workload and fatigue appear to increase, while cognitive performance degrades. **DISCUSSION/APPLICATION:** Quantitative assessment of workload is leading edge research but currently inconclusive. This demonstrates a need to thoroughly assess workload and which flights may be at an increased risk for causing elevated fatigue levels. More data is needed on workload, with the NASA TLX as the primary method of data collection to further understand this fatigue and performance factor. Then, this data needs to be compiled to be used as input into the current biomathematical models.

Learning Objectives

1. The audience will learn about the current literature on workload and short-haul operations.
2. The audience will learn about the results from some recent short-haul and multi-segment operation studies in regard to safety performance indicators and workload.
3. The audience will learn about how workload is currently interfacing with biomathematical modeling.

[134] FATIGUE MITIGATION STRATEGIES BEYOND MODELING AND SLEEP PATTERNS

Caio Rosante Garcia[1]
[1]*Azul Airlines, Campinas, Brazil*

(Education - Tutorial / Review)

Recent regulatory changes in Brazil have led to the implementation of RBAC 117 for Fatigue Risk Management. This regulation is very similar to FAR 117 and its prescriptive tables and approach to fatigue risk management (FRMS). FRMS, throughout the world, has focused more on long-haul and ultra-long-haul (ULR) flights and most material and studies have been focused on this sort of operation. Brazil has historically small numbers of ULR and long-haul operations in relation to the rest of the world. Apart from this, some airlines have a broad range of aircraft from small 9-seat single engine turboprop to 300 passenger A350 long range aircraft capable of flying up to 18 hours. This has created an enormous challenge for fatigue risk managing. Short-haul operations consist of 97% of operations, the focus of FRMS managers has been on these routes. FRMS talks in Brazil began as early as 2015, however, airlines started to prepare intensely in 2018 as the regulation matured. Since there was a proportionally smaller amount of material on short haul to reference in relation to long-haul operations, FRMS managers had to dig deep to properly understand the risk. The panelist's airline has had to create a strategy to map issues such as: workload, aircraft heat, poor hotel infrastructure, shift inversions, and other complementary issues to be able to grasp the complexity of its operation. This operation ranges from Cessna Caravans to A330s and has a significant amount of night operations (40% pre-Covid). This panelist will present how the airline tackled these issues and the on-going effort to further address its own complexity.

Learning Objectives

1. The participant will be able to get an overview of how a complex airline deals with fatigue mitigations strategies on short-haul operations.
2. The participant will learn how the airline delas with the difficulties of factoring workload, stress, personal issues and other complicators into pro-active and re-active fatigue mitigations strategies.

Tuesday, 08/31/2021 ***2:00 PM***
Governor's Square 15

[S-28]: PANEL: STATE OF PRE-CLINICAL RESEARCH ON THE EFFECTS OF HYPOBARIA DURING AEROMEDICAL EVACUATION IN MULTIPLE PRECLINICAL POLYTRAUMA RESEARCH MODELS

Chair: Catriona Miller
Co-Chair: Anke Scultetus

Panel Overview: *During recent conflicts, aeromedical evacuation (AE) has been demonstrated to be an effective way to rapidly evacuate patients to*

the continental U.S. (CONUS). While there appears to be minimal to no mortality during an AE, there is a dearth of knowledge on the possible adverse effects associated with hypobaria, hypo- or hyperoxia and vibration during extended transport. Clinical providers along the continuum of care over the past 19 years have reported neurological degradation in wounded warriors with TBI and unexplained physiological complications concerning for the potential adverse effects of CCATT and aeromedical evacuation. Data related to these observations will be presented. During the panel we will also provide an update on the most recent findings on the effects of the stressors of flight in various laboratories, across multiple pre-clinical injury models in different species, and correlate them with clinical observations made by active duty combat surgeons throughout the continuum of care. Exposure to hypobaria following traumatic brain injury (TBI) and hemorrhagic shock increased organ damage and mortality. Moreover, hypobaria adversely affected behavior and increased neuroinflammation in ferret polytrauma models. In a swine model of TBI with multiple flights, physiological instabilities were observed in the hypobaria animal group compared to normobaric control animals several hours into the flight, and there was a significant increase in white blood cells several days after the second flight. In a rat model of blast TBI with hypobaria and vibration we discovered that vibration reduced organ damage and modulated the inflammatory response. Overall, these clinical observations and basic science results could provide a possible explanation for unexplained clinical degradations upon arrival at CONUS hospitals or military treatment facilities, and upon further investigation could provide a platform for revisions of current clinical practice guidelines. Note: We are submitting 6 abstracts for 10 min presentations each to allow for ample discussion time.

[135] ADDING VIBRATION TO HYPOBARIA IN A RAT BLAST MODEL REDUCES TISSUE DAMAGE AND MODULATES THE INFLAMMATORY RESPONSE COMPARED TO HYPOBARIA ONLY

Yaron Dayani[1], Anke Scultetus[2], Joshua Stierwalt[1], Jordan Hubbell[1], Francoise Arnaud[1], Michelle Jefferson[2], David Burch[3], Carl Goforth[1], Debra Malone[1]
[1]Naval Medical Research Center, Silver Spring, MD, USA; [2]Walter Reed Army Institute of Research, Silver Spring, MD, USA; [3]Air Force Research Laboratories, Dayton, OH, USA

(Original Research)

INTRODUCTION: Aeromedical evacuation (AE) is a rapid and effective way to evacuate patients to higher levels of care. However, little is known about the effects of AE and its associated potential stressors such as hypobaria and vibration on patients with blast and other injuries. In the current study, we investigated the effects of hypobaria and vibration on histopathology and inflammatory response in rats exposed to blast overpressure (BOP) as a model of polytrauma injury. **METHODS:** Anesthetized male Sprague Dawley rats were exposed to BOP of 110kPa. After 48hrs, animals underwent a 12-hour simulated AE flight in a hypobaric chamber with simulated cabin pressure equivalent to long-range fixed wing flights (8,000 ft. altitude; HYPO group) or at sea level (NORMO group), with, or without simulation of constant vibration (mimicking the vibration in a C-130 during flight). Control animals underwent the same experiments but without injury (SHAM). 48 hours after flight, peripheral blood was sampled via cardiac puncture from the anesthetized animal for cytokine analysis. Animals were then euthanized, perfused, and organs were harvested for histopathologic analysis. **RESULTS:** Injured animals exposed to HYPO had more tissue damage in the intestine ($p<0.001$) and the brain ($p<0.01$) compared to NORMO. Overall tissue damage in HYPO animals that also underwent vibration was markedly reduced, and was statistically significant in lungs ($p<0.01$), heart ($p<0.01$) and intestine ($p<0.001$) compared to animals with hypobaria only. Similarly, animals exposed to hypobaria with vibration had a decrease in pro-inflammatory markers and increase in anti-inflammatory markers compared to hypobaria only.

Learning Objectives

1. The audience will learn about the effects of AE and its associated potential stressors such as hypobaria and vibration on patients with blast and other injuries.
2. The audience will learn about the effects of hypobaria and vibration on histopathology and inflammatory response in rats exposed to blast overpressure (BOP) as a model of polytrauma injury.

[136] HYPERHOMOCYSTEINEMIA-INDUCED PHYSIOLOGICAL STRESS EXACERBATES BLOOD BRAIN BARRIER DISRUPTION & PROMOTES INFLAMMATION IN A RAT MODEL OF BRAIN INJURY

Catriona Miller[1], Gary Fiskum[2], Flaubert Tchantchou[2]
[1]AFRL, Baltimore, MD, USA; [2]University of Maryland School of Medicine, Baltimore, MD, USA

(Original Research)

INTRODUCTION: Many military service members suffer psychological and physiological stress during combat and routine practices. These stressful conditions may cause systemic biochemical changes such as increases in the neurotoxin homocysteine, which may exacerbate combat-related injuries. This study investigated the deleterious effects of preexisting hyperhomocysteinemia (HHCY) on traumatic brain injury (TBI)-induced blood brain barrier (BBB) permeability and associated inflammation in rats. **METHODS:** A total of 85 Male Sprague-Dawley rats (250-300 g; Envigo, Denver, CO) received once-daily intraperitoneal injections of L-methionine (300 mg/kg), to induce HHCY, or saline as control for 7 consecutive days. They were then subjected to TBI by controlled cortical impact (CCI) method over the left parietal cortex or sham surgery under anesthesia. The impact velocity was 5 m/s and the penetration depth was 1.5 mm. CCI and sham rats were euthanized at different time points and brain tissue was collected for histological and biochemical analyses. There were four to six animals per group and statistical analysis was performed by one-way analysis of variance with Tukey-Kramer post-test analyses. The study was approved by the University of Maryland Institutional Animal Care and Use Committee. **RESULTS:** Methionine injections induced a sustained six-fold increase in homocysteine levels both in sham and CCI rats ($p < 0.001$), compared to controls. Histological and biochemical analyses performed on brain tissues at days 1 and 7 post-surgery to assess the integrity of the BBB demonstrated increased nitrotyrosine expressing astrocyte-like cells and reduced the expression of the cerebral tight junction protein occludin in HHCY rats compared to control rats. HHCY also caused an upregulation of the intracellular adhesion molecule 1 ($p < 0.05$) and increased Evans Blue extravasation ($p < 0.01$), both suggestive of increased BBB permeability. Moreover, HHCY increased the expression of the pro-coagulation markers von Willebrand factor ($p < 0.05$) and plasma-thrombin, resulting in diffuse presence of ferric ion positive cells and of activated microglia/macrophages prominently in HHCY rat-TBI brain sections. **DISCUSSION:** HHCY exacerbates nitrotyrosine-induced astrogliosis and BBB permeability and promotes blood clotting and diffuse inflammation following mild TBI in rats.

Learning Objectives

1. The audience will learn about how many military service members suffer psychological and physiological stress during combat and routine practices.
2. The audience will learn about the changes that stressful conditions may cause systemic biochemical changes such as increases in the neurotoxin homocysteine, which may exacerbate combat-related injuries.

[137] REDUCTION IN CEREBRAL BLOOD FLOW DURING AEROMEDICAL EVACUATION-RELEVANT HYPOBARIA FOLLOWING TRAUMATIC BRAIN INJURY IN RATS

gary fiskum[1], Julie Proctor[1], Catriona Miller[2], Rao Gullapalli[1], Su Xu[1], Boris Piskoun[1]
[1]University of Maryland School of Medicine, Baltimore, MD, USA; [2]USAF CSTARS Baltimore, Baltimore, MD, USA

(Original Research)

INTRODUCTION: Simulated air-evacuation (AE)-relevant hypobaria (HB) worsens neurologic outcomes after traumatic brain injury (TBI) in several animal models and species; however, the mechanisms responsible for this secondary brain injury are unknown. This study tested the hypothesis that cerebral blood flow (CBF) is reduced during exposure to HB 24 hr post-injury (hpi). **METHODS:** Animal protocols were approved by the University of Maryland, Baltimore and the US Air Force. Controlled cortical impact (CCI) and sham injured (craniotomy) adult male rats were

exposed to 6 hr simulated AE "flight" at 24 hpi. CBF was measured using arterial spin labeling MRI prior to and after CCI, and during and after flight in a pressure chamber located in the bore of the 7 Tesla magnet. Measurements during normobaria (NB) (200 ft) and HB (=8000 ft altitude) were made under normoxic (30-40% O_2) or hyperoxic (100% O_2) conditions. **RESULTS:** Cortical CBF was reduced one dpi and was not further inhibited during exposure to hypobaria. In contrast, while thalamic CBF was unaffected by CCI alone, it was reduced in sham and injured groups during exposure to HB, compared to the pre-flight scans. Further analysis of all groups during the flight period demonstrated that CBF was lower in rats that were exposed to HB compared to NB, regardless of ambient O_2 levels. Nevertheless, at 14 dpi, only injured animals that received 100% O_2 during HB displayed lower cortical and thalamic CBF. **DISCUSSION:** Although CCI did not reduce CBF to the thalamus, exposure to AE-relevant hypobaria one day after moderate TBI or Sham surgery resulted in lower CBF in the thalamus. CBF was least affected in rats maintained under normobaric conditions. These results, taken together with other lab animal studies and at least one clinical study indicate that TBI patients should either wait at least several days before flying or that AE aircraft should fly at cabin pressures higher than those typically used. In addition, the use of unnecessarily high levels of supplemental O_2 should be avoided during flights as hyperoxia can have a long-term dampening effect on CBF. Supported by US Air Force FA8650-17-2-6H13

Learning Objectives

1. The audience will learn about research indicating that exposure to air evacuation-relevant hypobaria worsens traumatic brain injury.
2. The audience will understand that the effects of hypobaria on the injured brain can be brain location specific.
3. The audience will consider the evidence that during hypobaria following brain injury there is a significant reduction in cerebral blood flow that can contribute to secondary brain injury caused by hypobaria.

[138] EFFECTS OF TWO CONSECUTIVE SIMULATED AEROMEDICAL EVACUATIONS ON TBI–INJURED SWINE

Francoise Arnaud[1], Jordan Hubbell[1], Natalie Coschigano[1], Debra Malone[2], Anke H. Scultetus[2]
[1]Naval Medical Research Center, Silver Spring, MD, USA; [2]WRAIR, Bethesda, MD, USA

(Original Research)

INTRODUCTON: Traumatic Brain Injury (TBI) is a signature injury in current conflicts. Aeromedical Evacuation (AE) is an accepted strategy to quickly transport severely wounded warriors to a higher level of care. However, AE could add another layer of potential complications which could become a serious concern for patient's recovery. In a TBI-injured swine model, we evaluated the impact of hypobaria during 2 long range simulated AEs 3-days apart from point of injury to definite care. **METHODS:** Anesthetized Yorkshire swine received a fluid percussion (FP) induced TBI on day 1. On day 3, the animals in the hypobaric group (H) were exposed to a 6-h simulated AE at 8,000 ft cabin altitude, followed by a 9-h AE on day 6. In the normobaric group (N), animals received similar treatment at ground level. Sham animals were instrumented but were not TBI-injured. All animals were monitored over 14 days. Vital signs, including Heart Rate (HR) and Mean Arterial Pressure (MAP), were measured via carotid arterial catheter. Intracranial Pressure (ICP), Oxygen saturation (SpO2), temperature, coagulation parameters, cytokines and chemistry laboratory assays were also measured. **RESULTS:** Survival was 100% in all groups. All animals were successfully recovered after TBI and following the two consecutive simulated AE scenarios. Baseline parameters for ICP, HR, MAP, and temperature were similar for all animals. The FP injury caused an average injury severity of 15.2±9.6 PSI for all injured animals. During day-1 surgery, hemodynamics parameters were similar in Sham and injured animals. During the AEs, MAP oscillated around 80 mmHg without time or group differences between Sham or injured animals in the N and H groups until the end of the flight. Hematology data were unremarkable and showed no significant difference between time and groups, except 3 animals in the TBI H group had an elevated WBC after the second AE without changes in specific cell populations. The coagulation time increased slightly after each AE likely due to dilution. Liver enzymes and creatinine levels were unchanged over time and between groups. Serum cytokine levels were low but without significance between groups; INF-γ tended to be elevated in the TBI group compared to Shams. **DISCUSSION:** MAP and HR some changes seen during hypobaria were not associated to AE but pig sedation. The WBC increase after the second hyopbaria AE could indicate some inflammatory complications but this was not confirmed by cytokines.

Learning Objectives

1. The participants will be familiarized with animals aero-evacuation-strategy and the relevance of animal model to study hypobaria.
2. The audience will understand the consequences of multiple evacuations of wounded patients with mild/moderate TBI.
3. The audience should consider the importance of the sedation regimen during experimental design.

[139] INDUCTION OF ENDOTHELIAL BARRIER DYSFUNCTION BY SERUM FACTORS OF TRAUMATIC BRAIN INJURY IN RAT

Yunbo Ke[1], Julie Proctor[1], Chenou Zhang[1], Juliana Medina[1], Catriana Miller[2], Thomas Grissom[1], Anna Birukova[1], Gary Fiskum[1], Konstantin Birukov[1]
[1]University of Maryland, Baltimore, Baltimore, MD, USA; [2]US Air Force c-STARS Baltimore, Baltimore, MD, USA

(Original Research)

BACKGROUND: Mild to severe acute respiratory distress syndrome (ARDS) can be induced by traumatic brain injury (TBI), but the molecular mechanism remains unknown. One of the key pathophysiologic events that cause lung edema and hypoxemia in ARDS is disruption of the alveolar–capillary barrier. Therefore, focus on EC barrier function is an important step in understanding of TBI-induced ARDS. **OBJECTIVE:** To gain insight into the potential mechanistic link between TBI and ARDS. **METHODS**: The adult male rat polytrauma model consisted of controlled cortical impact (CCI)–induced TBI followed by 30 minutes of hemorrhage shock and then exposed to hypo- or normal baric conditions. 48 hours after the CCI, blood was drawn from right ventricle. Serum collected from the TBI or sham rats were used to treat endothelial cells in culture with a 50-200 fold dilution. The endothelial barrier dysfunction was assessed by a decrease of electrical resistance across endothelial cell monolayers which was measured by electrical cell impedance sensing (ECIS) as previously described. **RESULTS**: Pronounced barrier-disruptive effects were registered in sera of TBI animals exposed to both, hypo- and normobaric conditions. However, hypobaric conditions decreased survival compared to normobaric groups. Further analysis indicated that thrombin was responsible for a transient early-phase barrier disruptive activity in TBI-serum because both thrombin inhibitor and thrombin receptor antagonist attenuated the TBI-serum-induced EC barrier dysfunction only during the early time, not in late stage. There were more sustained late-phase barrier disruptive activities following thrombin. It was found that both the early and late-phase barrier disruptive activities were inhibited by heparin, an anti-coagulant. In addition, the late phase barrier disruptive activities were depleted by heparin-sepharose. Moreover, AUY954, an EC barrier protective agent, partially inhibited the barrier disruptive activities of the TBI-serum. **CONCLUSION**: Serum from the TBI rats contain both early and late-phase barrier disruptive activities that are reversible by exogenous intervention and the early phase barrier disruptive activities were contributed by thrombin. Studies in our group are underway to identify late phase disruptive factors activated by hypobaric conditions and define severity of injury and associated levels of vascular barrier dysfunction.

Learning Objectives

1. In a rat model of traumatic brain injury(TBI) and hemorrhagic shock(HS), lung complications develop with characteristics of acute respiratory disstress symdromes(ARDS). Alteration of curculation may be responsible for ARDS induced by TBI and HS.
2. The serum from the model rat of TBI-HS contains at least two factors that causes endothelial barrier dysfunction--a key indicator of ARDS. We have defined that the serum factor that was responsible for early phase of endothleial barrier dysfunction was thrombin.
3. Both the early and later phase barrier dysruptive factors could be modulated or inhibited by artificial interventions.

Tuesday, 08/31/2021 ***2:00 PM***
Plaza A/B

[S-29]: PANEL: THE HISTORIC NASA/SPACEX DEMO-2 COMMERICAL CREW TEST-FLIGHT MISSION: PART 2

Sponsored by the Space Medicine Association

Chair: Joseph Dervay
Co-Chair: Stephen Hart

Panel Overview: BACKGROUND: *Crew Dragon Demo-2 (DM2) was the historic first crewed test-flight of the SpaceX (SpX) Crew Dragon spacecraft. It represented years of collaborative work between NASA and SpX (as the first commercial crew provider) to deliver astronauts into low-earth orbit and dock with the International Space Station (ISS).* ***OVERVIEW:*** *Demo-2 launched on May 30, 2020 from the Kennedy Space Center with NASA Astronauts Doug Hurley and Bob Behnken. It was the first crewed flight in 9 years from US soil since STS-135 in 2011. The 63-day mission concluded on Aug 2nd with a water recovery in the Gulf of Mexico, the first US splashdown in 45 years since Apollo-Soyuz. The test flight validated the hardware and operations necessary for subsequent crewed missions. This mission was executed in light of challenges with the global COVID-19 pandemic.* **DISCUSSION:** *This second of two panels will continue discussion on a range of topics addressing operational, technical, training, health, medical, and safety issues. Preventive health measures were addressed via the Health Stabilization Program, particularly important to DM2 and ISS crew during COVID-19. Training and support included suit pressure testing, support at the SpX Hawthorn facility, simulations for Flight Surgeons and Biomedical Engineers, and effective communication plans throughout all mission phases. Medical Readiness Reviews, training classes at potential MEDEVAC receiving hospitals, and Surgeon checklists were established. The development of a capsule Commercial Crew Medical Kit was required. Centrifuge training was established to provide crew experience for expected launch and entry G-force profiles.*

[140] PRE- AND POST-FLIGHT QUARANTINE FOR NASA/SPACEX DM-2 DURING THE COVID-19 PANDEMIC

Robert Mulcahy[1], Keith Brandt[2]
[1]NASA, Houston, TX, USA; [2]University of Texas Medical Branch, Galveston, TX, USA

(Education - Program / Process Review)

BACKGROUND: DM-2 launched and landed during the global COVID-19 pandemic. Ensuring crew health during this time required a comprehensive approach to allow training and necessary travel to be completed. The collective health of the DM-2 and International Space Station crewmembers was considered. **OVERVIEW**: Since Apollo 14, NASA has implemented pre-launch quarantine known as the Flight Crew Health Stabilization Program (HSP) to prevent adverse crew health outcomes during missions. NASA also enacted a post-flight quarantine from Apollo 11 to 14 (except 13), but this was ended after the Moon was found to be void of life. The HSP has evolved to meet mission demands and incorporate advances in knowledge. It became dormant after the Space Shuttle's retirement but was reestablished for the Commercial Crew Program and modified to account for the COVID-19 pandemic. Post-Flight COVID Countermeasures (PFCC) were also developed to protect crew health after landing. **DISCUSSION**: To prepare for future crewed launches from KSC and to meet the requirements set forth in multilateral agreements for the International Space Station Program, the HSP was revised in 2017. Major updates included increased quarantine duration from 7 to 14 days, stricter vaccination requirements, and the delineation of the roles & responsibilities of commercial launch providers. The robust HSP required no major modifications for the pandemic, but in consultation with infectious disease experts, additional measures included: COVID PCR testing at L-14, L-8, and L-2 for the crew, and L-14 and L-8 for key close contacts; daily electronic health surveys; temperature screening before onsite work; expanded mask usage and social distancing; and reduction in number of quarantined personnel. Due to the potential of immune cell dysfunction after spaceflight, the PFCC was enacted at landing to reduce infectious disease risks to the crew. These measures were similar in nature to the HSP, but modified to account for post-flight operational considerations.

Learning Objectives
1. Understand the Health Stabilization Program developed for Commercial Crew launches.
2. Identify unique aspects of COVID-19 testing, quarantine, and health for crew and support personnel during the global COVID-19 pandemic.

[141] TRAINING AND SIMULATIONS FOR MEDICAL OPERATIONS PERSONNEL SUPPORTING THE HISTORIC NASA/ SPACEX DEMO-2 (DM-2) COMMERCIAL CREW MISSION

Veronica Sabatier[1], Tara Willams[1], Rhonda Haralson[1], Joseph Dervay[2], Stephen Hart[2], James Pattarini[2], Benjamin Johansen[2]
[1]NASA Johnson Space Center/KBR, Houston, TX, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: The Commercial Crew Program reestablished crewed spaceflight from the United States to the International Space Station (ISS) using vehicles provided by commercial providers. Training medical team members to successfully support launch, free-flight, and landing operations of the NASA/SpaceX DM-2 mission was essential for success. **OVERVIEW**: An assessment and evaluation of the training needs and requirements depended on effective integration and collaboration with the commercial provider. The NASA/KBR training development team utilized experience of Shuttle, ISS, and Soyuz spaceflight programs to develop effective training. Preparation for DM-2 represented the first time NASA Flight Surgeons supported from the control center of a commercial provider. **DISCUSSION:** The presentation will cover the methodical approach to establishing a training plan for the Medical Operations team members supporting SpaceX Crew Dragon. It will include the strategies and key pieces involved in integrating with the provider to conduct a solid training need analysis. Training and simulations for every phase of flight was established. The execution of integrated simulations involved NASA Flight Surgeons, the Chief Medical Officer, and the Biomedical Engineers (BMEs), SpaceX personnel supporting from various locations including: Mission Control Center (MCC) at Johnson Space Center (JSC), MCC-X located in Hawthorne, CA, and at Kennedy Space Center (KSC). Phases covered pre-launch, launch, free-flight, docking with ISS, undocking, and entry/landing/splashdown. Detailed training plans were developed from NASA Flight Surgeons, BMEs, and Mission Management Team members. Mission preparation training included MEDEVAC helicopter orientation and Helicopter Underwater Escape Training (HUET) for those personnel potentially flying on a helicopter from the recovery ship. Portions of the training plan will be incorporated into International Partner medical personnel training as they support crewmembers from their respective space agency.

Learning Objectives
1. Understand the unique challenges of training medical support personnel for operations at multiple control centers.
2. Appreciate the types of training events needed for NASA and a commercial provider integrated operation.

[142] DEVELOPMENT OF A MEDICAL KIT FOR COMMERCIAL CREW VEHICLES DURING FREE-FLIGHT OPERATIONS

Rhonda Haralson[1], Rachel Richardson[1], Joseph Dervay[2]
[1]KBR, Houston, TX, USA; [2]NASA, Houston, TX, USA

(Education - Program / Process Review)

BACKGROUND: The Commercial Crew Program was established whereby commercial providers deliver crewmembers to the ISS. Various medications and equipment are merited to ensure the health and well-being of crew. Such a kit was developed and flown for the historic NASA/SpaceX Demo-2 mission. **OVERVIEW**: Selection of

appropriate medications and equipment for crew medical kits is important for in capsule use during the free-flight phase prior to International Space Station docking. Limitations in volume and weight are key factors considered for design for manifesting on both current commercial provider vehicles. **DISCUSSION**: The development of a Commercial Crew Medical kit required multiple phases. A review of past capsule, Shuttle, and Soyuz kits was completed. Potential medical scenarios in early flight were identified. Size and volume constraints were identified. Close integration by Flight Surgeons, pharmacy subject matter experts, and commercial provider medical representatives lead to the design and contents. A soft-sided 6 in. x 7 in X 10 in. kit was developed incorporating a total of 47 items. Medical procedures were developed for use of equipment and validated to ensure proper use. Hard copies of the medical procedures were attached to the kit via Velcro for the Demo-2 flown kit. Commercial Crew Astronauts received training on various medical conditions the kit contents are designed to mitigate. This Commercial Crew Medical Kit is now a standard component of medical care capabilities during the free-flight portion of future Commercial Crew Program missions.

Learning Objectives

1. Understand the need for a Commercial Crew medical kit for free-flight phase
2. Appreciate the approach to select medications and equipment for the kit, and the development of medical procedures for use

[143] NASA CENTRIFUGE TRAINING PROGRAM FOR COMMERCIAL CREW MISSIONS

Craig Murphy[1], Jonathan Dory[2], Robert Mulcahy[3], Samantha Testa[3], Michael Barratt[2], Joseph Dervay[2]
[1]NASA-USAF, Houston, TX, USA; [2]NASA-Johnson Space Center, Houston, TX, USA; [3]NASA-Kennedy Space Center, Merritt Island, FL, USA

(Education - Program / Process Review)

BACKGROUND: The development of new Commercial Crew space vehicles returns NASA to capsule configurations with ascent and entry accelerations in family with Apollo, Gemini, and Soyuz spacecraft. These acceleration loads, along with relevant capsule ergonomic factors, have necessitated new training updates to familiarize crewmembers with flight-like acceleration forces. NASA teams at the Johnson Space Center (JSC) and Kennedy Space Center (KSC) collaborated to design a capsule display-panel mockup inside a gondola at the Air Force Research Laboratory located at Wright Patterson Air Force Base (WPAFB) in Dayton, OH. Testing and training allowed for physiologic +Gx acceleration exposures emulating new vehicle flight profiles for astronauts and test subjects. **OVERVIEW:** Teams from KSC and JSC worked together in the fall of 2018 to design a hybridized mockup of commercial crew provider cockpit panels which were combined with flight-like centrifuge profiles at WPAFB. Selected cockpit panels emulated controls and displays deemed critical for reach and visibility under entry acceleration loads. The profiles and mockups aided teams in determining if reach aids would be needed for critical switches, whether touch-sensitive screens were feasible, and if provider space suits combined with flight-like restraints allowed for reach and visibility of controls. These centrifuge runs offered valuable training opportunities for astronauts, allowing them to experience extended Gx accelerations and develop techniques for performing reaches and precision cockpit tasks. There were multiple testing/training events from fall of 2018 through 2020, and responses post-training were very favorable from design teams and those experiencing the centrifuge events. **DISCUSSION:** The collaboration between KSC, JSC and WPAFB to design, test, review, and adapt equipment and hardware for new commercial space vehicles in the centrifuge has been effective. This has contributed to confidence in cockpit design and informed the design and use of adjuncts such as reach aids, and provided physical awareness of DM2 crewmembers of flight-like acceleration loads prior to their upcoming flight. The centrifuge training and +Gx profiles will continue to provide a unique and valuable training experience for assigned commercial crew. The facility also offers a platform for studies to develop more generalized knowledge that may inform design standards or requirements for future programs.

Learning Objectives

1. The participant will learn about the centrifuge program used to train commercial crew for spaceflight.

The audience will understand how these Gx centrifuge runs provided valuable training opportunities for astronauts, allowing them the experience extended Gx accelerations and develop techniques for performing reaches and precision cockpit tasks.

Tuesday, 08/31/2021 ***2:00 PM***
Plaza D/E

[S-30]: PANEL: COMPLEX PROBLEMS AND NOVEL SOLUTIONS FROM JUNIOR AND FUTURE FLIGHT SURGEONS LEADING INNOVATION

Sponsored by Society of U.S. Air Force Flight Surgeons

Chair: Brian Hanshaw

Panel Overview: *The constant and evolving mission of aviators, special duty operators, and aircrew trainees across the USA Air Force is diverse and presents complex operational medicine problems. This panel features junior and future Flight Surgeons across the Department of Defense, who will discuss how their flight medicine program delivers innovative solutions to combat the medical issues seen in their diverse population of war fighters. The following presentations carry one theme: bringing medical services directly to their supported populations to increase the value of clinical services to both the patient and the mission they support across the globe at any time and in any condition. This panel has become tradition over recent years and is critical as we strive to build the future of our Flight Surgeons. These individuals are showcasing their vision on the fight against complex and unique medical problems and the impact on keeping our flyers in the fight.*

[144] SMOKE AND FUMES IN THE COCKPIT

Jeremy Berger[1]
[1]U.S. Air Force, Jacksonville, AR, USA

(Education - Case Study)

INTRODUCTION: In June 2019, a C-130J aircraft with six crew members developed thick, acrid smoke on the active runway during a touch-and-go training profile. This case presentation describes the action and responses of the crew members and flight medicine response team during an in-flight emergency (IFE). The presentation will also review the most up-to-date treatment options available and make recommendations to further the proficiency of new flight surgeons. BACKGROUND: A cockpit with smoke and fumes is a common IFE, yet is challenging for junior flight surgeons to treat due to lack of experience and hands-on training. Smoke and fire can quickly incapacitate a crew unless immediate protective action is taken. **CASE PRESENTATION:** This presentation includes a case vignette where pungent smoke filled the cockpit while an aircrew was performing touch-and-go procedures in a C-130J. A follow-up mishap investigation revealed that the smoke originated from a fluid leak in the number two engine which, in turn, caused noxious fumes to fill the cabin. The flight surgeon onboard immediately urged the crew to don oxygen masks. The crew promptly obliged, opened the fuselage hatch, and performed the prescribed emergency procedures. Treatment options for smoke and fume exposure will be discussed along with a review of in-flight aircrew safety protocols and training. **DISCUSSION:** This case highlights the need of aircrew and flight medicine teams to effectively train together for IFE's. Post-hoc analysis revealed that an aircraft commander did not have time to don his oxygen mask due to task saturation. The flight surgeon lacked experience and relied on clinical intuition to triage the situation. Fortunately, an emergency medical kit was available, and the on-board medic closely monitored the at-risk pilot for incapacitation until the aircraft safely landed. The entire crew emergently egressed without assistance. In hindsight, the other crew members could have aided the pilot with donning his oxygen mask to ensure his safety while he was performing emergency

procedures. Three possible solutions can easily be implemented to prevent similar occurrences in the future. (1) Annual safety presentations by flight medicine teams to the flying squadrons can address these specific issues. (2) Shortly before takeoff, flight surgeons can provide the aircrew with succinct reminders of relevant safety procedures. (3) During AMP, junior flight surgeons can formally train for this IFE.

Learning Objectives

1. The participant will learn about treatment options for smoke and fumes in the cockpit.
2. The participant will learn about common causes of smoke and fumes in the cockpit.

[145] BUILDING THE AEROMEDICAL NURSE PRACTITIONER INTERNSHIP

Jessica Knizel[1], Christopher Kelly[2]
[1]96th OMRS/96 MDG/Eglin AFB, Eglin AFB, FL, USA; [2]14th MDG/Columbus AFB, Columbus AFB, MS, USA

(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. FNPs 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 predesignated 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 provider. 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. The learner will identify current training requirements of Aeromedical Providers.
2. The learner will be able to explain two benefits of the Aeromedical Provider internship.
3. The learner will identify three current training gaps for the Aeromedical Nurse Practitioner.

[146] BIOHACKING FLIGHT MEDICINE'S BEST: OPTIMIZING READINESS AND HEALTH WITH LIFESTYLE MEDICINE & PERFORMANCE MEDICINE

Regan Stiegmann[1]
[1]USAFA, Colorado Springs, CO, USA

(Education - Program / Process Review)

BACKGROUND: We recruit the healthiest men and women in America to serve in the U.S. 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 primely poised to execute out 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. At the conclusion of the session, the participant will be able to describe how Lifestyle/Performance Medicine is being integrated into the military and medical treatment facilities of the Department of Defense
2. At the conclusion of the session, the participant will be able to discuss various Department of Defense strategies that focus on implementing Lifestyle Medicine measures for our Soldiers, Sailors, Airmen, and Marines.
3. At the conclusion of the session, the participant will be able to discuss how military readiness is directly impacted by the tenets of Lifestyle Medicine, and how the MHS/Defense Health Agency's quadruple aims align within the field of Lifestyle Medicine

[147] AN INTERESTING CASE OF DECOMPRESSION SICKNESS IN A C-17 PILOT

Samuel Philbrick[1]
[1]Joint Base Elmendorf-Richardson, Anchorage, AK, USA

(Education - Case Study)

CASE PRESENTATION: A 28 y/o female pilot presented to flight medicine with 2 days of joint pain that started several hours after a HALO jump sortie in which the pilot's C-17 underwent a planned rapid decompression from cabin-pressurized effective altitude of 10,000 ft to its actual altitude, 17,000 ft. The patient had pre-breathed 100% O2 for 30 minutes before the decompression and questioned whether her joint pain was merely due to lack of sleep and spending too much time in the gym. She complained of 2/10 pain that started in the right hip, then partially improved in the hip but manifested in the right knee, and later the right S.I. joint. Her pain felt the same as aches experienced after working out. She had also had a headache the day after the flight that lasted for a few minutes, was not associated with any neurologic deficit, and resolved with over-the-counter NSAIDs. On presentation to the medical group, she was relocated to a treatment room, started on 100% O2 NRB, laid in the supine position, and oral hydration was

started. A head-to-toe neurological exam was normal. Musculoskeletal, pulmonary, and skin exams were also unremarkable. Her unilateral joint pain that started in a large joint and migrated to adjacent joints was concerning for decompression sickness, and the prior presence of a headache was concerning for neuro DCS. However, no hyperbaric chambers were available in the local area. The hyperbaric service in San Antonio was consulted, and the case was discussed with the SGP at Eielson. To avoid an air-evac that could worsen symptoms, the team decided to treat the patient using Eielson's Hyperlite chamber. The pilot was driven straight to Eielson. She was taken off 100% O2 in transit to avoid oxygen toxicity on the 8-hour drive. Immediately upon arrival she underwent the HAART table. While in the Hyperlite chamber she noticed her joint pain vanishing. On completion of the treatment her symptoms had resolved, and she was returned to duty without restrictions. This case illustrates the sometimes unassuming presentation of DCS. The patient had a normal exam and expressed that she thought she was probably sore from working out. Yet the immediately resolution of her symptoms in the hyperbaric chamber clearly established the diagnosis of DCS. The case also calls attention to the need to take all potential neuro DCS seriously. Finally, it highlights the importance of having a plan in a clinical setting with limited resources.

Learning Objectives

1. Audience will appreciate the value of having a pre-set plan for decompression sickness, with backups available, and the value of contingency options.
2. Audience will understand the importance of a high index of suspicion for DCS cases in the setting of an equivocal clinical presentation.

[148] A SURVEY OF AEROMEDICAL EVACUATIONS AND MEDICAL CHALLENGES FROM THULE AB GREENLAND

Thomas Powell[1]
[1]*The Ohio State University/US Air Force, Columbus, OH, USA*

(Original Research)

INTRODUCTION: Located only 1000km from the North Pole, Thule AB, Greenland is one of the most northern permanently inhabited communities in the world. Operated by both the US Air Force and the Kingdom of Denmark, the joint base was constructed as an early warning radar installation and northern base of operations; a task it still performs to this day. Although the base used to be home to some 10,000 personnel, only 700-900 live there on a daily basis. Logistical support of such a remote area is challenging, particularly the medical needs of the military personnel stationed there. Although serviced by Danish contractor physicians, the Air Force members there do not have access to sub-specialty care and must be sent back state-side for these needs in a costly "special medical trip". Additionally, the general austere location of this base can make aeromedical evacuation from the site difficult. **METHODS:** Here we describe two main logistical difficulties of medical operations for the base. First, the rates of medical TDY for both the contractor population and the military personnel were gathered and examined over a 5 year span. Second, the number of days of inclement weather which could preclude aeromedical evacuation to the base were averaged over a 20 year span from 1996 to 2016. **RESULTS:** Rates of medical travel for base military personnel were around 10% per year, with an annual rate of off-site medical use that approached 20% per year when these trips were combined with total MEDEVAC numbers. Weather averages of days with storm conditions, defined as winds above 35kts and visibility less than 800m, were found to average 48 days per year, preventing travel to and from the base at least 13% of the year. **CONCLUSIONS:** When compared to contractor personnel, a off-site medical usage rate of 20% is much higher than the average Contractor rate which was found to be 2%. Further, a MEDEVAC utilization of almost 10% is much higher than Air Force average. Complicating this picture is the severe nature of the weather of the weather at this location, which prevents aviation operations at least 15% of the time, complicating any potential aeromedical evacuation. These issues highlight the challenge of providing medical support to this austere locale.

Learning Objectives

1. The audience will understand the medical challenges of operating in the High Arctic.
2. Attendees will learn why USAF personnel have higher utilization rates of off-island medicine.
3. Listeners will understand the challenge of providing aeromedical evacuation to a high latitude locale with its complex weather and logistical challenges.

[149] MISSED MEDICAL APPOINTMENT SURVEY, 480TH ISR WING JBLE, JANUARY 2013 TO MARCH 2013

Brandon Sellers[1], Bryant Martin[2], Brian Hanshaw[3]
[1]*Medical College of Georgia at Augusta University, Augusta, GA, USA;* [2]*USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA;* [3]*USAF, JBER, AK, USA*

(Original Research)

INTRODUCTION: In the first quarter of 2013, January 2013 to March 2013, the 633th Medical Group identified an issue that urged them to contact the leadership of the 480th ISR Wing at Langley AFB. A trend of missed medical appointments was becoming prevalent and was leading to underutilization of medical resources. Upon notification of the problem at hand, the 480th ISR Wing leadership requested that the 433th Medical Group conduct a survey directed toward the airmen that missed a medical appointment. This report describes the survey that was conducted to assess the underlying cause of the missed medical appointments. The information extracted from the report can be utilized in the future to better utilize USAF medical resources. **METHODS:** From a broad perspective, questions were asked in such a way that categorized the missed appointment under the responsibility of the patient, hospital, or unit. The research was not conducted under anonymous circumstances, but the airmen were promised that no punitive action would be taken. The responses of the survey may have been impacted by the lack of anonymity; future studies could address this potential source of altered responses if the need arises for a subsequent survey. **RESULTS:** It was identified that nearly half, 44%, of the missed appointments were at the fault of the airmen. The additional half of missed appointments can be subdivided nearly equally into the fault of the hospital (29%) and unit (27%). **DISCUSSION:** From the data extrapolated by the survey, it was determined that the overarching responsibility of missed appointments fell upon the airmen. From this finding, future actions can be taken to reduce the number of missed appointments for better utilization of medical resources. Examples of such actions could include quarterly surveys until the number of missed appointments drop below the desired threshold, or appointment reminders could be sent out at pre-determined intervals prior to the scheduled appointment.

Learning Objectives

1. Learning Objective 1: The audience will learn the major causes of missed medical appointments according to the survey assessed in this report.
2. Learning Objective 2: The audience will be able to take into account information from the report in an effort to maximize USAF medical resources in the future.

Tuesday, 08/31/2021 ***2:00 PM***
Plaza F

[S-31]: SLIDE: TOPICS IN SPACE MEDICINE PRACTICE

Chair: Kris Lehnhardt
Co-Chair: John Sczepaniak

[150] REMOTELY GUIDED ULTRASOUND DRAIN PLACEMENT WITH "JUST IN TIME" TRAINING: AN ANALOGUE FOR TREATMENT OF SURGICAL EMERGENCIES ON LONG DURATION MISSIONS

David Lerner[1]
[1]*University of Washington, Seattle, WA, USA*

(Original Research)

INTRODUCTION: Surgical emergencies on Exploration Missions could have devastating effects. Using image guided procedures for treatment has been described. Previous research focused on subspecialists, however, a physician-astronaut with general training is likely to be selected. We show a novel technique for treating such emergencies with remote guidance and "just in time" (JIT) training by volunteers without image guided experience as an analogue for long duration missions. **METHODS:** A phantom with an internal fluid collection was made to simulate surgical emergencies in microgravity such as abscess. A "JIT" training video was made with instructions for performing ultrasound guided drain placement. Medical students and residents were recruited with zero exposure to dedicated ultrasound training. Individually, they were put in a room alone with an ultrasound, prepared phantom, equipment, and a tablet with video camera. Participants viewed the "JIT" video, and asked questions via remote interaction by video conference link on the tablet. They were talked through the procedure with remote guidance using the tablet in a stepwise function by a radiologist. The access needle was guided into the fluid under ultrasound, a wire advanced through the needle, and drain placed using Seldinger technique. Each volunteer was allowed one attempt. Technical success was demonstrated by imaging location of the drain in the collection and return of fluid. **RESULTS:** After watching the "JIT" video and using remote video guidance, each participant localized and advanced the needle into the collection under ultrasound, and placed the wire and drain into the collection. Technical success was achieved in all attempts. Time requirement for the entire process was under 20 minutes per participant. **DISCUSSION:** While surgical emergencies could have grave consequences on long duration missions, supplies might be limited. Using interventional radiologic guided procedures to treat these emergencies has been described by experienced radiologists. However, the question of whether an astronaut-physician with zero/minimal previous image guided experience could be educated with "just in time" training and guided remotely by specialists on Earth using a video link to perform the procedure has been discussed by flight surgeons at NASA. We describe a novel technique as proof of concept that such a remotely guided procedure could potentially be utilized for long duration missions.

Learning Objectives

1. The participant will be able to understand the feasibility of remotely guided surgical procedures for long duration missions in microgravity.
2. The participant with learn the technique for remotely guiding minimally invasive surgical treatments in microgravity using ultrasound.

[151] FOOT DROP REQUIRING SURGICAL INTERVENTION FOLLOWING LONG DURATION SPACEFLIGHT

Michael Harrison[1], Kathleen M Garcia[2], Catherine G Coleman[2], Richard A Scheuring[2]
[1]Mayo Clinic, Jacksonville, FL, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: This case report describes the diagnosis of lumbar disc herniation causing motor neuron dysfunction in an experienced astronaut following long-duration spaceflight. **BACKGROUND:** Back pain represents the most common acute complaint in astronauts on orbit. Additionally, astronauts are at an increased risk of spinal disc herniation as compared to the general population. The only imaging modality available on the International Space Station (ISS) is point-of-care ultrasound (POCUS). However, POCUS has not been used to diagnosis a significant cause of acute back pain in an active astronaut on orbit. **CASE PRESENTATION:** A 50-year-old female astronaut with more than 4,000 hours of spaceflight experience presented to clinic with complaints of progressively worsening right-sided sensory and muscular radiculopathy in the lower extremity that included foot drop. Her symptoms had started after an acute event with the advanced resistive exercise device (ARED) and managed her symptoms with a short course of corticosteroids following consultation with her flight surgeon. She returned to Earth via a nominal Soyuz re-entry and a post-flight MRI revealed a small, broad-based disc protrusion at L4-L5 with compression of the L5 nerve root on the right side. POCUS obtained at the same time in clinic revealed the same findings. The astronaut underwent decompressive laminectomy with resolution of her symptoms and a return to NASA flight status. **DISCUSSION:** POCUS is a valuable tool for diagnostic and procedural purposes. This case demonstrates the utility of this tool in arriving at clinical and image-based diagnoses that agree with each other. With further development and refinement of protocols and training, POCUS will become an indispensable medical resource for deep space exploration class missions. This case provides an example of an atypical POCUS target with diagnostic quality images that could guide therapy in a resource-limited environment such as a trip to Mars.

Learning Objectives

1. The audience will learn about the utility of point-of-care ultrasound (POCUS) in diagnosing acute pathology on the ISS.
2. The audience will learn about the utility of POCUS in spinal assessments of astronauts on the ISS.

[152] DENTAL CARE ON A LUNAR BASE: USING ANTARCTICA AS AN ANALOG

William Powers[1], Edward Powers[2]
[1]South Kipling Dental Center, Littleton, CO, USA; [2]The University of Texas Medical Branch at Galveston, Galveston, TX, USA

(Education - Tutorial / Review)

INTRODUCTION: The Apollo program furnished medical kits with little regard given to possible dental emergencies. ISS kits were improved but not adequate for a moon base. NASA is committed to return to the Moon in 2024. Due to its remote location and isolation, Antarctica serves as an excellent analog. Dental emergencies at this remote location have proven to be a significant concern and a cause for medical evacuation. This study will identify risks associated with dental issues on a lunar base and offer strategies to mitigate those risks. **METHODS:** A literature search of published data concerning dental issues encountered at all international bases in Antarctica was undertaken. In addition, unpublished clinical data from the Center for Polar Medial Operations at The University of Texas Medical Branch in Galveston was reviewed. This center is responsible for medical clearance and care for all individuals employed at the three US National Science Foundation bases in Antarctica. **RESULTS:** Data from compiled research suggests that over a 60-year period, health complications occurring on Antarctic bases have been trending toward an increase on a per person basis. Data also suggests that dental/oral health complications are the third most common healthcare occurrence among Antarctic bases and some required medical transport from the continent for treatment. **DISCUSSION:** Lunar base operations will require extended stays on the surface of this very remote environment. The study seeks to bring a better understanding of the dental equipment and training necessary to establish a lunar base using the Antarctic experience as an analog. Consideration for equipment selection includes minimizing size and weight due to the cost of transporting such items to the lunar surface. This research shows that dental health will be a key issue to understanding and properly preparing for future lunar missions. Results of this study are expected to identify dental risks and to suggest appropriate steps to mitigate the risks for a lunar base.

Learning Objectives

1. The participant will be able to understand dental risks associated with occupation of a lunar base.
2. The participant will be able to understand mitigation strategies to mitigate dental risks on a lunar base.

[153] AN INVESTIGATION INTO THE FEASIBILITY AND DESIGN OF A MICROGRAVITY SURGICAL WORKSTATION

Eleonor Frost[1]
[1]University of Aberdeen, Aberdeen, United Kingdom

(Original Research)

INTRODUCTION: As humanity plans for long-duration crewed missions to Mars and beyond, astronauts will need more autonomy and

training to deal with medical emergencies. Significant communication delays and long evacuation distances mean a surgical workstation will be a necessity on a spacecraft and could save lives. **METHODS:** The aim of this study was to assess the feasibility and design of such a microgravity surgical workstation. This research was conducted using two main approaches: the first was a thorough literature review to summarise current knowledge and inform the enclosure design; this was followed by an iterative process to perfect a workstation design proposal. Notably, a similar surgical enclosure has never been investigated and very few containment solutions have been tested in parabolic flight. **RESULTS:** This study proposes the design of a Crew Operating Microgravity Theatre Enclosure (COMTE), which has been shaped by conclusions from parabolic animal surgery experiments and by questionnaire feedback from space medicine experts and astronauts. A full technical characterisation of the proposed design is included in this report, and a prototype was constructed. The defining principle of the COMTE 'glovebox' was to use the capillary edge-effect of fluids in microgravity to contain surgical fluids and blood during an operation. This aims to improve operator visualisation of the surgical field, whilst maintaining a sterile surgical site and preventing contamination of the closed-loop spacecraft atmosphere. Additionally, the proposed design includes extensive research on weight, volume and power requirements, and has been reviewed by external experts. This research not only safeguards astronauts but could present a unique solution to terrestrial surgery in remote and extreme environments. **DISCUSSION:** In conclusion, this presentation proposes a novel solution to the problem of safe and efficient surgery in space, and further work on the design will lead to testing on the ground and in parabolic flights.

Learning Objectives

1. The audience will learn about the challenges of engineering and design in microgravity
2. The audience will learn about the history of surgery in space and future directions
3. The audience will learn about a novel design solution to the problem of surgery and aseptic technique in space

[154] SPINAL ANAESTHESIA IN SPACE: NEURAXIAL REGIONAL TECHNIQUES AS A SOLUTION TO ANAESTHESIA IN MICROGRAVITY? A LITERATIURE REVIEW

Daniel Olaiya[1], Aliya Mackenzie[2], Rohan Sant[1]
[1]University College London Hospital, London, United Kingdom; [2]St. George's University Hospital, London, United Kingdom

(Education - Program / Process Review)

BACKGROUND: This paper highlights the need for standardized anesthetic (specifically neuraxial) protocol in the microgravity environment and further research in this field; based on the serious, time critical nature of aerospace emergencies, and logistical barriers which have accounted for the current inadequacies of medical equipment, staffing and management. **OVERVIEW:** Significant trauma and injuries to the lower limbs requiring emergency surgery and anesthesia continue to be an anticipated risk of long-term space flight. This is largely due to alteration and deconditioning of physiological and biochemical parameters of the musculoskeletal system. The significant premise for further investigation is combined, furthermore, by current gaps identified in the knowledge base regarding neuraxial anesthesia; the length of space travel (and subsequent incidence of emergencies; distance from terrestrial medical care; lack of immediate resources, required crew skill and training; and universal guidance. We also must consider preparation for future commercial and longer distance travel and the risk of exponential rise in emergencies. This is related to both increased passenger number and comparative lower medical fitness in relation to the optimum health of rigorously tested astronauts on scientific journeys. **DISCUSSION:** Regional anesthesia has been proposed to be potentially suitable for the microgravity austere environment. Several reasons have been outlined in the key papers reviewed; with the more substantial body of knowledge focusing on regional limb nerve blocks (as opposed to neuraxial blocks). However, importantly there have been highlighted several substantial advantages to neuraxial blocks; we have analyzed in detail the advantages and disadvantages, (including barriers, accessibility, safety and more). Therefore, there are clear advantages established in investigating the pharmacokinetic, pharmacodynamics and fluid physics of neuraxial anesthetic use in the microgravity environment.

Learning Objectives

1. The audience will understand the challenges brought about by providing general anesthesia in microgravity and therefore why regional anesthetic techniques may be vital to the success of long-term spaceflight.
2. The audience will understand the clinical application and potential benefits that neuraxial anesthesia may provide in a microgravity environment. The focus will be on lower body injuries and obstetric anesthesia in space.
3. The audience will understand the challenge we must overcome if we are to provide neuraxial anesthesia in microgravity environments and therefore open the door to research looking at this.

[155] SIMULATION OF INTRAVENOUS FLUID RESUSCITATION CAPABILITIES IN REDUCED GRAVITY

George Pantalos[1], Justin Heidel[1], Ishita Jain[1], Scott Warner[1], Thomas Barefoot[1], Rachel Baker[1], Melinda Hailey[2]
[1]University of Louisville, Louisville, KY, USA; [2]KBR Wyle Science, Technology, and Engineering, Houston, TX, USA

(Original Research)

INTRODUCTION: Critical care for exploration space missions may require intravenous fluid resuscitation therapy. Resource constraints may limit availability of standard Earth-based, infusion technologies, therefore, the effect of variable acceleration on infusion flow rates using simple fluid resuscitation supplies was investigated. We hypothesize that the reduced hydrostatic pressure experienced in reduced gravity environments will reduce the infusion flow rate for intravenous fluid resuscitation therapy and that this reduced hydrostatic pressure can be sufficiently overcome with the use of pressure bag augmentation. **METHODS:** Infusions of water (μ= 1.0 cP viscosity) or 40% glycerol in water (blood analog, μ=3.5 cP) from a 1 L IV bag were performed using pressure bag augmentation at 0, 150 or 300 mmHg. The bag rested on an adjustable mount positioned at different heights to simulate relevant gravitational accelerations (1-G, Martian-G, Lunar-G, and 0-G). The bag emptied through an IV line with a bubble trap, into a 14 or 20 gauge angiocath submerged in a venous pressure reservoir of 3 mm Hg. Flow rates were measured using an in-line flow probe; three determinations were made for each test condition. Statistical analysis was performed in GraphPad Prism 8 using a Shapiro-Wilk test for normality and a 2-way ANOVA for determining statistical significance ($\alpha = .05$). **RESULTS:** Temporal flow rate data for the test conditions displayed one-phase exponential decay. At 300 mmHg pressurization, maximum infusion rates ranged from 92 to 222 mL/min for water and from 21 to 49 mL/min for blood analog. For 500 mL infusion volumes, infusion times were significantly less for 1-G compared to Lunar-G and 0-G for both test solutions ($p<0.05$). For 1000 mL, all reduced gravity conditions had significantly longer infusion times in comparison to 1-G for both test solutions ($p<0.05$). **DISCUSSION:** Reduced acceleration significantly altered flow rates and infusion times for fluid resuscitation. Infusion flow rates are highest with less viscous fluid at greater acceleration through larger bore needle at a higher infusion pressure. Fluid resuscitation protocols specify a desired volume to infuse for a target time (e.g. 20-30 mL/min for a 75 kg adult). This data demonstrates that this protocol parameter can be achieved with pressure infuser bag augmentation alone and provides information for the refinement of fluid resuscitation protocols for exploration space missions.

Learning Objectives

1. The first objective is to understand how various levels of gravitational acceleration (1-G, Martian-G, Lunar-G, and 0-G) impact standard methods of delivering intravenous fluid therapy.
2. The second objective is the determine ways to augment intravenous fluid infusion rates sufficient for resuscitation therapy using existing augmentation methods with minimum logistics requirements that are appropriate for exploration spaceflight.
3. The third objective to is become familiar with methods to determine intravenous fluid infusion rates and how to simulate the effect of various gravitational levels in the lab in 1-G.

Tuesday, 08/31/2021 ***2:00 PM***
Governor's Square 12

[S-32]: PANEL: USAF DISTRIBUTED COMMON GROUND STATION OPERATOR OCCUPATIONAL STRESS

Chair: Lillian Prince

Panel Overview: *This panel presents the results from a 2019 occupational health assessment given to the U.S. Air Force (USAF) distributed common ground system (DCGS) intelligence community. The assessment was conducted by USAF School of Aerospace Medicine researchers to identify the unique characteristics of the DCGS operational environment. We will provide a broad-spectrum snapshot of occupational health for these USAF operators and draw comparisons to findings from previous assessments of this population in 2011, 2013, and 2016. The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. The first presentation gives overarching findings from the occupational health questionnaire and introduces psychological distress. The second presentation introduces post-traumatic stress disorder (PTSD) and specific symptom endorsement from the PTSD Checklist. The third presentation addresses both positive and negative coping strategies employed by this population for psychological distress and PTSD. The fourth presentation addresses the importance of unit and member social support for the DCGS community. The fifth presentation gives a psychological review of the reported moral issues and spirituality and their relationship with psychological distress and PTSD in this population.*

[156] DISTRIBUTED COMMON GROUND SYSTEM OCCUPATIONAL HEALTH QUESTIONNAIRE RESULTS: SOURCES OF STRESS AND RATES OF PSYCHOLOGICAL DISTRESS

Lillian Prince[1]
[1]*Nation Defense Intelligence University (Washington D.C.), Birmingham, AL, USA*

(Original Research)

INTRODUCTION: The increasingly dynamic state of global political and military affairs sustains the high demand for distributed common ground system (DCGS) capabilities. The nature and magnitude of missions conducted by DCGS intelligence operators impart unique stressors. Thus, the need to monitor stressors, psychological distress, and associated risk factors is critical to the success and livelihood of these individuals. **METHODS:** The present study included 1007 DCGS intelligence operators who responded to a comprehensive occupational health assessment that included questions on demographics, sources of stress, health and occupational factors, and stress outcomes. The Outcome Questionnaire was used to assess psychological distress. The study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. Rates of psychological distress were examined and comparisons to findings from previous assessments were conducted. The relative risk of various demographic, occupational, and health factors on psychological distress was also examined. **RESULTS:** Self-reported sources of occupational stress are similar to those reported in previous assessments of this population. Approximately 20-25% of DCGS operators reported high psychological distress, a modest increase from previous assessments. With respect to operational risk factors, high role overload and role conflict were associated with greater risk of psychological distress. Low professional efficacy and low job satisfaction also emerged as operational risk factors, as did high levels of exhaustion and cynicism. When reviewing personal risk factors, operators endorsing relationship difficulties with a significant other, chronic inadequate sleep, and increased caffeine, alcohol, or tobacco use had an increased risk for psychological distress. **DISCUSSION:** The descriptive nature of this study can increase awareness among military medical practitioners as to factors that may increase an operator's likelihood of experiencing psychological distress. The results of this study further clarify potential risk factors for negative psychological outcomes among individuals working in the Air Force DCGS community. Interventions designed to mitigate the impact of potential risk factors can be designed to improve the health and well-being of DCGS operators.

Learning Objectives

1. The audience will learn the prevalence of psychological distress for DCGS operators.
2. The audience will learn the facets and prevalence of burnout among DCGS operators.

[157] DISTRIBUTED COMMON GROUND SYSTEM OPERATORS: PTSD CHECKLIST FOR DSM-5 SYMPTOMS AND POST-TRAUMATIC STRESS DISORDER

Tanya Goodman[1]
[1]*USAF School of Aerospace Medicine (Neurostat Analytic Solutions, LLC), Alexandria, VA, USA*

(Original Research)

INTRODUCTION: U.S. Air Force distributed common ground system (DCGS) operators experience the combat environment on a day-to-day basis. The relationship between vicarious exposure and post-traumatic stress is particularly important to understand for this community, given their unique "deployed-in-garrison" work environment. The prevalence and expression of post-traumatic stress disorder (PTSD) symptoms are critical to the effective delivery of comprehensive healthcare for this population. **METHODS:** In the current study of 1007 operators, 701 DCGS intelligence (intel) operators were asked if they had experienced an extremely stressful event that they would characterize as traumatic in nature. Those who endorsed this type of event were asked to complete the PTSD Checklist for DSM-5 [Diagnostic and Statistical Manual of Mental Disorders, 5th Edition] (PCL-5). The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. The patterns of individual symptom and symptom categories were examined and compared to PTSD findings from previous assessments of the DCGS population. **RESULTS:** A total of 258 DCGS intel operators responded to the PCL-5. Approximately 4% of DCGS intel operators met symptom criteria for PTSD, and 2% had a high rate of symptom expression, indicated by a high score on the PCL-5. Compared to a similar study in 2011, an upward trend of PTSD symptom criteria endorsement was found, but rates were similar to another study of this population in 2016. Operators with PTSD symptom criteria tended to report trouble falling or staying asleep, feeling very upset when something reminded them of the stressful experience, avoiding memories, thoughts, or feelings related to the stressful experience, and feeling distant or cut off from other people. **DISCUSSION:** The results of this study suggest that specific PTSD symptoms and symptom categories are more relevant for DCGS operators than other symptoms. This study provides military practitioners with specific PTSD symptoms to watch for in this unique work environment.

Learning Objectives

1. The audience will learn of the PTSD symptoms most commonly reported by DCGS operators.
2. The audience will learn about the similarity/difference in PTSD expression rates since previous assessment in 2016.

[158] POSITIVE AND NEGATIVE COPING STRATEGIES FOR PSYCHOLOGICAL DISTRESS AND POST-TRAUMATIC STRESS DISORDER AMONG DISTRIBUTED COMMON GROUND SYSTEM OPERATORS

KINSEY BRYANT-LEES[1]
[1]*USAF School of Aerospace Medicine (Neurostat Analytic Solutions, LLC), Alexandria, VA, USA*

(Original Research)

INTRODUCTION: U.S. Air Force (USAF) distributed common ground system (DCGS) operators have higher rates of psychological distress and post-traumatic stress disorder (PTSD) than other mission areas in the USAF. Understanding both the positive and negative coping strategies

employed by DCGS intelligence (intel) operators is critical to the effective delivery of mental healthcare of this population. **METHODS:** DCGS intel operators responded to a comprehensive occupational health assessment that included questions on demographics, occupational factors, stress outcomes, and health behaviors. The Outcome Questionnaire was used to assess psychological distress. The PTSD Checklist for DSM-5 [Diagnostic and Statistical Manual of Mental Disorders, 5th Edition] was used to assess PTSD symptom criteria. The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. Relative risks for high psychological distress and PTSD symptom criteria were run. Demographic, occupational, and health behavior patterns of those reporting low psychological distress and low symptom criteria were also examined. **RESULTS:** Positive health behaviors included sleeping 7 or more hours per night and engaging in aerobic exercise three or more days a week. These results are consistent with the most commonly self-reported stress coping strategies: exercise, sleep, leisure/recreational activities, and personal time. Additionally, when examining individuals who presented low psychological distress and few PTSD symptoms, this population also tended to reflect healthier utilization rates of alcohol, caffeine, and tobacco products. Negative health behaviors for PTSD symptom criteria were similar to those reported for high psychological distress in the current study and in previous assessments of this population. These negative health behaviors included inadequate sleep, minimal exercise, and elevated use of stimulants and alcohol. **DISCUSSION:** These findings highlight the importance of consistent sleep and exercise and moderate use of alcohol and various caffeine and nicotine-based products among individuals working in the USAF DCGS community. Interventions designed to promote better sleep, exercise, and other healthy lifestyle habits should be implemented to improve the health and well-being of DCGS operators.

Learning Objectives

1. The audience will hear the importance of healthy sleep routines, in addition to other healthy lifestyle habits in relation to negative stress outcomes.
2. The audience will hear the importance of healthy exercise routines, in addition to other healthy lifestyle habits in relation to negative stress outcomes.

[159] IMPORTANCE OF UNIT AND MEMBER SOCIAL SUPPORT FOR MENTAL HEALTH AND JOB SATISFACTION AMONG DISTRIBUTED COMMON GROUND SYSTEM OPERATORS

Rachael Martinez[1]
[1]*USAF School of Aerospace Medicine, Dayton, OH, USA*

(Original Research)

INTRODUCTION: The need to sustain operational situational awareness over long, back-to-back shifts, combined with exposure to extreme levels of combat, results in an extremely stressful work environment that may make distributed common ground system (DCGS) operators particularly susceptible to negative occupational outcomes. Social support from unit members and leaders can play a critical role in the success and general well-being of these individuals, particularly in relation to mitigating psychological distress and post-traumatic stress disorder (PTSD) and enhancing job satisfaction. **METHODS:** The present study included 1007 DCGS intelligence operators who responded to a comprehensive occupational health assessment. Psychological distress was measured by the Outcome Questionnaire, a 45-item measure assessing difficulties in interpersonal relationships, social roles, and overall quality of life. The PTSD Checklist for DSM-5 [Diagnostic and Statistical Manual of Mental Disorders, 5th Edition], a 20-item measure of PTSD symptoms, was used. Unit social support (member and leader) was measured by the Deployment Risk and Resilience Inventory-2 Social Support Scale, a 12-item subscale. Job satisfaction was measured with a single item on a 0-10 scale. The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. Relationships among the measures were examined and, where possible, comparisons to previous assessment findings were made. **RESULTS:** In comparison to a 2016 study of DCGS operators, rates of high psychological distress were moderately higher, and rates of PTSD symptom criteria endorsement and job satisfaction were similar. Higher levels of member and leader social support presented as protective factors against negative stress outcomes, both moderately associated with lower levels of psychological distress and fewer reported PTSD symptoms. In addition, higher levels of member and leader social support were significantly associated with greater job satisfaction. **DISCUSSION:** Findings underscore the importance of member and leader engagement in mitigating the negative psychological outcomes frequently associated with working in the Air Force DCGS community. Interventions designed to promote unit and member social support can be implemented to improve the emotional and social well-being of DCGS operators.

Learning Objectives

1. The audience will understand the importance of member engagement for psychological resilience for DCGS operators.
2. The audience will understand the importance of leader engagement for psychological resilience for DCGS operators.

[160] IMPORTANCE OF MORAL AND SPIRITUAL WELL-BEING AMONG DISTRIBUTED COMMON GROUND SYSTEM OPERATORS

Anne Shadle[1]
[1]*USAF School of Aerospace Medicine, Dayton, OH, USA*

(Original Research)

INTRODUCTION: High levels of stress have been shown to impact job satisfaction, mental wellness, and overall well-being. U.S. Air Force distributed common ground system (DCGS) operators work in high-stress environments and are exposed to potentially traumatic events that can contribute to anxiety and other mental health problems. This study seeks to determine the impact of high occupational and combat-related stress on moral beliefs, social and emotional functioning, and a sense of purpose in the DCGS community. **METHODS**: DCGS operators were asked to complete an anonymous comprehensive occupational health assessment that included the Outcome Questionnaire 45.2, the PTSD [post-traumatic stress disorder] Checklist for DSM-5 [Diagnostic and Statistical Manual of Mental Disorders, 5th Edition], and questions assessing moral injury. The Spiritual Well-Being Scale was also used in this survey, with particular focus on its subcomponents of existential and religious well-being. The present study was reviewed and granted exemption by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2011-0070-E. Responses to the scales were used to identify relationships between indicators of social and emotional functioning as they relate to aspects of spiritual well-being. **RESULTS:** Rates of high psychological distress were moderately higher than a similar study of DCGS operators from 2016. Rates of PTSD symptom criteria endorsement were similar to the 2016 study. Intelligence operators who endorsed high existential well-being were less likely to endorse high levels of psychological stress and PTSD symptom criteria. Those with high existential well-being were also less likely to report feeling that their moral beliefs had been violated by their experiences with remote combat or combat support. **DISCUSSION:** Existential well-being appears to contribute to psychological resilience for DCGS intelligence operators. This suggests that life satisfaction and sense of purpose are related to more positive stress coping capabilities and the ability to better manage reactions to combat experiences. Mental wellness is an important component of overall health and is essential for remote warriors to effectively carry out their mission. Future research should examine the impact of interventions and education that are focused on increasing existential well-being and how this impacts psychological resiliency.

Learning Objectives

1. The audience will understand the importance of spiritual well-being for psychological resilience for DCGS operators.
2. The audience will understand the relationship between existential well-being and psychological distress among DCGS operators.

Tuesday, 08/31/2021 ***4:00 PM***
Governor's Square 14

[S-33]: PANEL: HYPOXIA RESEARCH FROM THE PAST TO THE FUTURE; SERVING AEROSPACE MEDICAL NEEDS

Chair: Jonathan French
Co-Chair: Karen Gaines

Panel Overview: *This panel will examine the contributions of research to our understanding of hypoxia in the aerospace environment, current applications of the research and some discussion of new techniques and directions for future training. Recent physiological events in military aircraft such as the T-6 and F-22 have highlighted the continued need for hypoxia awareness training and for continued research into hypoxia symptoms. New devices and training ideas are discussed that will make this training less costly and more widely available, but research is needed to determine how they compare to traditional training. The first presentation describes the critical need for hypoxia countermeasures for air crew arising from America's entry into WWII. Within a few years, combining science and hypobaric training dramatically reduced fatalities and injuries in unpressurized aircraft. The second presentation illustrates how hypoxia research is currently used in NATO hypobaric protocols, which have grown more sophisticated as the airframes and mission demands have become more complex. The third presentation reviews two new techniques for hypoxia training and research used by military and civilian aviators as well as athletes: the normobaric recurrent hypoxia training and on-demand individual hypoxia training. The fourth presentation shows recent research demonstrating the need for a closer look at the individual in hypoxia awareness training to determine who is more at risk and what symptoms might one show. Finally, the last presentation argues that mild hypoxia may accelerate the onset and effects of spatial disorientation and that spatial disorientation awareness should be included in hypoxia training. This panel illustrates the continued use of hypoxia research for supporting training needs, now and in the future.*

[161] OXYGEN, ALTITUDE, AND THE AVIATOR: APPLIED RESEARCH AND TRAINING PRACTICES IN THE U.S. ARMY AIR FORCES (USAAF) IN WORLD WAR II (WWII)

Jay Dean[1]
[1]*University of South Florida, Tampa, FL, USA*

(Education - Tutorial / Review)

INTRODUCTION: WWII was the world's first high-altitude air war and pilot performance depended on good "oxygen discipline" by U.S aviators flying unpressurized warplanes. To this end, aviation physiologists developed America's first large scale hypobaric hypoxia awareness training program that ultimately reduced flyer fatalities during operations. The knowledge gained from applied research during WWII formed the foundation for aerospace medicine and current NATO practices. **TOPIC:** In 1940, America's aeromedical research and altitude training programs had only 3 research laboratories (Wright Field, Mayo Clinic, and Harvard School of Public Health). The U.S. National Research Council's Committee on Aviation Medicine (Oct 1940-Dec 1945) combined with increased government support for expansion of military aeromedical labs at Wright Field, Randolph Field, and Naval Air Station Pensacola, and funding of academic research labs, soon corrected this deficiency in America's air war preparedness. **APPLICATION:** By 1945, America's aeromedical training program was without equals; e.g., the USAAF employed over 200 aviation physiologists at 45 Army airfields who made ~700,000 simulated flights in 65 altitude chambers at the rate of more than 58,000 men per month! The altitude chamber was viewed as the best tool for instruction in the correct use of O_2 equipment. The military's goal was to reduce the incidence of accidents from failure of O_2 equipment through instruction accompanied with demonstrations in the use of the equipment and the physiological effects of "anoxia". As a result, the trend in anoxia accidents in unpressurized heavy bombardment crews in the U.S. Eighth Air Force (1943-Nov 1944) decreased by 80% and fatalities from anoxia decreased by 68%. Initial efforts to classify flying personnel based on their O_2 ceiling became less important by 1942 than classification as to their resistance to aeroembolism; e.g., aviators that qualified for high altitude flying missions "withstood decompression at altitudes as prescribed in flight schedules [35,000-40,000 feet] for four hours without severe symptoms [of decompression sickness, DCS]." In addition to O_2 discipline, aviators were taught prevention of DCS with O_2-prebreathing ("supercharging"), appropriate use of bailout O_2 equipment, and how to survive an explosive decompression in the pressurized B-29 Superfortress bomber (beginning April 1944).

Learning Objectives

1. The participant will be able to understand the origins of the high-altitude indoctrination programs in the U.S. military during WWII and the rationale for using the altitude chamber as a training tool.
2. The participant will be able to understand the goals of altitude training and criteria for pilot selection.
3. The participant will learn the positive outcomes of oxygen and altitude training as measured by improvement in warfighter performance during the air war of 1939-1945.

[162] HYPOXIA TRAINING AND PHYSIOLOGY RESEARCH IN THE NORWEGIAN ARMED FORCES: LESSONS LEARNED AND FUTURE PLANS.

Jon-Arild Kjeserud[1]
[1]*Norwegian Institute of Aviation Medicine, Oslo, Norway*

(Education - Tutorial / Review)

INTRODUCTION: Hypoxia awareness has long been required physiological training for military aviators. Standards and protocols have developed through theoretical and practical research within the NATO alliance since the outset of WWII and it has left lasting impressions on every aircrew member trained since. **TOPIC:** Norwegian chamber operations began in 1955 and have trained over 7000 aviators. The training has evolved with applied research and currently consists of three main profiles: 16000 ft (31% of total exposures), 25000 ft with 3 sec Rapid decompression (RD) (9% of total exposures) and 25000 ft with 12 second RD (60% of total exposures). The latter two involve 45 minutes of detnitrogenisation. Research has shown that the actual denite time is considerably longer. Strict regime in regard to oxygen discipline and time–management has shown to be profitable. Hypoxia for no longer than 4 min 30 sec each at 25000 ft, descent to 17000 ft for a 7 min hypoxia and night vision acuity test. Time above 18000 ft no longer than 11 minutes 30 seconds. Each student is equipped with pulse-oximeters and chamber oxygen sensors monitor ambient air to secure a 21% O_2 concentration. Data collected since 2005 will be summarized and discussed by an ongoing research project. The F-35 is our first platform with OBOGS life-support. In light of events and research done within the alliance, we also introduced annual Reduced Oxygen Beathing Device (ROBD) training in 2017. This protocol has hypoxia onset at 16000 ft then proceeds to 25000 ft. Our F-35 population have embraced the ROBD training. **APPLICATION:** The pedagogical environment surrounding chamber training produces a long lasting learned effect and history has shown it can be done safely. Accordingly, the chamber flight is the primary training platform and has introduced the ROBD as a platform for annual F-35 hypoxia training. For all active duty personnel, there is a chamber flight initially and every 5 years thereafter. For the F-35 pilots annual ROBD is mandated the 4 years in between chamber flights. These 4 years of annual training focuses more on recovery training in more sophisticated simulator scenarios. Future efforts might consider including civilian aviators and other categories of personnel that would profit from this type of training. More on the development of normobaric hypoxia training and ROBD training will be discussed in the next abstract.

Learning Objectives

1. The audience will learn how past lessons learned can secure a safe and effective hypoxia awareness training.
2. The audience will understand the use of new techniques and technology, like the ROBD, can help guide the future trajectory of hypoxia training.

[163] NEW CONSIDERATIONS FOR HYPOXIA RESEARCH AND TRAINING

Nicholas Lee[1], Bayleigh Graham[1], John French[1]
[1]*Embry-Riddle Aeronautical University, Daytona Beach, FL, USA*

(Education - Tutorial / Review)

INTRODUCTION: Since the days of the first lighter than air balloons aviators often died from what must have been frightening new forces in the ether. Building on the sacrifices of applied research in WWII, air crew are far less at risk and better trained to recognize hypoxia today. Scientific research is only now unraveling the far-reaching importance of hypoxia during cellular respiration. Otto Warburg won the Nobel prize in 1931 for elucidating the pathologies of hypoxia, particularly cancers. This work led Guyton to conclude that "all chronic pain, suffering and diseases are caused from a lack of oxygen at the cellular level". **TOPIC:** Two new devices for training and for hypoxia research have only recently become available, making hypoxia training possible for many more aviators; civilian and military. It is well known that hypoxia affects the central nervous system first and disproportionately to other organ systems. This is particularly insidious since the oxygen deprived individual will have difficulty recognizing and responding to their situation in time to save themselves. The costs and difficulties of maintaining a hypobaric chamber for hypoxia awareness training has been circumvented by the normobaric hypoxia chambers. This device only requires that oxygen levels in ambient air of the chamber be reduced to equivalent altitudes. A third device, individual hypoxia generators, have made it even easier to get supplemental training for a larger number of aviators than ever before. The use of hypoxia generators to stimulate the production of erythropoietin (EPO) and increase aerobic endurance has made them important to elite athletic training. The On Demand Hypoxia Trainer (ODHT) was upgraded more recently to fit the training needs of pilots in high performance aircraft. There is a need for an FAA approved protocol for these newer systems that will allow aviators to recognize the earliest symptoms of hypoxia. The next panelist will make training even more individual by discussing demographic criteria that might indicate those more sensitive and those more resistant to hypoxia. **APPLICATION:** A concern to be discussed is the absence of hypobaric conditions in the normobaric and ODHT devices on physiological hypoxia like that derived from high altitude. This discussion will focus on the uses of individual hypoxia devices for aircrew training.

Learning Objectives

1. The audience will learn important new findings in cellular hypoxia.
2. The audience will understand the advantages and disadvantages of individual hypoxia awareness training devices.

[164] NEW DISCOVERIES FOR HYPOXIA TRAINING: THE TRAINEE CONSIDERATIONS.

Richard Simonson[1], Joseph Keebler[1]
[1]*Embry-Riddle Aeronautical University, Daytona Beach, FL, USA*

(Education - Tutorial / Review)

INTRODUCTION: Our knowledge of the personal factors of pilots and the environmental conditions they are exposed to is the basis for our abilities to prepare for and predict symptoms they experience during a hypoxic event. This presentation describes a set of analyses to help further our understanding of the latent factors of hypoxia symptoms and their relationships with individual pilot demographics. **TOPIC:** Symptoms and demographic variables were collected from a set of approximately 100 participants who were active Navy aircrew during indoctrination and refresher hypoxia training using the Reduced Oxygen Breathing Device (ROBD). We collected an array of common symptom data affiliated with hypoxia and their associated severity (low, medium & high), as well as demographic data (exercise routines, sleep patterns, and caffeine, alcohol, and tobacco use). Two analysis methods were utilized. First, factor analysis was used to reduce the number of variables in the data set for more manageable analysis. Following, regression analyses were then conducted with the resulting factors to assess demographic predictors and correlates of symptoms. The factor analysis first utilized parallel analysis to develop a set of *a priori* cutoff values. The parallel analysis led us to retain 9 factors for symptoms – cyanosis, confusion, tingling, air hunger, difficulty speaking, lack of coordination, hot flashes, difficulty concentrating, and cold flashes. We also extracted 4 factors for the demographic variables including experience, mental health physical health, drugs. Following, we conducted regression analyses to understand the influence of the 4 demographic factors on the 9 symptom factors. This resulted in 4 significant models: confusion predicted by experience tingling predicted by experience and mean heart rate; air hunger predicted by experience, mean heart rate, and irregular low heart rate, and difficulty concentrating predicted by experience, mean breathing rate, and irregular low heart rate. **APPLICATION:** Our results present a baseline foundation for future research to investigate the correlations between pilot demographics as well as the observable and self-reported symptoms of hypoxia in a simulated training environment. However, more work is needed to better understand these phenomena. The last presentation in the panel will provide evidence that mild hypoxia may have serious effects on spatial disorientation at levels previously thought to be safe.

Learning Objectives

1. High level overview of factor analysis and regression techniques, and how they can be applied in this setting.
2. How hypoxia can be studied in an aviation training environment.
3. How individualized hypoxia training algorithms can be an effective new tool for a diverse population.

[165] NEW CONSIDERATIONS FOR HYPOXIA RESEARCH AND TRAINING

John French[1]
[1]*Embry-Riddle Aeronautical University, Daytona Beach, FL, USA*

(Education - Tutorial / Review)

INTRODUCTION: Over the last 10 years, there has been a dramatic increase in hypoxia related physiological events in the military, resulting in fatalities and the grounding of particular high performance aircraft. These events have highlighted an unprecedented re-examination of aviation related hypoxia effects and countermeasures to supplement the mechanical fixes. **TOPIC:** Evidence was found in the literature that implicates spatial disorientation as a co-factor in hypoxia related performance effects. While the effects of acceleration on vestibular function have been well studied, sparse attention has been given to the effects of hypoxia on the vestibular sense. Vestibular related spatial disorientation (SD) has long plagued general aviation as one of the leading causes of fatalities. Reports suggest mild hypoxia, between 8,000 feet and 10,000 feet, may have effects on postural stability and thus may be the first physiological symptom of hypoxia. Acute Mountain Sickness (AMS) includes symptoms that are consistent with vestibular dysfunction such as dizziness, clumsiness, and inability to walk a straight line above 6000 feet. Color vision loss is not a known AMS symptom. These effects would be missed in hypoxia chambers and aircraft since traditionally, everyone is sitting. This has implications for training and countermeasures somewhat different from those that only consider hypoxia during the physiological events. In a preliminary investigation, we tested six flight instructors on their postural stability at sea level and at 12,000 feet equivalent altitudes using a portable hypoxia generating mask in a double blinded manner. We used a Barany chair and a virtual reality based optokinetic experience to induce vestibular effects and then measured postural stability on a pressure pad. More of the pilots (62%) showed postural impairment in response to vestibular stimulation. Since we did not see color vision effects at this equivalent altitude and we expected to, we believe we need a longer period of hypoxia and a larger sample. **APPLICATION:** Implications for military and GA aviation, countermeasures current and proposed and recommendations for future research will be discussed. In addition, there are important considerations for loss of balance in elderly who may have poor circulation but good vision.

Learning Objectives

1. The audience will learn the effects that moderate hypoxia has on postural sway and possibly why.
2. The audience will consider the possibility that AMS and elderly falls might be related to proprioception impairment rather than vision impairment.

Tuesday, 08/31/2021 ***4:00 PM***
Governor's Square 15

[S-34]: SLIDE: CHARACTERIZING ACCIDENT RATES AND SEVERITY

Chair: Geoffrey McCarthy
Co-Chair: Sara Khan

[166] A STUDY OF FIXED-WING AIR-TAXI ACCIDENT RATES, INJURY SEVERITY AND CONTRIBUTING HUMAN FACTORS (2004-2018)

Douglas Boyd[1], Don Budde[1], Jochen Hinkelbein[2]
[1]Embry Riddle Aeronautical University, Daytona Beach, FL, USA; [2]University Hospital of Cologne, Cologne, Germany

(Original Research)

INTRODUCTION: Air-taxis conduct non-scheduled passenger/freight transport and employ aircraft with various powerplant types (piston, turbo-props, turbojet/turbofan). Although prior research has investigated air-taxi safety, such studies included an amalgam of fixed-wing/rotary aircraft and commuter operations. Herein, focusing on air-taxi airplanes (i.e. fixed-wing) we (i) compared accident rates/occupant injury across the aforementioned powerplants (ii) identified contributing human factors for fatal piston-powered airplane accidents. **METHODS:** Accidents (2004-2018) in the USA/territories were identified from the National Transportation Safety Board database. The General Aviation/Part 135 Activity Surveys provided annual fleet times. Fatal accident contributing factors were per Human Factors Classification System analysis. Statistics utilized Poisson distributions, Chi-Square and Mann-Whitney tests. **RESULTS:** 269 air-taxi mishaps (53 fatal) were identified. Over the 15 years, the accident rate (1.10/million flight hours-all powerplants) declined 50% (p<0.001) largely due to a reduction in turbojet/turbofan airplane crashes (p=0.001). However, little temporal change was evident for reciprocating engine airplanes (1.5/million flight hours) and injury severity trended higher. Safer operations for the former were associated with greater pilot flight experience. HFACS analysis identified low cloud ceilings/night/dusk (63%) and deficient pilot skills (78%) as frequent contributory factors in fatal piston-engine air-taxi accidents. In contrast, operator deficiencies were less often implicated (6-16%). **DISCUSSION:** Although safety for air-taxis operating turboprop/turbojet/turbofan airplanes has improved, deficits remain for the piston-powered fleet. Since accidents for the latter often occur in impoverished lighting/IMC with single pilots, increased instrument flight training and utilization of the mandatory 3-axis autopilot under such conditions is advocated for air-taxi operations.

Learning Objectives

1. The audience will learn about how some, but not all, sectors of the air taxi industry have improved on safety over the 2004-2018 period.
2. Injury severity trends for the different powerplant categories of air taxi airplanes used will be shown.
3. Attendees will learn of the human factors contributing to fatal accidents for piston powered air taxi airplanes.

[167] INCREASING DISTANCE TO TRAUMA CENTERS IS ASSOCIATED WITH GREATER MORTALITY IN AIRCRAFT ACCIDENTS

Francesca Izzo[1], Edward Kelly[1], Kristina Kramer[1], Danielle Carroll[2], Tyler Putnam[1], Tovy Kamine[1]
[1]Baystate Medical Center, Springfield, MA, USA; [4]UCSF, San Francisco, CA, USA

(Original Research)

INTRODUCTION: Multiple studies have demonstrated that geographic distance to a trauma center increases mortality rate in motor vehicle collisions. Similar results have been demonstrated in pedestrian versus motor vehicle trauma as well. To date, no analogous study has been performed involving aircraft accidents, which are often higher speed and higher energy mechanisms than motor vehicle collisions. Though most aircraft accidents occur in and around airports, some do occur far from roads or habitation. We sought to determine if the distance from trauma centers affects mortality in aircraft accidents. **METHODS**: The National Transportation Safety Board database was queried for all aircraft accidents with substantial damage in the United States between 01/01/2018 and 06/30/2018. For accidents in which injuries were sustained, the distance to the nearest level 3 or higher trauma center (level 3+ TC) was determined. Distance to nearest level 1 and level 2 trauma centers were determined, as well. Distances were compared between fatal and non-fatal accidents with *t*-Test for level 3+ TC, level 2+ TC, and level 1 TC. **RESULTS**: 550 accident reports were inspected, with 382 corresponding injuries and fatalities (250 minor, 82 serious, 50 fatalities). The average (95% CI) distance to nearest level 3+ TC for fatalities was 31.8 (24.8-38.8) miles and for nonfatal injuries 18.8 (16.8-20.8) miles, p = <0.001. The average (95% CI) distance to nearest level 2+ TC for fatalities was 36.5 (27.9-45.0) miles and for nonfatal injuries 24.1 (21.3-26.8) miles, p = 0.002. The average (95% CI) distance to nearest level 1 TC for fatalities was 52.3 (40.8-63.8) and for nonfatal injuries 31.9 (28.0-35.8), p=<0.001. **DISCUSSION**: Similar to motor vehicle collisions, aircraft accident fatalities are associated with a farther distance from a trauma center than non-fatal injuries. Some of these results may be partly explained by an increase in fatality in off-airport compared to on-airport accidents.

Learning Objectives

1. The audience will learn about the relationship between mortality and trauma center distance in aircraft accidents.
2. The audience will learn about the relationship between morality and different levels of trauma centers in aircraft accidents.

[168] IMPACT OF DAYLIGHT SAVINGS TIME ON AIRCRAFT ACCIDENT RATE IN THE UNITED STATES

Tovy Kamine[1], Arthur Formanek[2]
[1]Baystate Medical Center, Springfield, MA, USA; [2]Brigham and Women's Hospital, Boston, MA, USA

(Original Research)

INTRODUCTION: Each year, clocks in the United States (US) move forward one hour in the spring for daylight savings time (DST), thus decreasing sleep by one hour on the day of the switch. There is conflicting data in the literature as to whether this decrease in sleep affects the motor vehicle collision rate. There has been no study thus far on the effects of the change on the aircraft accident rate. **METHODS**: The National Transportation Safety Board (NTSB) Database was queried for all aircraft accidents and incidents in the US between January 1, 2000-October 30, 2019. Rates of Fatal Accidents (FA), Nonfatal Accidents (NA), and Incidents (I) were compared between 2000-2009 and 2010-2019. The daily rate of FA, NA, and I were compared between the 2 days after the DST change and March and April overall. Total yearly and monthly flight data, and in the days after the DST change were queried from the Federal Aviation Administration (FAA) Air Traffic Activity System (ATADS). All comparisons were done with unpaired T-Test. **RESULTS**: The average rate, per million flights, of fatal accidents (7.4 ± 0.7 to 5.9 ± 0.08, p<0.001), nonfatal accidents (32.0 ± 2.2 to 26.9 ± 2.9, p<0.001), and incidents (1.2 ± 0.3 to 0.8 ±0.6, p=0.04) all declined significantly from 2000-2009 to 2010-2019. There was a significant decrease in the average yearly number of flights from 2000-2009 to 2010-2019 (45.0x10^6 ± 2.2x10^6 to 41.2x10^6 ± 3.3x10^6, p=0.007). There was no significant difference between the daily rate of fatal or nonfatal accidents, or incidents per million flights between the 2 days after the DST change and the remainder of March and April (4.9±4.6 vs 5.5±1.1, p=0.583; 25.0±12.0 vs 27.1±4.5, p=0.476; 0.6±1.5 vs. 1.6±0.7, p=0.134, respectively). There was no significant difference in the daily average number of flights between the 2 days after the DST change and the rest of March and April (122,190±6714 vs. 123,444±8343, p=0.604). **DISCUSSION**: Despite a decrease in total number of flights, the overall rate of aircraft accidents, both fatal and nonfatal, and incidents has declined significantly over the last two decades. The loss of one hour of sleep from the DST change does not appear to affect the accident rate in the following days. Since the number of flights on the days after the DST change is not significantly different that the rest of the month, pilots may be self-compensating for less sleep by using other methods to decrease risk.

Learning Objectives
1. The switch to Daylight Savings Time does not affect the aircraft accident rate.
2. The aircraft accident rate has declined in the last 20 years.

[169] STANDARDIzATION OF AVIATION ACCIDENT INJURY DATA

Alasdair Mackay[1]
[1]*Royal Air Force Centre of Aviation Medicine, Henlow, United Kingdom*

(Education - Program / Process Review)

BACKGROUND: Injury data is collected during aviation accident investigations. There is little standardization in the collection of this data internationally. This presentation will suggest ways of recording injury data to allow comparison of injuries across different platforms and an objective assessment of mitigation strategies. **OVERVIEW:** A head to toe assessment of injuries sustained by aircrew is recorded during the investigation process. Much of this data is subjective in nature and can lead to interobserver error. Descriptions of injuries sustained are stored in hard or electronic format. It is difficult for the observer to easily compare the severity of injuries sustained and the efficacy of injury mitigation strategies. To reduce future risk of death and disability, injury data must be accurate, objective and allow quantitative assessment**.** A systematic process allows easier identification of injury patterns within the data set. The abbreviated injury score (AIS) is currently used inconsistently in the aerospace medicine community. It allows a simple reproducible method for recording injuries, but its efficacy is limited. AIS is an internationally recognized injury scoring system used by the automotive industry and is the basis for several large international trauma databases. AIS is an anatomical scoring system with injuries categorized on a six-point ordinal scale. Each score represents a threat to life for that specific injury. AIS is objective and allows a standardized method for recording injuries but does not allow a comparison of the total overall injury severity for each individual. An injury severity score (ISS), uses the highest score in each body area to come up with an overall severity score which gives the observer an understanding of the total level of injury sustained. This allows an objective comparison of total injuries and can establish whether one aircraft configuration is more injurious than another. **DISCUSSION:** Standardized recording of injuries would improve access to and analysis of anonymized accident data. AIS is one method of achieving this but the additional use of an ISS would improve comparisons across different aircraft and equipment types and ultimately reduce the risk of morbidity and mortality in future aircraft accidents.

Learning Objectives
1. The audience will understand the importance of a standardized injury scoring system in aviation accident analysis.
2. The audience will understand that using a systematic scoring process will improve the comparison of injuries across different accidents.

[170] CHARACTERIZATION OF FATAL INJURIES IN OIL AND GAS INDUSTRY-RELATED HELICOPTER ACCIDENTS IN THE GULF OF MEXICO, 2004–2014

Mary O'Connor[1], Kristin Yeoman[2], Gerald Poplin[2], Sara Heltzel[3]
[1]*CDC/National Institute for Occupational Safety and Health, Anchorage, AK, USA;* [2]*CDC/National Institute for Occupational Safety and Health, Spokane, WA, USA;* [3]*University of Virginia, Charlottesville, VA, USA*

(Original Research)

INTRODUCTION: Helicopter crashes contribute to high fatality rates in the oil and gas industry. Previous research has focused on the underlying causes of crashes or aircraft structure and design rather than on the injuries sustained in crashes. Helicopter operators in the Gulf of Mexico have established high safety standards and promote robust aviation safety programs and yet fatalities continue to occur in helicopter crashes. **METHODS:** Accident reports from the National Transportation Safety Board's Aviation Accident database were reviewed manually for helicopter accidents occurring in the Gulf of Mexico in support of the oil and gas industry and resulting in at least one fatality from crash-related injuries. Autopsy reports were requested, reviewed, and coded using the Abbreviated Injury Scale. A descriptive analysis of injury distributions was performed. **RESULTS:** Fourteen fatal helicopter accidents resulting in 42 fatalities met the study criteria. Autopsies were conducted on 35 decedents with 568 injuries documented, with a median of 12 injuries per decedent and a range of 1–44 injuries. The proportion of minor, moderate, and severe or worse injuries differed by body region. Minor injuries were most prevalent in the face, neck, upper and lower extremities, and abdomen. Serious or worse injuries were most prevalent in the thorax, spine, head, and external/other regions. The most frequent injuries were thoracic organ, thoracic skeletal, abdominal organ, and leg injuries. Not all decedents had injuries classified as critical or maximal severity, however death likely occurred as a result of concomitant injuries or drowning. Drowning occurred in 37.1% of victims with and drowning victims experiencing had a higher proportion of moderate brain injuries compared with non-drowning victims. **DISCUSSION:** Further research is needed to better understand the highest priority injuries on which to focus engineering and safety designs. Findings suggest further evaluation of airbag restraint systems to decrease torso and extremity injuries, helmets to decrease head injuries, and egress training and supplemental breathing devices to prevent drownings are warranted.

Learning Objectives
1. The audience will obtain an understanding of the severity and body region frequencies for injuries incurred by pilots and passengers during fatal oil and gas-related helicopter accidents in the Gulf of Mexico.
2. The participant will learn the similarities and differences in severity and body regions between injuries among drowning and non-drowning victims and potential prevention strategies.

Tuesday, 08/31/2021 ***4:00 PM***
Plaza A/B

[S-35]: PANEL: CURRENT STATE OF KNOWLEDGE: SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS)

Chair: Tyson Brunstetter
Co-Chair: Mary Van Baalen

Panel Overview: *First discovered in 2005, Spaceflight Associated Neuro-ocular Syndrome (SANS; formerly known as "Vision Impairment, Intracranial Pressure" or VIIP) is a condition unique to long-duration spaceflight. SANS is associated with a multitude of signs such as optic disc edema and retinal nerve fiber layer (RNFL) thickening; chorioretinal folds; globe flattening; and hyperopic shifts in refractive error. Other potential signs include RNFL infarcts (i.e., cotton wool spots), optic nerve tortuosity, optic nerve sheath distention, cephalad brain shift, and lateral ventricle enlargement; however, it is unclear whether or not these signs are truly associated with SANS. While the pathogenesis and pathophysiology of SANS remain elusive, several theories exist. This panel will provide the current state of knowledge in detecting, defining, and diagnosing SANS; present the latest analyses of short- and long-duration crewmember data; and explore factors that may contribute to the generation and mitigation of SANS.*

[171] A NEW CASE DEFINTION FRAMEWORK FOR SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS)

Tyson Brunstetter[1], Sara Mason[2], Charles Gibson[3], Mary Van Baalen[1], Steven Laurie[5], Brandon Macias[1], William Tarver[1]
[1]*NASA Johnson Space Center, Houston, TX, USA;* [2]*MEI Technologies, Houston, TX, USA;* [3]*Coastal Eye Associates, Houston, TX, USA;* [4]*KBR, Houston, TX, USA*

(Original Research)

INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) has been described based on numerous ocular findings. However, the latest official case definition was limited to the presence of optic disc edema (ODE) as visualized by fundoscopy. While the standard for terrestrial ODE cases, this protocol lacks sensitivity; it relies on subjective interpretations and disregards other SANS signs. An updated SANS case definition framework is required to overcome these limitations. **METHODS:** Pre-, in-, and post-flight astronaut ocular data (n=78) were obtained from clinical records and reviewed for SANS signs and symptoms. In addition, SANS subject matter experts (SMEs)

provided input on how best to transition towards a more comprehensive, objective-based SANS case definition. **RESULTS:** Four primary signs of SANS (i.e., ODE, chorioretinal folds, globe flattening, and hyperopic shifts in refractive error [RE]) pose risks to vision and mission effectiveness. With regard to ODE, reversible visual field (VF) defects have been detected in at least two crewmembers following long-duration spaceflight (LDSF). Chronic ODE could induce permanent retinal nerve fiber layer thinning and VF defects similar to Earth-based pathologies. Severe, centrally located chorioretinal folds could distort vision and reduce best-corrected visual acuity (VA), while chronic folds could damage retinal pigment epithelial and photoreceptor cells. Finally, globe flattening can contribute to hyperopic RE shifts which can reduce uncorrected VA. While cotton wool spots, optic nerve (ON) tortuosity, and ON sheath distention were thought related to SANS, they have not consistently emerged in crewmembers demonstrating the primary four signs; they are not included in the case definition. **DISCUSSION:** Clinical and Research SMEs are pursuing new SANS case definitions tied to the four primary SANS signs associated with vision/mission risk. In 2020, an objective quantification of the "earliest sign of ODE" was established from optical coherence tomography (OCT). A crewmember is now diagnosed a SANS case whenever ≥1 of the following signs is detected in ≥1 eye during/following LDSF: ODE (i.e., ≥20 micron increase in peripapillary total retinal thickness), chorioretinal folds, globe flattening, and RE shift ≥+0.75 diopters. By this definition, the earliest signs of SANS are detected in 69% of LDSF crewmembers. The "pathological threshold of SANS" definition has not been established, but is being pursued.

Learning Objectives

1. Understand the limitations of the current case definition of Spaceflight Associated Neuro-ocular Syndrome (SANS).
2. Describe the rationale for selecting optic disc edema, chorioretinal folds, globe flattening, and hyperopic refractive error shifts as components of the updated SANS case definition framework.

[172] QUANTIFICATION OF SPACEFLIGHT-INDUCED OCULAR CHANGES

Karina Marshall-Goebel[1], Tyson Brunstetter[2], Charles Gibson[3], Larry Kramer[4], Steven Laurie[1], Stuart Lee[1], Bryn Martin[5], Nimesh Patel[6], Stuart Sater[7], Robert Ploutz-Snyder[8], Brandon Macias[2]
[1]KBR, NASA JSC, Houston, TX, USA; [2]NASA Johnson Space Center, Houston, , USA; [3]Coastal Eye Associates, Webster, TX, USA; [4]University of Texas Health Science Center at Houston, Houston, , USA; [5]Alcyone Therapeutics Inc., Moscow, ID, USA; [6]University of Houston College of Optometry, Houston, TX, USA; [7]University of Idaho, Moscow, ID, USA; [8]University of Michigan, Ann Arbor, MI, USA

(Original Research)

INTRODUCTION: The spaceflight associated neuro-ocular syndrome (SANS) is characterized by multiple ocular structural changes during long-duration spaceflight including optic disc edema, hyperopic shifts, and choroidal folds. The purpose of this study was to quantify morphologic changes of the eye and optic nerve that are hypothesized to be associated with the development of SANS during long-duration International Space Station (ISS) missions. **METHODS:** The Ocular Health study included 11 long-duration (170 ± 19 days) ISS crewmembers with measurements taken before, during (on flight days 10, 30, 90, and 150), and after spaceflight (10, 30, 90, 180, and 365 days after landing). Measurements included global total retinal thickness (from Bruch's membrane opening to 250 µm) and peripapillary choroid thickness from optical coherence tomography (OCT) images, optic disc edema calls from fundoscopy, and ocular globe flattening from 3D reconstructed magnetic resonance imaging (MRI). A linear mixed-effects regression model was used to test for significant differences from preflight. **RESULTS:** OCT-derived total retinal thickness increased from preflight by flight day 10 (mean: +11.9 µm, 95% CI: 6.6-17.3 µm, $P < 0.001$) with a maximum increase by flight day 150 (mean: +27.6 µm, 95% CI: 22.7–32.6 µm, $P < 0.001$). Similarly, peripapillary choroidal thickness also increased by flight day 10 (mean: +24 µm, 95% CI: 15-33 µm, $P < 0.001$), with a maximum increase by flight day 150 (mean: +43 µm, 95% CI 35-46 µm, $P < 0.001$). However, only 2 of 11 subjects demonstrated Frisèn grade 1 optic disc edema in flight. In addition, flattening of the posterior ocular globe was found immediately postflight (mean: -9.9 mm^3, 95% CI: -4.6 to -15.2 mm^3, $P < 0.0001$). **DISCUSSION:** The results from this study demonstrate that ocular structural changes are not limited to the ~15% of astronauts diagnosed with optic disc edema identified by fundoscopy, but rather develop in the majority of crewmembers. Quantitative OCT-based metrics of choroid and optic nerve head morphology during long-duration spaceflight may provide an early monitoring tool of optic disc edema and further characterize the complexity of SANS.

Learning Objectives

1. The audience will learn about recent quantitative ocular structural changes associated with Spaceflight Associated Neuro-ocular Syndrome (SANS).
2. The audience will learn about the relationship between quantitative cerebral and ocular structural changes associated with SANS.

[173] PREVENTION AND MITIGATION STRATEGIES FOR CENTRAL NERVOUS SYSTEM EDEMA: POTENTIAL COUNTERMEASURES FOR SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME

John Marshall[1], Tyson Brunstetter[3], Charles Gibson[4], William Tarver[3]
[1]University of Texas Medical Branch, Galveston, TX, USA; [3]NASA Johnson Space Center, Houston, TX, USA; [4]Coastal Eye Associates, Webster, TX, USA

(Original Research)

INTRODUCTION: Long-duration spaceflight is associated with optic nerve head (ONH) edema, globe flattening, hyperopic shifts in refractive error, choroidal and retinal folds, and nerve fiber layer infarction, i.e., cotton wool spots, as demonstrated by multiple imaging modalities. These findings reflect Spaceflight Associated Neuro-ocular Syndrome (SANS). The etiology behind SANS remains elusive, but novel research in terrestrial intracellular cerebral and ONH edema is advancing treatments that may be applicable to SANS. **METHODS**: A literature review was conducted on the pathogenesis and current and novel treatment strategies of terrestrial intracellular cerebral and/or ONH edema via PubMed and MEDLINE databases. Only literature related to cerebral and/or ONH edema in the context of idiopathic intracranial hypertension, cerebral venous sinus occlusion, acute mountain sickness, high altitude cerebral edema, acute liver failure, and traumatic and ischemic brain injury was included in this review. **RESULTS**: Gross pathophysiologic mechanisms proposed for terrestrial cerebral or ONH edema include increased central venous sinus pressures, cerebrospinal fluid overproduction or outflow obstruction, and altered oxygen/carbon dioxide tensions. Current day therapies for cerebral or ONH edema related to cerebral venous sinus occlusion, high altitude cerebral edema, or traumatic brain injury include acetazolamide, corticosteroids, hyperosmolar therapy, or surgical interventions. However, novel research in acute liver failure and ischemic/traumatic brain injury proposes differential expression and activity of channels such as NKCC1 and SUR1-TRPM4-AQP4 as possible etiologies. Consequently, there is interest in targeting the SUR1-TRPM4 channel via intravenous glibenclamide in ischemic and traumatic brain injury to reduce intracellular edema, which may reduce ONH edema as well. **DISCUSSION**: Many terrestrial instances of cerebral and/or ONH edema cluster around common channel mediators of intracellular edema, among which SUR1-TRPM4 is targeted in stroke- and TBI-induced cerebral edema by glibenclamide. Similarly, targeting SUR1-TRPM4 may be a promising countermeasure in reducing ONH edema, and further investigations into this treatment as a possible SANS countermeasure are recommended.

Learning Objectives

1. Understand current-day strategies to mitigate cerebral and optic nerve head (ONH) edema related to cerebral venous sinus occlusion, high altitude cerebral edema, ischemic or traumatic brain injury, and acute liver failure.
2. Understand the physiologic basis of targeting SUR1-TRPM4 channels to mitigate terrestrial cerebral edema and, potentially, ONH in SANS.

[174] TERRESTRIAL PATHOLOGIES EXHIBITING OPTIC DISC EDEMA: COMPARISONS WITH SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS)

Michael Harrison[1], Tyson Brunstetter[2]
[1]Mayo Clinic, Jacksonville, FL, USA; [2]NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: First diagnosed in 2011, Spaceflight Associated Neuro-ocular Syndrome (SANS) is a constellation of signs and symptoms observed in astronauts following long duration spaceflight. SANS is diagnosed based upon the observation of one of optic disc edema, chorioretinal folds, globe flattening, new hyperopic refractive errors, and focal areas of retinal ischemia. The exact etiology of the condition is not well understood, and hypothesized causes include a combination of factors including cephalad fluid shifts, increased intracranial pressure, alterations in cerebral venous circulation and drainage, and one-carbon metabolism. The identification of terrestrial pathologies with features similar to those observed in SANS would enhance our ability to study and mitigate this condition. **METHODS:** A narrative literature review was performed to identify terrestrial pathologies with physical exam findings and clinical presentations similar to what is observed in SANS. Selection criteria included common chronic conditions with insidious onset, conditions exacerbated by changes in environmental conditions (i.e., hypercarbia), and those without severe systemic disease. **RESULTS:** After a comprehensive assessment of the literature associated with pulmonary and respiratory diseases, hematological and circulatory disorders, nutritional and electrolyte disorders, and environmental stressors and exposures, mild obstructive sleep apnea (OSA) was identified as a suitable terrestrial analogue for future SANS study. **DISCUSSION:** OSA represents a common disease process that is associated with ocular findings, similar to what is observed in SANS. These findings correlate with the degree of hypoventilation and the associated hypercarbia. Additionally, these findings often improve or resolve with appropriate therapy. Compared to the terrestrial environment, the ISS environment is chronically hypercarbic. Based upon the current event horizon for manned spaceflight, this review makes further recommendations intended to optimize future retrospective and prospective SANS research on Earth and in microgravity.

Learning Objectives

1. The audience will learn about a potential terrestrial analogue for the study of SANS.
2. The audience will learn about the role of carbon dioxide and ventilation on the ocular changes observed in patients with obstructive sleep apnea.

[175] IDENTIFYING REFERENCE POPULATIONS FOR THE ASTRONAUT CORPS: NEURO-OPHTHALMOLOGY DATA

Mary Van Baalen[1], Sara Mason[2], Tyson Brunstetter[1], Suzy Osborne[3], Wafa Taiym[3], Jacqueline Charvat[3], William Tarver[1]
[1]NASA Johnson Space Center, Houston, TX, USA; [2]MEI Technologies, Inc, Houston, TX, USA; [3]KBR, Houston, TX, USA

(Original Research)

INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) signs, symptoms, and/or potential outcomes have previously been thought to be most similar to those of terrestrial idiopathic intracranial hypertension (IIH), optic neuritis, and glaucoma. However, these disease analogs differ from SANS in presentation, and the populations exhibiting these outcomes can differ from the astronauts in health status. Moreover, the anatomical and physiological changes documented in SANS are generally compared to normal ranges described in the literature that are generated from populations with other health concerns. A robust understanding of the "normal range" for many of the SANS findings is warranted. The rigorous selection, frequent screening, and specialized medical care of the astronaut corps challenge the understanding of what are normal outcomes. The purpose of this project was to identify and evaluate other longitudinal cohorts that include vision outcomes that are also highly selective and healthy. **METHODS:** Cohorts identified through a systematic review were evaluated as potential comparisons to the US astronauts. These cohorts included US military, Beaver Dam Eye Study, and European public health studies. Demographic and health outcome data in astronauts were compared with each of the cohorts. Further, study design characteristics included years of data collection, geographic location, and cohort inclusion/exclusion in order to identify appropriate longitudinal comparison cohorts. **RESULTS:** The resulting comparisons found that military cohorts tend to be younger while ocular studies tend to evaluate older individuals. Additionally, the level of specialized testing performed on astronauts, particularly for OCT and MRI, far exceed that in general population studies. The US Health and Retirement Study and two European public health studies, the Gutenberg Health Study and the Rotterdam Study hold promise for future studies. **DISCUSSION:** NASA is challenged to determine what SANS-related anatomical and physiological changes reach the level of "clinical significance" and require treatment. Results from these proposed comparison studies of terrestrial cohorts will enhance the understanding of the spectrum of findings that describe SANS, and may be critical to determining the pathological thresholds of SANS.

Learning Objectives

1. Understand the limitations in the interpretations of SANS findings in relationship to the findings in a healthy population and explore cohort studies that might offer improved interpretations.
2. Understand the systematic literature review process undertaken to identify cohort studies that may prove useful in the interpretations of SANS findings.

Tuesday, 08/31/2021 ***4:00 PM***
Plaza D/E

[S-36]: PANEL: RESIDENT GRAND ROUNDS

Chair: David Miller

Panel Overview: INTRODUCTION: *Resident Grand Rounds (5 Case Presentations and a Case Series)* ***BACKGROUND:*** *Each case presentation is presented by current USAFSAM RAMs who will review the clinical case presentation, diagnosis, treatment pathway and current policies from different agencies. They will discuss the clinical and waiver outcome (if appropriate). The final case series reviews an outbreak of COVID-19 in a geographically confined location and discusses tracking, policy implications and descriptive epidemiology. Case Presentations: 1. "A Risk Worth Taking" - Dr. Caleb James 2. "Is This Guy Really Safe to Fly?" - Dr. Mark Dudley 3. "Neurologic Decompression Sickness in an Aero Physiologist" - Drs. Maxwell Dickey and Jeffrey Kinard 4. "Physiologic Incident or Psychiatric Disorder" - Dr. Tyler Negrey 5. "High Performance Pilot with Paroxysmal Atrial Fibrillation Treated with Cardiac Ablation" - Dr. Jason Burchett 6. "COVID-19 Outbreak Among Military Members in a Geographically Isolated Location: A Public Health Perspective" - Drs. Jason Burchett and Tyler Negrey.*
DISCUSSION: *These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and mental health conditions encountered in the practice of our specialty.*

[176] A RISK WORTH TAKING?

Caleb James[1]
[1]USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: This case report describes a 45-year-old male U.S. Air Force Sensor Operator (SO) who suffered from myocardial infarction (MI). **BACKGROUND:** The military flying community has historically been viewed as healthier than the general population requiring fairly uncomplicated medical management. This is likely due to self-selection as well as social and organizational pressure to maintain fitness. It is rare to have an aviator with multiple comorbidities, but it is more common in some subsets of the community. **CASE PRESENTATION:** The SO in this case suffered from dyslipidemia, pre-diabetes, hypertension, obstructive sleep apnea, and previous MI. He was admitted to a local facility for scrotal abscess and presented to Flight Medicine five days after discharge. He endorsed nine bowel movements over 24 hours, tested positive for clostridium difficile, and was treated with vancomycin. He presented the day after antibiotic completion and requested acetazolamide for horseback riding and hiking at 11,000 feet. The physician explained that horseback riding would worsen the scrotal wound and his heart history was concerning. However, the physician agreed if the patient's squadron

commander signed off as a high risk activity. The commander signed off, so the physician complied. The patient was in a minor vehicle accident the morning of the trip, which triggered substernal chest pain. He was diagnosed with MI and underwent percutaneous intervention, which resulted in 100% patency in all stented vessels per civilian report. Despite this incident, he met all requirements for waiver. Ultimately, the patient refused follow-up cardiac catheterization with the Aeromedical Consult Service and retired. **DISCUSSION:** This case highlights common health issues in western populations that are rare in active military aviation. The increased tolerance in standards and waiver requirements for the remotely piloted aircraft community could increase the number of individuals with similar comorbidities. This patient's squadron had five other individuals medically retired (2 Intelligence, 1 SO, 2 Pilots) during that same year. We must prepare for these issues to become more commonplace in military aviation. Furthermore, this case raises the question whether aviators/operators should be allowed to engage in certain high risk activities without medical clearance.

Learning Objectives

1. Understand the growing list of comorbidities in the aviation community.
2. Identify risk mitigation strategies to maintain aviator health and extend service capability.

[177] IS THIS GUY REALLY SAFE TO FLY?

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

(Original Research)

INTRODUCTION: Pilot candidate with Glucocorticoid-induced mood disorder, with suicidal ideation, psychotic, depressive and anxious features granted exception to policy (ETP) against medical advice (AMA). **BACKGROUND:** Glucocorticoids are widely used in the treatment of common ailments and diseases. Glucocorticoids are known for their benefit but they are associated with a litany of toxicity and adverse effects. Glucocorticoids can induce neuropsychiatric effects causing a broad range of psychiatric and/or cognitive impairments. The adverse consequences are dependent on dose and duration of therapy, and symptoms are usually mild and reversible. **CASE PRESENTATION:** Candidate reports to clinic on 3 separate occasions in April 2019 due to lower respiratory symptoms. After lingering symptoms he was prescribed azithromycin and prednisone 60 mg for 5 days. After start of medications, he noted increased anxiety and insomnia which he attributed to the medications and stress. Due to adverse symptoms, prednisone dosing was changed to 20mg TID. Despite change to dosing, symptoms continued to spiral to thoughts of failing class and not getting into Undergraduate Pilot Training (UPT). His rumination stemmed into thoughts of suicide without intent. His symptoms of little to no sleep for several days, lack of focus, difficulty in controlling thoughts, and illogical speech at times were observed by others leading to a mental health evaluation and an inpatient psychiatric admission for 3 days. He was discharged on quetiapine 50 mg which was titrated up to 150 mg during outpatient follow-up, and shortly discontinued after being cleared by mental health. Due to his diagnoses a waiver was needed for RTFS. Case was originally reviewed by the Aeromedical Consult Service (ACS) May 2019 with disqualification from all flight duties. An ETP was granted from the acting SECAF July 2019 with RTFS after a one-year delay with stability. His case has since been re-evaluated by ACS prior to UPT start. **DISCUSSION:** The primary aeromedical risks from Glucocorticoid-induced neuropsychiatric effects are a variety of cognitive, emotional and behavioral symptoms which could lead to incompatibility with aviation safety and flying duties. As these medications are widely used, it is important to discern risks and benefits. Finally, when exceptions are made AMA it is crucial such cases are tracked routinely to ensure both the health of the member and the safety of flight are well preserved.

Learning Objectives

1. Understand all of the aeromedical risks when treating with Glucocorticoids.
2. Identify the characteristics Glucocorticoids-induced neuropsychiatric effects cause and their increased aeromedical risk.
3. Understand the importance of exception to policy against medical advice and the aeromedical risk associated with it.

[178] MY BABY'S GOT THE BENDS - OH NO!

Maxwell Dickey[1], Stephanie Wilson, Jeffrey Kinard
[1]*U.S. Air Force School of Aerospace Medicine, Wright-Patterson AFB, OH, USA;*

(Education - Case Study)

INTRODUCTION: This case report describes a case of neurologic decompression sickness (DCS) in a military aerospace physiologist with an unreported history of migraines. **BACKGROUND**: Possible signs and symptoms of neurologic DCS include sensory disturbances and alterations of consciousness. Unfortunately, these symptoms overlap with the aura associated with classical migraine headaches. Distinguishing medical etiologies can be particularly difficult in the aviation environment. **CASE PRESENTATION**: The subject is a 26-year-old active duty U.S. Air Force aerospace physiologist with a history of lattice degeneration of the retina who at the time of incident only had an active waiver for that condition. During a routine altitude chamber flight, the subject experienced bilateral flashes of light and blurred vision to the left lateral visual field during descent. The subject remained on 100% O2 throughout the descent. He was seen by his flight surgeon shortly after the flight, by which point he was asymptomatic with an unremarkable clinical exam. The subject received hyperbaric O2 therapy and remained asymptomatic during his hyperbaric treatment. Evaluations by Neurology and USAF Aeromedical Consult Service revealed an unreported 10-year history of migraine headaches with aura and a clinically insignificant patent foramen ovale. **DISCUSSION**: DCS can be a problematic disease process to diagnose among patients with routine exposure to extreme altitudes and the associated pressure changes. Commercial and military aviators generally fly in aircraft pressurized to under 8,000ft above mean sea level, where the risks of altitude-related illness are minimal. However, physiologists with chamber duties often operate at 25,000ft , where the risks of hypoxia and DCS are significant. There is also symptomatic overlap between migraines and neurologic DCS. In this case, light flashes and blurred vision could reasonably represent either etiology and present a diagnostic and treatment conundrum. Clinicians cannot write off such symptoms as migraines given the risks of untreated DCS and need for hyperbaric treatment. Given that this ambiguity cannot be reliably resolved in-flight, the member was denied a flying class III aeromedical waiver and restricted to non-flying, non-chamber duties.

Learning Objectives

1. Understand common clinical signs and symptoms of decompression sickness in an aviator and how to appropriately respond to them.
2. Appreciate the diagnostic dilemma that may exist when a patient with potential decompression sickness has medical comorbidities that may mimic the signs and symptoms of DCS.

[179] PHYSIOLOGIC INCIDENT OR PSYCHIATRIC DISORDER?

Matthew Negrey[1]
[1]*USAFSAM, Wright-Patterson AFB, OH, USA*

(Education - Case Study)

INTRODUCTION: This case report describes a 28-year-old U.S. Air Force male pilot with new-onset panic disorder initially thought to be an in-flight physiologic incident. **BACKGROUND:** Panic disorder is relatively common in the United States, with a lifetime prevalence of approximately five percent in women and two percent in men. The median age of onset is 24 years old. Panic disorder involves recurrent panic attacks plus consistent worrying about recurrence or avoidance of potential triggers. Genetics, neurobiology, temperament, childhood adverse events, and life stressors are all thought to contribute to an individual's risk for panic disorder. The symptoms of a panic attack can closely resemble a physiologic incident in flight. **CASE PRESENTATION:** This pilot first became symptomatic while flying a single-seat high-performance aircraft. He initially experienced shortness of breath, lightheadedness, and paresthesias during a climb at an altitude in the "teens" of thousands of feet. He was concerned about hypoxia, so he started emergency oxygen and returned to base. No specific cause of his symptoms was identified. However, in the next several months his symptoms recurred. He described episodes lasting up to 90 minutes and occurring two to three times per week. These initially only happened during flight but began starting at unexpected times throughout the day. He experienced severe anxiety, diaphoresis, shortness of breath, nausea,

and fear of dying. He was evaluated after several of these episodes, with no apparent cause found. After he refused to participate in simulator training, he was referred to the mental health clinic and diagnosed with panic disorder. He started sertraline alongside psychotherapy. With treatment, he became asymptomatic for nearly a year. He was eventually waived to return to flying with frequent close follow-up. **DISCUSSION:** Panic disorder poses significant aeromedical risk given that attacks can be disabling and difficult to predict, and is therefore disqualifying in aviators. The prognosis is relatively poor, with the majority of untreated individuals experiencing recurrence of symptoms. However, individuals who continue medication may have a relapse rate around 10%. In aviators with sudden onset of unexplained symptoms in flight, mental health should be considered in the differential.

Learning Objectives

1. Understand the aeromedical risks for high-performance aviators with panic disorder.
2. Understand the presenting symptoms and prognosis of panic disorder in aviators.

[180] HIGH PERFORMANCE PILOT WITH PAROXYSMAL ATRIAL FIBRILLATION TREATED WITH CARDIAC ABLATION

Jason Burchett[1], Eddie Davenport
[1]*USAFSAM, Wright-Patterson AFB, OH, USA;*

(Education - Case Study)

INTRODUCTION: This case report describes a 37-year-old USAF F-16 pilot with paroxysmal atrial fibrillation treated with cardiac ablation and medical testing conducted to mitigate aeromedical risk. **CASE DESCRIPTION:** The patient, an experienced F-16 pilot, presented to the local flight surgeon for palpitations and chest discomfort, which may have been lifelong. An ECG was normal, however, a 7-day cardiac monitor revealed paroxysmal a-fib. He underwent pulmonary vein isolating cardiac ablation, Metoprolol XL 25mg PO Q24, and Eliquis 5 mg PO BID for one week prior to the ablation to three months post ablation. He reported no palpitations after ablation. As part of an ACS evaluation, the pilot underwent a treadmill test that showed rare ventricular ectopy with no other arrhythmia or ischemia. This was followed by a normal ECG and normal 24 hour Holter monitor. He underwent cardiac monitoring during an F16 protocol centrifuge that showed normal cardiac response to +Gz and only three ectopic atrial beats in the 3G-8G profile. Given his excellent results, he was recommended to be returned to full flight duties in the F-16 with ongoing ACS follow-up. **DISCUSSION:** The primary aeromedical risk from paroxysmal a-fib is hemodynamically significant a-fib that results in sudden incapacitation and may be exacerbated under high +Gz conditions. Stroke is also a risk; however, is <1% if no other risk factors are present. Long term success rates for pulmonary vein isolation in paroxysmal a-fib are 70 to 80% after single ablation, and therefore unrestricted (high-performance) waivers have been uncommon. It was felt that this pilot had non-hemodynamically significant paroxysmal a-fib on diagnosis with likely a long history of well tolerated arrhythmia. Furthermore, he responded well to ablative treatment and excelled on both the maximal exertion stress test and a full F-16 centrifuge profile. Based on aggressive non-invasive testing and good functional status, it was felt that he was low risk for sudden incapacitation. This pilot is the first USAF high performance pilot with paroxysmal a-fib recommended for return to unrestricted flight duties. His case highlights the challenges in aeromedical disposition for trained aviators with paroxysmal a-fib in high performance aircraft.

Learning Objectives

1. Participants will understand the aeromedical risks of Atrial Fibrillation in high performance fighter pilots.
2. Participants will understand how to mitigate the aeromedical risks of Atrial Fibrillation in high performance fighter pilots.

[181] STRANGE BEHAVIOR IN AN AVIATOR

Michelle Hong Chan[1]
[1]*University of Texas Medical Branch, Galveston, TX, USA*

(Education - Case Study)

INTRODUCTION: This case report describes a 55-year-old male commercial pilot who presented for a fitness for duty evaluation due to concerns about his flying capability and unusual behavior. **BACKGROUND:** Approximately 7% of American adults struggle with cognitive impairment. Cognitive difficulties place the aviator, passengers and airspace at significant risk for mishap. Brain tumors are one cause of, often subtle, cognitive impairment. Intracranial tumors in adults are due to meningiomas in 36% of cases, making it the most common primary CNS tumor. Meningiomas are typically benign and often discovered incidentally on imaging. Approximately 12% of meningiomas are olfactory. **CASE DESCRIPTION:** A 55-year-old male commercial airline pilot presented at the request of his employer for a fitness for duty evaluation due to concern from peers and management at his company that he had been acting strangely and making mistakes. The patient was late to his appointment and struggled to find the location of the clinic. He has no significant past medical, surgical, or family history and does not use alcohol or illicit substances. He exhibited unusual and labile behavior during the visit. His physical exam was normal. There was concern that he would not be able to safely travel home, and his behavior was sufficiently bizarre to warrant further investigation. A CT head with contrast was obtained same-day and he was admitted to the hospital. **DISCUSSION:** The patient was found to have an olfactory meningioma causing significant changes in executive functioning and behavior due to mass effect and associated vasogenic edema of the frontal lobe. Given the size and symptoms, the best treatment option for this patient is surgical resection. Based on Title 14 CFR Part 61.53, the pilot was grounded, and his company was made aware. The majority of meningiomas have a good prognosis. Following treatment, most pilots can return to unrestricted flying if they remain seizure free. However, olfactory meningiomas are slow growing and, like this case, patients typically present with a large tumor burden. Because of this, olfactory meningiomas are associated with a higher risk for irreversible visual and cognitive impairment.

Learning Objectives

1. Be aware of the signs and symptoms of an olfactory meningioma.
2. Understand the considerations and implications for return to duty for pilots diagnosed with an olfactory meningioma.

Tuesday, 08/31/2021 ***4:00 PM***
Plaza F

[S-37]: SLIDE: LIFE & DEATH IN SPACE

Chair: Jochen Hinkelbein
Co-Chair: Timothy Carswell

[182] BEHAVIORAL HEALTH ISSUES DURING AN EXPEDITION TO MARS

Nick Kanas[1]
[1]*University of California, San Francisco (UCSF), San Francisco, CA, USA*

(Education - Tutorial / Review)

INTRODUCTION: A number of unique behavioral stressors will impact on crewmembers undergoing an expedition to Mars. Space agencies need to identify and prepare for the effects of these novel stressors on crews and on the crew-ground relationship. **TOPIC**: Psychological research studies conducted on-orbit on the Mir and International Space Stations and during Mars-relevant space simulation studies on Earth were reviewed in order to identify unique behavioral stressors that will be a part of a Mars expedition. Stressors identified relate to: crewmember selection, individual and organizational culture, limited social contacts, increased free time, heightened feelings of isolation due to the disappearing Earth, communication delays with family members and mission control personnel back home, increased crew autonomy, and nearly complete dependence on machines and local resources. These stressors may produce drops in crew morale, personality conflicts, loss of group cohesion, crew tension that may be displaced to people on Earth, and confusion in leadership behavior. The diminishing size of the Earth with distance may result in unprecedented feelings of isolation and an Earth-out-of-view phenomenon. **APPLICATION**: It is important that these behavioral stressors be understood so that proper countermeasures can be established to lessen their effects and enhance the possibility of mission success. These countermeasures will be discussed, such as periodic "bull sessions" to ameliorate crew tension and access to a telescope to view

the Earth in order to mitigate loneliness and the Earth-out-of-view phenomenon. **RESOURCES**: [1] Kanas, N.A. et al (2007) "Crewmember and mission control personnel interactions during International Space Station missions", *Aviat Space Environ Med* 78, 601-607. [2] Kanas N. and Manzey D. (2008) *Space Psychology and Psychiatry.* Dordrecht, The Netherlands: Springer. [3] Boyd, J.E. et al (2009) "Cultural differences in crewmembers and mission control personnel during two space station programs", *Aviat Space Environ Med* 80, 532-540. [4] Kanas N. (2015) *Humans in Space: The Psychological Hurdles*. Switzerland, Springer International Publishing. [5] Kanas, N. (2020) "Spirituality, humanism, and the Overview Effect during manned space missions", *Acta Astronaut* 166, 525-528.

Learning Objectives

1. Based on on-orbit and Mars simulation studies on Earth, the audience will learn about unique behavioral stressors that will impact on crewmembers during an expedition to Mars.
2. The audience will learn about possible countermeasures that can be implemented to mitigate the effects of behavioral stressors during an expedition to Mars.

[183] EVALUATION OF MEDICAL IMAGING MODALITIES FOR EXPLORATION SPACEFLIGHT

Michael Boyle[1], Benjamin Easter[2], Kris Lehnhardt[3]
[1]University of California, San Francisco, San Francisco, CA, USA; [2]NASA Johnson Space Center; Baylor College of Medicine, Houston, TX, USA; [3]NASA Johnson Space Center, Houston, TX, USA

(Original Research)

INTRODUCTION: Exploration-class spaceflight will impose an array of challenges, including severe resource constraints. To design an exploration medical system (EMS) within these constraints, it is important to identify the relative contributions to crew health and performance of every capability in the system. Ultrasound (US) and plain radiography (XR) are ubiquitous imaging modalities with applicability to spaceflight due to their versatility and portability; however, to our knowledge, a comprehensive quantification and comparison of their utility for the diagnosis and management of spaceflight medical conditions does not exist. This work seeks to perform that assessment, an essential step in determining if they should be included in an EMS. **METHODS:** The Exploration Medical Condition List (EMCL), an evidence-informed and subject matter expert-endorsed group of 100 medical conditions of sufficient likelihood or consequence to consider their implications for spaceflight, formed the basis of the analysis. Professional medical society guidelines and the medical literature were reviewed to evaluate the utility of XR and US for the diagnosis and management of each condition. While not systematic, the review was performed with a repeatable search strategy across multiple databases of academic journals and textbooks. Utility was scored on a 0-1-2 scale ("not useful"-"unlikely to change diagnosis/management"-"very useful"). **RESULTS:** US scored > 0 in 44 of 100 conditions, 27 of which had a score of 2. Four commonly-used US probes had scores of 2 for at least one condition, and only 4 of 9 common US modes had a score of 2 for any condition. XR scored > 0 in 27 of 100 conditions, 19 of which had a score of 2. Importantly, neither XR nor US had any utility for 50 of the 100 conditions.

DISCUSSION: These results demonstrate that both US and XR can aid in the diagnosis and management of numerous EMCL conditions, but that US provides a wider range of capabilities. XR provided superior utility to US in only 8 conditions. In addition, this work describes a pilot process to appraise the literature to determine the contributions of various capabilities to the EMS. While the ultimate determination of which capabilities to include in such a system requires assessment of their mass, volume, power, and training costs, the development of a traceable process to quantify benefits, such as is described here, is a critical step to a more evidence-based, risk-informed approach.

Learning Objectives

1. The audience will learn about the relevance of ultrasound and plain radiography for the medical management of conditions that could occur on an exploration class space mission.
2. The participant will be able to describe a framework for evaluating the utility of diagnostics and therapeutics for use in spaceflight mission planning and statistical modeling.

[184] MORTALITY OF COSMONAUTS WHO TRAVELLED INTO SPACE AND THOSE WHO DIDN'T

Kristina Betts[1], Igor B. Ushakov[2], Yuri I. Voronkov[3], Igor V. Bukhtiyarov[1], Galina I. Tikhonova[1], Tatyana Yu. Gorchakova[1]
[1]Federal State Budgetary Scientific Institution "Izmerov Research Institute of Occupational Health", Moscow, Russian Federation; [2]Russian State Research Center – Burnasyan Federal Medical Biophysical Center of Federal Medical Biological Agency, Moscow, Russian Federation; [3]State Research Center, Institute of Biomedical Problems, Russian Academy of Sciences, Moscow, Russian Federation

(Original Research)

INTRODUCTION: Human spaceflight programs are becoming increasingly ambitious and more extended in time and space, which explains why researches are highly interested in health status problems of cosmonauts, especially in the distant period. Assessing the real effects of the adverse spaceflight factors on cosmonauts' health status and mortality remains a problem due to the absence of an adequate comparison group. Before joining the group, cosmonauts undergo a thorough medical selection process, which continues during training in preparation for spaceflight. That ensures their better initial health status in comparison with the general population and other professional groups ("healthy worker" effect). In our opinion, cosmonauts who underwent the selection process and special training but did not fly into space must be considered as a group for comparative analysis. The goal of this work is to study the causes and rates of mortality in two cohorts of cosmonauts: those with and without spaceflight experience. **METHODS:** A historical cohort epidemiological study of USSR and Russian cosmonauts' mortality has started in 2019, including 2 cohorts of cosmonauts: 118 cosmonauts with spaceflight experience (cohort 1) and 145 cosmonauts without it (cohort 2). The follow-up period was 59 yr (01.01.1960-31.12.2018), 8351,4 person-years obtained. Using standardized mortality ratio (SMR) with 95% confidence interval (95% CI) we compared both cohorts to the male population of Russia, cohort 1 was also compared to the cohort 2. **RESULTS:** Both cohorts are at much lower all-cause mortality risk than the general population of Russia (SMR=0,39, 95%CI 0,28-0,54 for cohort 1; SMR=0,53, 95%CI 0,41-0,69 for cohort 2). For the first time it is shown that the cosmonauts who travelled into space experienced significantly lower all-cause mortality risk compared to cosmonauts who had not been to space (SMR=0,66, 95%CI 0,46-0,91). Moreover, cosmonauts in cohort 2 died at a younger age than the cosmonauts in cohort 1 (56,1 and 72,3 respectively). **DISCUSSION:** Further research is required to assess the cause-specific mortality risk of cosmonauts, as well as depending on total number of space flights, their duration and cumulative duration of EVA.

Acknowledgments: The reported study was funded by RFBR, project number 19-315-90023.

Learning Objectives

1. The audience will learn about the application of epidemiological methods to determine the relationship between work and health.
2. The participants will be able to understand the effects of the adverse spaceflight factors on cosmonauts' health.

[185] OPERATIONAL CONSIDERATIONS FOR DEATH IN SPACE: HARDWARE CONSIDERATIONS FOR PREPARATION, STOWAGE, AND POTENTIAL RETURN OF REMAINS

Travis Houser[1], Natacha Chough[2], Philip Stepaniak[3], Kathleen McMonigal[3], Kjell Lindgren[3], Michael Barratt[3], Joan Bytheway[4], Edward Mazuchowski[5], Steven Uhl[1], Michael Misiora[1], Robert Patlach[1]
[1]KBR, Houston, TX, USA; [2]University of Texas Medical Branch, Galveston, TX, USA; [3]NASA, Houston, TX, USA; [7]Sam Houston State University, Huntsville, TX, USA; [5]USAF, San Antonio, TX, USA;

(Education - Program / Process Review)

BACKGROUND: An in-flight fatality would pose significant challenges with regard to preparation, storage, and final disposition of the decedent's remains. Ready access to refrigeration capability in the terrestrial model of remains handling has driven hardware down a path that is not entirely

suitable for use in the space flight environment. The products of human decomposition are well documented in forensic literature, and pose no significant physical health risk to the surviving crew. Odoriferous compounds do pose some level of psychological health risk however, and likewise there is an unquantified risk to the hardware of the space vehicle. The inability to inhibit or arrest the decomposition process via refrigeration while onboard any current or planned future vehicle requires us to assume the stance of complete containment of the remains. **OVERVIEW:** The current Human Remains Containment Unit (HRCU) is nearing the end of its service life and is no longer commercially available. A replacement HRCU was found from a manufacturer that primarily serves the defense market with body bags designed to facilitate the transportation and disposition of chemically or biologically contaminated remains. The proposed new HRCU utilizes a NASA designed zipper and modified 3M filter canisters to ensure full containment of chemical or biological contaminants while still allowing for pressure equalization across the bag barrier. **DISCUSSION:** The spaceflight environment presents a number of inherent challenges to stowage and disposition of human remains. Commercial off the Shelf solutions are, reasonably, designed for terrestrial use. Any potential HRCU will, necessarily, require some level of modification in order to meet the challenges presented by spaceflight. This presentation addresses the specific challenges and workarounds involved with the stowage and final disposition of crewmember remains. All decisions were made in the context of current vehicular constraints while simultaneously considering potential constraints imposed by future vehicles.

Learning Objectives

1. The audience will become familiar with the hardware limitations and challenges associated with handling and stowage of the remains of deceased crewmembers in the event of a space flight fatality.
2. The audience will become familiar with the modifications necessary to adapt terrestrial products for handling and stowage of remains to a microgravity environment.
3. The audience will become familiar with some of the challenges and constraints inherent to returning a deceased crewmember to Earth in a space vehicle.

[186] TRANSLATIONAL RESEARCH FOR MEDICAL AUTONOMY IN DEEP SPACE EXPLORATION

Emmanuel Urquieta[1]
[1]*Baylor College of Medicine/Translational Research Institute for Space Health, Houston, TX, USA*

(Education - Tutorial / Review)

INTRODUCTION: Deep space exploration class missions will require unique and state of the art technologies to ensure astronaut's health, reliability of medical care and health and performance. Several challenges such as distance from Earth (time delay communications and loss of signal), isolation and confinement, environment, etc. will need to be resolved. From the medical perspective, augmented reality (AR), mixed reality (MR), extended reality (XR), and new virtual astronaut simulations will pave the way for future space travel. The Translational Research Institute for Space Health (TRISH) is in the frontline of these developments. Mature technologies will be presented in this abstract. **TOPIC:** A portfolio review was conducted, and 3 TRISH funded technologies (completed and ongoing) will be presented as part of this abstract. Three technologies were identified as technologies and capabilities being developed for deep space missions responsive to this panel. VisualDX has developed a photo recognition and clinical symptoms medical decision support tool ideal for exploration class missions. LevelEx has developed a virtual human simulation based on physiologic and physical parameters relevant to changes encountered in microgravity and space exploration including ultrasound simulation capabilities responsive to current medical needs such as jugular vein thrombosis. The autonomous medical response agent (AMRA) is a Boolean based medical conditions predictive tool that is being developed. Future deep space missions will require not only support in diagnostics but prediction even before a medical condition exists, in order to optimize constrained resources. These technologies are some examples of tools and capabilities that will be essential for a successful deep space mission to the Moon, Mars, and beyond. **APPLICATION:** In order to ensure astronauts' safety, mission reliability, health and performance and medical capabilities during deep space missions to Mars; a paradigm shift from real time communications and support to time delay and loss of signal communications will need to be considered and successfully resolved. Novel technologies, computer simulations and analogs are currently being developed and supported by TRISH in order to ensure that space missions to Mars and beyond are successful.

Learning Objectives

1. To understand the concept of operations paradigm shift from low Earth orbit (LEO) to deep space exploration to the Moon and Mars.
2. To understand new technologies being developed to tackle the medical needs for deep space exploration.

[187] MEDICINA AD ASTRA (A REVIEW OF NASA SPACE FLIGHT SURGEON ACTIVITY FROM 1958 – 2020)

Jason David[1], Richard Scheuring[2], Charles Doarn[3], Michael Barratt[2], James Polk[4], Josef Schmid[2], Thomas Marshburn[2]
[1]*Nellis Air Force Base/University of Nevada Las Vegas, Las Vegas, NV, USA;* [2]*NASA-Johnson Space Center, Houston, TX, USA;* [3]*University of Cincinnati, Cincinnati, OH, USA;* [4]*NASA-HQ, Washington, DC, USA*

(Education - Tutorial / Review)

BACKGROUND: Space operations in the US have required the skills of aerospace medicine specialists since the inception of the national space agenda in 1957. The literature extensively covers physiology, clinical science, and conjectures on the nature and future of space medicine. Yet there is a paucity of subject matter on the operational aspects of the space medicine. The goals of this project are to examine the evolution of the space flight surgeon, define the role today, and explore the future of operational space medicine. **METHODS:** The data gathered for this project was taken from several sources including a literature review identified by searches of MEDLINE, Current Contents, PubMed, Google Scholars, internal NASA records and databases, and references from relevant articles. Only articles published in English between 1961 and 2019 were included. Finally, to provide a primary account to compliment the findings from above, ten personal interviews and eight oral histories were examined. **RESULTS/DISCUSSION:** To our knowledge, this paper is the first to review operational space flight medicine's evolution, offer a modern definition by those who practice it on a daily basis, and explore its future development as a profession. While this work is inherently limited as defined by the experiences of a select few individuals, the 336 combined years-of-service of the sources, personal interviews, and command perspectives of the authors attempt to lay a foundation for such a definition.

Learning Objectives

1. The audience will learn about the evolution of the Operational Space Flight Surgeon as well as a proposed definition of the modern operational space flight surgeon.
2. The audience will be able to explore ideas about the future of operational space medicine.
3. The Participant will understand the importance of understanding the history of the specialty of operational space medicine, and how it affects and will affect the human spaceflight enterprise.

Tuesday, 08/31/2021 ***4:00 PM***
Governor's Square 12

[S-38]: PANEL: AVIATION DENTISTRY. DIGITAL ADVANCES & COMMON RELATED ISSUES

Chair: Jose L Mompell
Co-Chair: Juan Lara Chao

Panel Overview: *Dentistry has been evolving rapidly in recent decades. It can often be a challenge to dental professionals to keep updated with all the developments occurring simultaneously all around the world. It is important for the practitioner to identify important trends within the profession. Within the last 10 years digital dentistry is very present in very dental office. This panel will be a great opportunity for all those interested in improving their medical skills incorporating dentistry, aerospace dentistry into their daily practice. Some very precise guidelines will be shared with the audience in order to make "dental aviation" safer. We will discuss how new technologies will help us in this task.*

[188] PREVENTION AND CONTROL OF SURFACE POLLUTION DURING USE OF DENTAL SPRAY. CONSIDERATIONS IN MICRO-GRAVITY CONDITIONS

Victor Lloro Boada[1], María Laura Giovanonni[1], Vicente Lozano de Luaces[1]
[1]*Universitat de Barcelona, Barcelona, Spain*

(Education - Tutorial / Review)

INTRODUCTION: The use of spray is necessary for the cooling of dental tools and machinery in the practice of dentistry. These aerosols when expelled from the oral cavity can cause environmental and surface contamination around the initial focus. This situation can be aggravated by achieving higher levels of dispersion in microgravity conditions. **TOPIC:** The study of the dispersion and levels of pollution produced by the dental spray in controlled environments and the creation and study of containment methods. **APPLICATION:** In future long stays or space trips, the crew must be trained and must be able to treat dental pathologies, using the usual machinery modified for microgravity conditions, without the risk of creating secondary problems in the crew or the ship. It is therefore necessary that we study and give solution to the dispersion of aerosols and their involvement in cross contamination in enclosed spaces.

Learning Objectives

1. The audience will learn about the importance of dispersion of dental aerosols in enclosed space.
2. The audience will learn about the dispersion control systems of dental sprays outside the oral cavity.
3. The participant can understand the need to control and avoid contamination of surfaces around the focus of dental spray dispersion.

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

Daniel Robles[1], Juan Lara[2], Jose Luis Dominguez-Mompell Mico[2]
[1]*Miguel De Cervantes University, Valladolid, Spain;* [2]*DL Cirugia Oral, Madrid, Spain*

(Education - Tutorial / Review)

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. 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. 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.

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

Juan Lara Chao[1], Jose L Mompell[1], Soumaya Berrazzouk[2], Rafael Gomez De Diego[3]
[1]*DL Oral Surgery, Madrid, Spain;* [2]*Univ. Complutense of Madrid, Madrid, Spain;* [3]*Univ Rey Juan Carlos, 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 trautamism? **BACKGROUND:** Guidelines of how to act depend on 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.

[191] WOULD YOU LET THIS PATIENT FLY?

Jose L Mompell[1], Juan Lara Chao[1], Ramon Mompell[2], Rafael Gomez de Diego[3], Estefania J Gulin Arias[4]
[1]*DL Oral Surgery, Madrid, Spain;* [2]*UCLA Dental School, Madrid, Spain;* [3]*Univ. Rey Juan Carlos, Madrid, Spain;* [4]*Private Practice, 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 this medical acts may affect or not the capability of flying, as a passenger or as a crew member.

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.

[192] MODERN DENTAL TECHNOLOGY AS A MEANS TO MINIMIZE RISK TO PILOTS AND ASTRONAUTS

Michael Hodapp[1]
[1]*Private Practice, Houston, TX, USA*

(Education - Program / Process Review)

Pilots and astronauts face a multitude of conditions that can adversely affect their health. The hazards of additional radiation, sharp changes in temperature, high "G" forces, and barometric changes in atmospheric pressure all can have an effect on the pilot's health and performance. Whatever the distraction, the flyer must "Stay in the game" to keep their crew safe and accomplish the mission at hand. Over the last twenty years, dental technology has advanced exponentially. Recent technological advances have made dentistry, safer, less invasive, and with increased comfort for the patient. Digital radiography uses one tenth the radiation of conventional radiography and offers the intrinsic ability to manipulate the brightness and contrast, thus aiding in the diagnostic process. 3-D cone beam computed tomography (3-D CBCT) may use half the radiation of a standard panoramic X-ray and allows the clinician the ability to perform an extensive evaluation of the teeth, skeletal structures, airway and sinus patency as well as locating pathological anomalies. Other modern diagnostic equipment such as high-definition intraoral cameras, and near-infrared transillumination offer the clinician additional diagnostic capabilities in areas where the conventional oral exam and oral radiography fail. Modern 2940 nm, and 1064 nm dual wavelength dental laser systems provide a means of performing restorative procedures with little to no dental anesthetic. Procedures performed without local anesthetic have the benefit of increased accuracy in the "bite" adjustment, very few post-op complications, and may allow the

pilot to fly after the dental procedure. Additional features include, simplification of difficult surgical procedures, biopsies and tissue contouring that has minimal bleeding with little to no anesthetic, pain relief for acute phases of temporomandibular disorders, and the ability to treat periodontitis and peri-implantitis. As a clinician, we have a responsibility to offer our patients the safest, and most effective treatment available. Keeping abreast with the latest research, and evaluating modern technological advances, can increase the margin of safety for our pilots and minimize distractions during flight.

Learning Objectives

1. The participant will be able to identify what modern technological advances have improved safety for pilots and astronauts and why.
2. The participant will gain an understanding of how laser energy interacts with different tissues, and what wavelength works best for different applications.

WEDNESDAY, SEPTEMBER 1, 2021

Wednesday, 09/01/2021 ***8:30 AM***
Governor's Square 14

[S-39]: PANEL: MAKING SENSE OF SPECIAL SENSES

Sponsored by Aerospace Human Factors Association

Chair: Harriet Lester
Co-Chair: David Schall

Panel Overview: *Intact vision and neuro-vestibulo-auditory functionality are critically important to human performance in the aerospace environment. Techniques and equipment used to assessing these sensory functions can be mystifying to non-specialists. This panel will attempt to demystify some of the current advanced testing tools that may be used to evaluate aviators and share case examples. Seeing, vestibular function, and hearing have unique nuanced qualities and their functions are intertwined in the aeromedical world. Spatial orientation depends upon intact vestibular and visual function. Communication requires visual and auditory input. Danger cues are heard and seen. The brain must integrate all this information to enable human performance in the aerospace environment. We cannot well understand our own anatomy and function without technology, which continues to advance. The impact of some pathology on aeromedical performance can often be mitigated, sometimes not. The aeromedical decision maker needs to be reasonably conversant with current tools and techniques used to assess remaining functionality. They need to understand the information provided in order to apply it to clinical risk-based decision making. Clinical testing is usually not functional testing, and aeromedical risk determinations often require extrapolating clinical data to functional performance. Utilizing case presentations, this panel will explain some current technologies used to assess vision and neuro-vestibulo-auditory function, and how technology can help make operational aeromedical determinations about human performance.*

[193] "DIZZYING TESTS" OR NEUROVESTIBULAR TESTING MADE EASY

David Schall[1]
[1]*FAA, Colorado Springs, CO, USA*

(Education - Tutorial / Review)

INTRODUCTION: This presentation will address neurovestibular testing for aviators. **TOPIC:** Accurate diagnosis is critical when assessing whether an aviator with dizziness can safely return to the sky. Often the diagnosis is elusive creating a conundrum. Understanding tests available to evaluate the Neurovestibular system may help get the answer. There is a plethora of vestibular tests out there, with a variety of acronyms, which create a bewildering array for the clinician. Tests such as oVEMP, cVEMP, VNG, CDP and ECOG are just a few of them. **APPLICATION:** The author will present an overview of these vestibular tests, who does them, what they measure, when it should be used, what it can tell you, and some of the pitfalls associated with their use. Case studies will highlight their clinical application.
RESOURCES: 1) "Practical Management of the Dizzy Patient," Edited by Joel Goebel; Lippincott Williams & Wilkins Philadelphia, 2001 ISBN 0-7817-1820-1 2) "Vestibular Function; Clinical and Practice Management" 2nd Edition, by Alan Desmond; Thieme, New York; 2011 ISBN 978-160406-361-5

Learning Objectives

1. The clinician will have a better understanding of what Neurovestibular tests are currently available.
2. The clinician will understand what these tests measure, when to use them, and pitfalls associated with using them.
3. The clinician will have understand what conditions can be diagnosed with these tests.

[194] TO THE COCHLEA AND BEYOND: PURE TONES ARE NOT THE WHOLE STORY

John Allen[1]
[1]*NASA, Washington, DC, USA*

(Education - Case Study)

INTRODUCTION: Conductive and sensorineural hearing losses impact aviators differently, often require differing test procedures, and require different management procedures. **BACKGROUND:** Referrals for hearing evaluations of aviators are generated for issues ranging from middle ear pathology to neurotologic conditions. Assessments required encompass a variety of measures beyond pure tone audiometry. Two cases are presented to help better understand the measures conducted and the information they can provide, both diagnostic and operational. **CASE PRESENTATION:** The first case describes a pilot suffering a tympanic membrane rupture secondary to inability to ventilate the middle ear during rapid altitude change. The second case involves a pilot who has a bilateral, asymmetric sensorineural hearing loss. In each case the evaluation procedures are described and results are interpreted. Test batteries that include pure tone and speech audiometry; middle ear analysis; otoacoustic emissions; central auditory processing measures; and auditory fitness for duty evaluations will be discussed. **DISCUSSION:** Audiological assessments can do much more than identify peripheral sensitivity. Proper assessment can help with differential diagnosis of conductive, sensorineural, and central pathology; identify need for and type of treatment; guide preventive measures; and determine the potential impact of a loss on quality of life and aviation abilities. Understanding what tests are needed, as well as how they are interpreted and reported is very helpful to the referring aerospace medicine professional.

Learning Objectives

1. The clinician will understand the variety of audiological tests conducted, for what they are used, how they can guide career/life decisions.
2. The clinician will know what best to request when making a referral for an audiological evaluation.

[195] VISION PERFORMANCE ISSUES: QUALITY OF VISION (QoV) AND COLOR VISION (CV) TESTING

Douglas Ivan[1]
[1]*ADI Consultants, San Antonio, TX, USA*

(Education - Tutorial / Review)

Advanced ophthalmic diagnostic testing has revolutionized the ability to visualize histopathological and functional changes in common vision disorders to degrees previously not possible. These diagnostic tools not only provide clinicians and patients with easy diagnostic assessment of the status of their condition, but also provide enhanced understanding of the optical consequences of such disorders, the latter of which contribute to our overall quality of vision (QoV). These technologies go well beyond assessing disease impact by using only traditional high contrast Snellen letter visual acuity (SLVA) testing under ideal conditions, a functional limitation that underestimates the occupational impact of such diseases under all operational conditions. Using a progressive clinical corneal thinning and steepening disorder, keratoconus, as an occupational case example, this presentation will introduce current and emergent QoV technologies as tools to better