

affected even when the pilots did not recognize the illusion ("Type-1"). Although the other illusions can be effectively demonstrated in single maneuvers, the maneuvers flown in our active scenario did not induce adequate simulator motion response. Also, whereas the illusions are normally pointed out by the instructor, in our scenario pilots were oblivious to the SD events. In conclusion, different SD events can be combined in an active scenario, but it requires appropriate illusions and simulator motion.

#### Learning Objectives:

1. The audience will learn that adequate SD simulation requires appropriate illusions and simulator motion.
2. The audience will learn that there is a relation between SD, control input and gaze behavior.

5:15 PM

#### [94] FINGER TAPPING TEST FOR ASSESSMENT OF PSYCHOMOTOR FUNCTION ON EXTENDED STAY AT HIGH ALTITUDE

Munna Khan<sup>1</sup>, Ashok Salhan<sup>2</sup>, Sanjeev Sharma<sup>2</sup>, Taru Tevatia<sup>3</sup>, Sudhir Rao<sup>4</sup>

<sup>1</sup>Jamia Millia Islamia, New Delhi, India; <sup>2</sup>Defense Institute of Physiology and Allied Sciences, DRDO, Timarpur, India; <sup>3</sup>Al-falah University, Faridabad, India; <sup>4</sup>IBM Research Government Programs, Denver, CO, USA

(Original Research)

**INTRODUCTION:** Acute decrement in psychomotor performances is common at high altitude but is not as well understood as the physiological adaptation. Objective is to assess psychomotor functions on a short duration exposure to high altitude (HA) and during extended stay using simple Finger Tapping Test (FTT). Effectiveness of supplementation of glutamic acid has also been assessed during both stays. **METHODS:** The PBG probe of BIOPAC MP30 system was used to record signals from the finger of human subjects at sea level (SL), just reaching high altitude of 10700 feet (HA1) and extended stay of one month at same altitude (HA2). Total 30 healthy, young, right-hand dominant volunteers aged between 24 to 28 years were studied. They were randomly divided into two groups. The 15 subjects were administered oral glutamic acid and designated as supplemented group (SG) and rest were designated as the control group (CG). The signal was acquired from tapping movement of index finger for 30 seconds. Total time taken for first 10 taps and last 10 taps was calculated from the recordings. **RESULTS:** The CG took average 1.99 seconds (sec) for first 10 taps and 2.27 sec for last 10 taps at SL while corresponding values for SG were 2.13 and 2.37 sec respectively. At HA1, average  $\delta T$  for start and end taps was 2.12 and 2.49 sec for CG and 2.31 and 2.63 sec for SG. At HA2, average  $\delta T$  was 1.98 and 2.35 sec for CG and 2.08 and 2.45 sec for SG for start and end taps respectively. The FTT resulted percentage change average area (PCAA) at SL as 29.37 and 23.70 for CG and SG respectively. The PCAA at HA1 was found to be 17.71 and 15.28 for CG and SG respectively. The PCAA at HA2 was 24.18 and 27.06 for CG and SG respectively.

**DISCUSSION:** The  $\delta T$  for start and end 10 taps for both groups was highly significantly increased in 30 sec ( $P < 0.0001$ ) signifying slowing of finger taps at HA1 and HA2. Tap Index was created by dividing the area by  $\delta T$  and found significantly different ( $P < 0.05$ ) in both groups at SL. The FTT proved significant for both phases. There was a significant slowing in the initial and highly significant slowing in the final 10 seconds at high altitude. The FTT can clearly show a deteriorating psychomotor function at high altitude and easy fatigue on muscular effort and also the effect of Glutamic acid supplementation at high altitude.

#### Learning Objectives:

1. How Finger Tapping Test can be utilized for short and long duration at high altitude.
2. How supplementation of glutamic acid affects small muscle performances.
3. How Finger Tapping Test is useful for assessment of psycho-motor function at high altitude.

**TUESDAY, MAY 7, 2019**

Tuesday, 05/07/2019

8:00 AM

#### 6TH ANNUAL REINARTZ LECTURE

Prof. dr. Floris Wuyts, Ph.D.

#### "The Impact of Microgravity and Hypergravity on the Human Brain Studied with Advanced MRI Methods"

Tuesday, 05/07/2019

10:30 AM

Brasilia 1

#### [S-21] PANEL: CHANGES OF PARADIGMS IN MODERN DENTISTRY

Sponsored by International Association of Aerospace Dentistry (IAAD)

Chair: Jose Luis Mompell

Co-Chair: Juan Lara Chao

**PANEL OVERVIEW:** Dentistry has developed considerably within the last few decades, many of these developments have come from the computer aided systems that were already present in Aviation in the late 80s, This Aviation Dentistry panel will be focused on many aspects where aviation and dentistry merge. X-Ray interpretation from an AME or flight surgeon's point of view will be also discussed. How may dentistry help an AME/Flight Surgeon to prevent in flight complications? From the CAD/CAM systems to the human factors. Every single field of specialization in dentistry is experiencing a huge change in the way it was previously conceived. Technology developed from aviation is taking a main role in dentistry in daily practice. Short implants are also a huge revolution in implant dentistry allowing shorter periods of recovery and therefore less complication for inflight tripulations in compare to bone grafting procedures. Also, the relation between microgravity and dental health will be discussed. A very interesting topic in relation to future aerospace missions.

#### [95] THE PANORAMIC XRAY AS A DIAGNOSTIC SCREENING TOOL

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

<sup>1</sup>DI Cirugia Oral, Madrid, Spain; <sup>2</sup>Clinica Mompell y Mico/DL Cirugia Oral, Madrid, Spain; <sup>3</sup>Universidad Miguel de Cervantes Valladolid, Valladolid, Spain

(Education - Program / Process Review Proposal)

Radiographs are an essential part of the examination process. They serve as a diagnostic tool for baseline reference, aid in the diagnosis of disease, detection of asymmetries, as well as other anomalies. Panoramic x-rays play a special role in the diagnostic arsenal by allowing the clinician to see a broad area on one image, thus allowing the clinician to screen and detect multiple pathologies on the same. This presentation will look at some of the different pathologies that may be detected during the examination with a panoramic radiograph, discuss the risk-benefits of acquiring the image, radiation protocols, and the appropriate frequency for taking the panoramic radiograph.

#### Learning Objective:

1. To gain a basic understanding of the benefits of utilizing the panoramic x-ray in the examination process.

**[96] SHORT DENTAL IMPLANT: AN EFFECTIVE AND SIMPLE ALTERNATIVE IN ATROPHIED MAXILLAE**Daniel Robles<sup>1</sup>, Juan Lara<sup>2</sup>, Jose Luis Mompell<sup>2</sup><sup>1</sup>UEMC University of Valladolid, Madrid, Spain; <sup>2</sup>URJC University, Madrid, Spain*(Original Research)*

Bone resorption patterns in the posterior maxilla may preclude the implants of implant length around 10 mm. In order to attain adequate height for implant placement below the sinus floor, or posterior atrophied maxilla, additional bone grafting may be necessary. After bone regeneration surgeries a 6 to 9 month healing period is often required prior to implant placement, which prolongs the healing time and increases cost, time, and more complicated surgeries with more side effects to the patients. Regarding general and local contraindications for dental implants, most posterior edentulous ridges have minimal bone height. The short implants avoid complication of the procedure and time of the treatment. The main objective of this communication is to determinate that we consider a short implants as an alternative of treatment in posterior atrophied maxilla, what is the rate of success, and whether we can consider short implants a real long-term alternative compared to bone regeneration techniques, as well as the benefits that this entails for patients in terms of recovery, time, biological cost.

**Learning Objectives:**

1. What is the indications of the short implants and what is the predictability of this treatments.
2. Main differences with standard dental implants as in the surgical procedure as in the prosthetic aspects.
3. To know if the shorts implants is a real alternative to Guide bone regenerations.

**[97] THE EFFECT OF BARODONTALGIA ON THE DENTAL HEALTH OF FLIGHT PERSONNEL**

Leon Dychter

College of Dental Surgeons of Rosarito, Mexico

*(Education - Case Study: Clinical / Human Performance)*

Pilots and flight attendants spend a great deal of time aboard a commercial aircraft, which may subject them to many external factors (i.e., changes in barometric pressure, vibrations, etc.) that can lead to dental alterations that may not be present at ground level. Thus, aviation dentistry has emerged as a dental specialty responsible for the prevention, diagnosis, and treatment of diseases of the mouth in patients exposed to the elements of flight. One of these important factors leading to dental disease in flight personnel is a condition called barodontalgia, which is due to the barometric pressure differential inside the aircraft cabin. Barodontalgia produces dental pain in faulty obturations or deep caries near the pulp cavity. This may also be present in patients with poor teeth positioning, such as impacted third molars. Patients with occlusive trauma, through improper jaw alignment and/ or temporomandibular joint disease may lead to barodontalgia.

**Learning Objective:**

1. To understand the pathological features through clinical examination and radiological findings associated with barodontalgia.

**[98] DIGITAL DENTISTRY; PRESENT OR FUTURE? CAD/CAM FROM AVIATION IN THE 80s TO THE NEW DENTAL DIGITAL ERA**Jose Mompell<sup>1</sup>, Juan Lara Chao<sup>2</sup>, Ramon Dominguez-Mompell<sup>1</sup>, Victor Lopez Pizarro<sup>3</sup>, Gomez de Diego Rafael<sup>4</sup><sup>1</sup>Clinica Mompell & Mico, Madrid, Spain; <sup>2</sup>DL Cirugia Oral, Madrid, Spain; <sup>3</sup>Hospital Principe de Asturias, Madrid, Spain; <sup>4</sup>University Rey Juan Carlos, Madrid, Spain*(Education - Tutorial Proposal)*

The new era of digitalization has brought new parameters to all fields of dentistry. With these recently developed technologies it is possible to reach high standards of quality in most dental procedures. The new digital systems allow for greater predictability of results and have considerably reduced the duration of the dental treatment.

Computer Assisted Design/Computer Assisted Manufacture (CAD/CAM) technologies have simplified our routine and improved the production and quality of dental treatments. This technology that has been implemented in aviation since the late 80s allows you to store data for design and the capability to handle multiple changes in these data, including long and complex calculations. It made aviation evolve from pencil drawings and calculators to the CAD/CAM systems and Electronic Data Processing (EDP) programs. These issues and technologies extrapolated to every single field of dentistry will offer more accuracy and detail, which allows for better design and quality. They let us solve aesthetic and functional problems in less clinical sessions. These new systems have revolutionized the way to see, think and work in dentistry. Transitioning from a conventional workflow to a digital one requires a change of paradigms and thinking but progress in dentistry it is directly linked to these technologies. It will continue to evolve until it is indispensable in everyday practice.

**Learning Objective:**

1. Participants will learn how digital dentistry allows for high levels of productivity and replicability.

**[99] WHAT DO WE KNOW ABOUT THE RELATIONSHIP BETWEEN DENTAL HEALTH AND MICROGRAVITY CONDITIONS?**

Victor Lloro

Universitat de Barcelona, Barcelona, Spain

*(Original Research)*

**INTRODUCTION:** Since the start of the space age, the health of the astronauts has been a subject with more importance in this area. Until now there are several studies about the effect of microgravity on the body health of the astronauts. Some of the studies were in conditions of simulated microgravity and others were in International Space Stations during short periods or long periods. NASA elaborated a medical condition list in which some dental diseases are considered clinically relevant to be treated in short and long period missions. Starting for that NASA investigation and the increase of long space missions, it is necessary and adequate to do a systematic review of the dental diseases in short and long period missions with all the available evidence to current date. **METHODS:** To identify all relevant dental disease due to the effects of the microgravity on the human body, we performed a rigorous systematic review regarding the published articles regarding microgravity and dental diseases considered the period from 1969 to 2017. Relevant databases including Pubmed, Cochrane, Scielo, NASA web page and Google Scholar. It has been considered the additional articles from the reference lists of the selected papers in order to get a complete overview of the state of the art. 60 full-text articles were assessed and the inclusion criteria were that the articles had to have a direct relation with oral and dental Health and microgravity. **RESULTS:** The relevant dental events have been grouped to study the global incidence and the percentage, of all the dental events of this article. The bigger percentages are the increases of metalloproteinases MM-P8 and MM-P9, increases in salivary cortisol and increases in salivary glucosyltransferasa. **DISCUSSION:** Following missions to Mars will require 18-24 months of exposure to microgravity conditions, which could have potentially deleterious effects on oral health. We have to be prepared to prevent and cure dental pathologies that will occur during the trip.

**Learning Objective:**

1. The audience will learn about the effect of microgravity conditions on oral health.

Tuesday, 05/07/2019

10:30 AM

Brasilia 2

**[S-22] PANEL: SHARING LESSONS FROM A SAFETY INVESTIGATION INTO DECOMPRESSION SICKNESS DURING HIGH ALTITUDE PARACHUTING****Chair: Peter Hodkinson**

**PANEL OVERVIEW:** The panel presents the results of a safety investigation into decompression sickness (DCS) during high altitude

parachuting. It will start with an introductory talk on the event and overview of the subsequent safety investigation, its findings and recommendations; focusing on the ones of aerospace medicine relevance. The next three talks explore activities that were undertaken to address three aerospace medicine recommendations. First is a literature review related to hypobaric DCS presentations, symptoms and severity, which provides the background evidence base for the following talk. The second talk describes the review process undertaken to assess DCS risk associated with high altitude parachuting, which has resulted in an updated version of the RAF pre-oxygenation and high altitude parachuting exposure limits. One challenge in undertaking this first task was the limited evidence base and disparity between operational experience of DCS incidence (low) compared with predicted DCS risk from hypobaric chamber studies (high). This led to a recommendation presented in the next talk that is intended to assess whether the incidence or chamber studies are closer to reality. The talk describes, and presents the findings from, a retrospective survey of DCS-like symptoms experienced by aircrew, dispatchers and parachutists who have undertaken multiple high altitude parachute exposures. Finally, the panel will conclude with a contrasting set of considerations for a high altitude parachuting expedition planned to take place from an elevated terrestrial base altitude. The evidence-based approach to DCS from the Occurrence Safety Investigation permitted DCS risk for this to be re-visited (no requirement for pre-oxygenation) and associated implications for the oxygen delivery system (doesn't need to deliver 100% oxygen). The project also provided an opportunity to apply some of the medical planning lessons from the safety investigation to a different scenario. Summary: Throughout these talks are recurrent themes highlighting the importance of sharing our learning from incidents and assessments of life support equipment. Additionally, the talks will highlight the nuances and limitations of current evidence base for DCS risk in high altitude parachuting. Finally, they draw out the need for considered application of aerospace medicine expertise to inform and support evidence-based approaches to managing risks in aerospace activities whilst supporting operational capability.

#### **[100] MEDICAL LESSONS FROM A SAFETY INVESTIGATION FOLLOWING TWO CASES OF DECOMPRESSION SICKNESS DURING HIGH ALTITUDE PARACHUTING**

Bonnie Posselt<sup>1</sup>, Peter Hodkinson<sup>2</sup>

<sup>1</sup>Royal Air Force, Dayton, OH, USA; <sup>2</sup>Royal Air Force, Henlow, United Kingdom

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Despite following extant pre-oxygenation guidelines there were two cases of decompression sickness (DCS) during the same high altitude parachute sortie. This led to a Occurrence Safety Investigation (OSI) to understand what happened, why and whether any changes were required to reduce likelihood of recurrence. The OSI generated 22 recommendations, of which 16 were medical in nature. This talk will introduce the process of an OSI, highlight the medical recommendations and briefly present some of the associated follow on actions. It will also set the scene for subsequent talks within the panel, which address several specific recommendations in more detail. **OVERVIEW:** An OSI is convened when a serious risk to life has occurred during military operations. A number of military personnel outside the command, usually two to three, are tasked to conduct an independent investigation of the events, drawing upon Subject Matter Expertise as required. The purpose is to identify causal factors, and suggest mitigating recommendations, communicating this to the responsible duty holders, so that lessons can be learned and similar events avoided in the future. Urgent issues identified during the process of an investigation would be raised as an interim recommendation for action prior to completion of the investigation. **DISCUSSION:** One of the broader observations from the OSI was that DCS and the risk of it occurring during high altitude parachuting were poorly understood and communicated. Additionally, medical planning for such activities was considered to have inadequate Aviation Medicine input. Early recommendations from the OSI, therefore, included additional DCS briefs for parachutists, their supervisors and medical teams along with provision of high altitude awareness cards, similar to those issued after hypobaric chamber training. Additionally, the DCS component of

aviation medicine teaching for operators and medical staff has been updated and medical plans revised with greater aviation medicine input to place greater emphasis on management of DCS in high altitude parachuting. These lessons identified from the OSI are of value to other medical personnel involved with high altitude parachuting and may benefit practice of international colleagues.

#### **Learning Objective:**

1. The participant will understand aeromedical lessons that were identified from a safety investigation on high altitude parachuting.

#### **[101] THE RISK OF DECOMPRESSION SICKNESS (DCS) IN HIGH ALTITUDE PARACHUTE OPERATIONS UP TO 25,000 FT: A LITERATURE REVIEW**

Sonny Gates

*QinetiQ, Farnborough, United Kingdom*

*(Education - Tutorial Proposal)*

**INTRODUCTION:** The risk of altitude decompression sickness (DCS) when flying in unpressurised aircraft above 25,000 ft is well recognized. Whilst considered uncommon, evidence in the literature of DCS following exposures to lower altitudes may have serious implications for the safety of aircrew undertaking parachute operations.

**TOPIC:** DCS occurs when nitrogen is released from body tissues due to a relative reduction in atmospheric pressure. The severity of DCS may vary from mild limb pain or 'bends' (Type I) to more serious, potentially life-threatening neurological or respiratory manifestations (Type II). The risk of DCS is commonly mitigated by the process of denitrogenation, typically achieved through a period of breathing 100% oxygen prior to altitude exposure, which has been shown to decrease, but not eradicate the risk of DCS. Whilst probabilistic in nature, the risk of DCS increases with both increasing altitude, and duration of time spent at altitude, although it is difficult to establish an accurate altitude risk threshold due to individual variability. Despite this, it is generally considered that DCS is uncommon below 25,000 ft, although evidence in the literature provides reports of cases occurring at altitudes as low as 12,000 ft. The incidence of DCS has previously been reported to be as high as 50% following altitude exposures to 23,000 ft, and more relevant to parachute operations, 22% following four separate 30-minute exposures to 25,000 ft, both without prior denitrogenation. With further relevance to parachute operations, exercise, both prior to or during decompression, and exposure to low ambient temperatures, has also been shown to increase the risk of DCS. Subsequently, it may be necessary to take a more conservative approach towards the risk of DCS in parachute operations, even when flying at altitudes of less than 25,000 ft, for what is considered short durations. **APPLICATION:** A combination of factors known to increase the risk of developing DCS including exercise, low ambient temperatures and repeated exposures to altitude are pertinent risks to aircrew on parachute operations and should not be underestimated. It is important to ensure mitigations to decrease the risk of DCS are considered, including the use of appropriate denitrogenation protocols, whilst early recognition of symptoms, and subsequent diagnosis and treatment of DCS is vital to improving the chances of successful outcomes.

#### **Learning Objective:**

1. The participant will understand the current evidence base around decompression sickness risk for high altitude parachute operations up to 25,000 ft.

#### **[102] EVIDENCE BASED REVISION OF PRE-OXYGENATION AND ALTITUDE EXPOSURE GUIDELINES FOR HIGH ALTITUDE PARACHUTING**

Peter Hodkinson, Nicholas Green

*RAF Centre of Aviation Medicine, Hitchin, United Kingdom*

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Following two cases of severe decompression sickness (DCS) during high altitude parachuting a directed Safety Investigation was undertaken. As part of the investigation UK and international guidance material was reviewed to inform the risk held by the Duty Holder (DH; accountable person) for these operations. Sources include international agreements and UK military regulations, Standing

Orders and Operating Manuals. None of these documents include information on what risk of DCS is associated with each pre-oxygenation and altitude exposure profile. Thus, one of the recommendations of the safety investigation was a review of the underlying medical literature regarding the risk of DCS associated with such operations.

**OVERVIEW:** Review of medical literature and discussion with international colleagues highlighted the limitations in evidence base associated with DCS risk estimates for high altitude parachuting. The consensus was that the USAF Altitude Decompression Risk Assessment Computer was still the best and most applicable tool for prediction of DCS risk in this context. The predicted risk of DCS associated with accepted UK pre-oxygenation and high altitude exposure profiles prior to these incidents will be presented. The process of subsequent collaborative efforts with operators and flight safety personnel to generate a new risk-based guidance table for pre-oxygenation and altitude exposure limits for high altitude parachuting will then be presented. These proposals permitted the DH to make an evidence informed, risk-based decision regarding what is considered tolerable and 'As Low As Reasonably Practicable' (ALARP) for high altitude parachuting at pressure altitudes up to 25,000 ft, which will also be presented. **DISCUSSION:** The review included consideration of the medical literature in the context of desired operational practice to generate risk based, operationally focused guidelines for considerations by the DH. These new guidelines have been introduced to Service in the RAF. The safety investigation has resulted in multiple activities that will improve the safety of our high altitude parachute operations and demonstrate both the challenges and benefits of taking an evidence based approach to practice. This collaborative approach between operators, aerospace medicine and flight safety personnel proved an effective vehicle to undertake a considered review; the process will be used as a model for provision of future advice to the DH.

**Learning Objectives:**

1. The audience will learn about the evidence base for prediction of compression sickness risk in high altitude parachuting.
2. The audience will learn about the new UK pre-oxygenation and altitude exposure guidelines for high altitude parachuting.

**[103] SURVEY OF DCS-LIKE SYMPTOMS IN HIGH ALTITUDE PARACHUTING POPULATIONS**

Joanne Rollo, Peter Hodkinson

RAF Centre of Aviation Medicine, Hitchin, United Kingdom

(Original Research)

**BACKGROUND:** The reported incidence of DCS in operational hypobaric environments is markedly lower than that found in hypobaric chamber studies. The reason for this discrepancy is not clear and whether it represents e.g. genuine difference in risk between these exposures or differences in reporting. The aim of this project was to address a recommendation of a high altitude parachute safety investigation and determine whether the incidence of DCS-like symptoms during high altitude parachuting is greater than currently reported incidence of DCS. **METHODS:** A retrospective questionnaire was used to gather anonymized experience of DCS like symptoms. This was for altitude exposures below and above 16,000 ft to allow distinction between symptoms that occur routinely during parachuting and those that may be due to DCS. 64 respondents with high altitude exposures (aircrew, dispatchers and parachutists) completed the questionnaire. The survey was approved by the Royal Air Force Scientific Advisory Committee. **RESULTS:** Excluding two reported cases of DCS, the majority reported never experiencing symptoms. Of symptoms that were rarely or sometimes experienced they were more commonly reported above 16,000 ft. These included (above vs below 16,000 ft, respectively) headache (20 vs 10.5%), altered sensation/tingling (19 vs 7%), inappropriate fatigue (16 vs 5.3%), skin itch and rash (15 vs 5.3%), dizziness and disorientation (15 vs 3.5%), lower limb pain (13.3 vs 1.8%), nausea (11.9 vs 8.8%), visual disturbance (10.2 vs 1.75%), and confusion/slowed thought/forgetfulness (8.3 vs 0%). **DISCUSSION:** Symptoms are more often experienced with altitude exposures above 16,000 ft than below this altitude. If these additional DCS like symptoms above 16,000 ft are due to DCS then these findings would suggest DCS is more common than formally reported. However, the

additional symptoms are still uncommon and occur infrequently, suggesting that even if they are DCS symptoms then hypobaric chamber studies still overestimate incidence of DCS in operational settings. The symptoms above 16,000 ft may alternatively be caused by other conditions that might be more common at these higher altitudes e.g. mask irritation, hypoxia or hypocapnia but this survey methodology does not permit analysis of cause. Thus while these findings suggest DCS like symptoms occur more than is formally reported, further prospective investigation is required to assess actual causation of these symptoms.

**Learning Objective:**

1. The audience will learn about the subjective symptom experience of high altitude personnel and how this compares for exposure above and below 16,000 ft.

**[104] COMPARE AND CONTRAST: DCS AND OXYGEN SYSTEM CONSIDERATIONS FOR HIGH ALTITUDE PARACHUTING FROM HIGH ALTITUDE TERRESTRIAL BASE**

Joseph Britton, Bonnie Posselt, Alex Short, Peter Hodkinson  
Royal Air Force, Henlow, United Kingdom

(Education - Program / Process Review Proposal)

**BACKGROUND:** High altitude parachuting carries not only risks of trauma but also aviation medicine considerations of hypoxia and decompression sickness (DCS), which were highlighted in a recent Occurrence Safety Investigation (OSI). One of the principal means to mitigate DCS risk in such activities is pre-oxygenation. This requires oxygen delivery systems (ODS) capable of delivering 100% oxygen; a much greater  $F_{O_2}$  than needed to prevent hypoxia at these altitudes. Use of the evidence-based approach to DCS risk adopted in the OSI permitted a review of this risk for high altitude parachuting expeditions taking place from a high terrestrial base altitude (rather than from sea level). This paper presents these calculations, associated implications for ODS requirements and unmanned ODS test findings. **OVERVIEW:** Hypobaric DCS risk is considered in operations above 16-18,000 ft and is a significant concern for high altitude operations at 25,000 ft PA. However, permitting acclimatization at terrestrial altitude of 11,290 ft (equivalent to 12,200 ft PA) alters the baseline nitrogen load in the body. The equivalent absolute and relative pressure changes from here to 25,000 ft PA would be equivalent to ascent from sea level to 8,100 ft and 13,600 ft PA, respectively. In contrast to the high altitude parachuting from near sea level described in the OSI, this high terrestrial base altitude means DCS is considered extremely unlikely, akin to normal parachuting from sea level to less than 15,000 ft PA. In this setting, therefore, pre-oxygenation is not required so the ODS only has to supply sufficient oxygen to prevent hypoxia. Unmanned altitude chamber testing demonstrated one ODS was unsuitable but that an alternate ODS could protect the individuals at 25,000 ft PA equivalent to breathing air at 10,000-14,000 ft PA, depending on their breathing pattern. Limitations of unmanned testing must be considered in interpreting these findings. **DISCUSSION:** Preparation for this expedition demonstrates a practical example of scenario specific aviation medicine advice including lessons for future ODS testing. This project utilized lessons from the OSI to inform expedition preparations but also to challenge established assumptions regarding DCS risk in this setting, which permitted use of lightweight, portable ODS. This is not only useful in this non-operational parachute setting but, with further investigation it may have potential for operational use.

**Learning Objectives:**

1. The participant will understand aeromedical lessons that were identified from a safety investigation including implications for medical planning and provision of medical support to high altitude parachuting.
2. The participant will learn about different approaches to consider aeromedical risk and its application to scenario specific considerations when baseline assumptions are different e.g. high altitude parachuting from elevated terrestrial altitude.
3. The participant will understand the process for and limitations of unmanned oxygen system testing.

**Tuesday, 05/07/2019**  
**Brasilia 3**

**10:30 AM**

### **[S-23] PANEL: SAFETY CENTERS YEAR-IN-REVIEW**

*Sponsored by Aerospace Safety Committee*

**Chair: David Romine**

**Co-Chair: Tyler Brooks**

**PANEL OVERVIEW:** This panel presents the results of a review of 2018 aerospace safety data. Representatives from military and civil aerospace organizations will present summaries and analyses of their safety data collected in 2018. Cause factors including mechanical and human factors will be explored, identifiable trends will be highlighted, and updates on risk mitigation strategies will be discussed. With certain types of accidents increasingly becoming rare events, the panel discussion is a unique opportunity to review the collective experiences of multiple safety programs and consider a variety of risk mitigation solutions.

#### **[105] U.S. ARMY AVIATION SAFETY: FY 2018 YEAR IN REVIEW**

David Romine<sup>1</sup>, Jon Dickinson<sup>2</sup>

<sup>1</sup>*U.S. Army Combat Readiness Center / HQ Dept. of the Army Safety, Fort Rucker, AL, USA;* <sup>2</sup>*U.S. Army Combat Readiness Center, Fort Rucker, AL, USA*

*(Education - Program / Process Review Proposal)*

**INTRODUCTION:** Discuss (FY) 2018 statistics and analysis for USA Class A aviation mishaps including Human Factors Analysis. **METHODS:** FY2018 data was obtained from the USA Combat Readiness Center database (ASMIS) for Class A thru C aviation mishaps and reviewed for human factors as determined by the Accident Investigation Boards. **RESULTS:** In the manned aircraft category, Army aviation experienced 68 Class A-C aircraft flight mishaps in FY18. This equals the 68 Class A-C aircraft flight mishaps reported in FY17. The U.S. Army experienced 10 Class A aviation flight mishaps during FY18, an increase of two (25%) from the eight Class A flight mishaps in FY17. The accident rate for Class A flight mishaps (per 100,000 flying hours) was 1.30 in FY18, a 31.3% increase from the FY17 rate of 0.99. There were 6 fatalities in FY18 compared to 10 in FY17. **DISCUSSION:** Human error was the primary cause factor in nine of the 10 Class A mishaps. The FY18 Class A flight mishap rate of 1.30 was slightly higher than the 5-year rate of 1.23. Four of the Class A flight mishaps occurred during ground taxi operations. There was a 4.5% decrease in flying hours the previous year. Overall flying hours have been reduced nearly 31% since FY13.

#### **Learning Objectives:**

1. Review the overall trend in U.S. Army flight mishaps and the most common identified causal factors.
2. Discuss elements of risk and loss common to other international and interagency partners.
3. Explore interdisciplinary avenues for how to best communicate lessons-learned and affect in loss of life and materiel in real terms.

#### **[106] NAVAL AVIATION SAFETY: 2018 YEAR IN REVIEW**

Paul DeMieri, Mike Penny, Corey Littel, Andrew Miranda  
*Naval Safety Center, Norfolk, VA, USA*

*(Education - Program / Process Review Proposal)*

**INTRODUCTION:** The Naval Safety Center analyzes Navy and Marine Corps aviation safety investigation reports in order to identify mishap causal factors. **METHODS:** All Class A flight mishaps involving U.S. Navy and Marine Corps aircraft during fiscal year 2018 (FY18) were reviewed using the Human Factors Analysis and Classification System (HFACS). **RESULTS:** During FY 18 there were 11 Class A Flight mishaps in the U.S. Navy (1.31 per 100,000 flight hours) and 5 Class A Flight mishaps in the U.S. Marine Corps (2.10 per 100,000 flight hours). A review of Class A flight mishaps over the past 10 years demonstrated that human factors were the predominant causal factors. A review of current Physiological Episodes in Naval Aviation will also be presented. **DISCUSSION:** HFACS is

a useful tool in safety investigation analysis and assists in identifying causal factors to focus mitigation strategies to prevent future mishaps. Its standardization across the Department of Defense facilitates cross-analysis and shared efforts to prevent future mishaps.

#### **Learning Objectives:**

1. Review the overall trend in U.S. Navy and Marine Corps flight mishaps and the most common human factors identified as causal factors.
2. Identify the most common Human Factors Analysis and Classification System (HFACS) categories for Naval Aviation mishaps and review the trends in Naval Aviation mishap HFACS causal factors over the last decade.
3. Become familiar with the emerging topics of discussion at the Naval Safety Center related to aviation.

#### **[107] ROYAL CANADIAN AIR FORCE FLIGHT SAFETY: YEAR IN REVIEW 2018**

Ajiri Ikede

*RCAF, Ottawa, Ontario, Canada*

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** In October 2018, cannabis became legalized in Canada. In response to this change in legislation, the Canadian Armed Forces (CAF) developed policies to ensure continued safety in operations. Furthermore, the Royal Canadian Air Force (RCAF) developed regulations and restrictions pertaining to the use of cannabis among aircrew and other personnel involved in aviation. The details of the RCAF policy will be discussed. **OVERVIEW:** The RCAF developed a 3-tiered system with regard to cannabis use, taking into account the different duties and responsibilities that are required. The period of abstinence from cannabis differs between the tiers. **DISCUSSION:** Cannabis, like other substances with psychological effects, poses a hazard to aviation. The RCAF has developed a robust strategy to ensure that the recent change in Canadian legislation with regard to cannabis will not adversely affect flight safety and interoperability.

#### **Learning Objectives:**

1. The audience will learn about the changes in cannabis legislation in Canada and how the RCAF has adapted to ensure continued safety in flight operations.
2. The audience will learn about the different tiers with regard to abstinence from cannabis within the RCAF.

#### **[108] U.S. AIR FORCE AVIATION SAFETY: FY 2018 YEAR IN REVIEW**

Craig Pack, Heather Tevebaugh

*U.S. Air Force Safety Center (AFSEC), Albuquerque, NM, USA*

*(Original Research)*

**INTRODUCTION:** Review of fiscal year (FY) 2018 statistics and analysis for USAF Class A, Aviation mishaps including classification with DoD Human Factors Analysis and Classification System (DoD HFACS). **METHODS:** FY18 data was obtained from the USAF Safety Center database for Aviation mishaps and reviewed for human factors as determined by the Safety Investigation Boards (SIB). The human factors present were categorized for the present year and the preceding 9 years. **RESULTS:** The U.S. Air Force experienced 21 Class A aviation mishaps during FY18 (a rate of 1.36 per 100,000 flight hours) with 9 destroyed aircraft and 19 fatalities. The review of Class A aviation mishaps over the past year demonstrated that most are attributed to human factors. The use and analysis of DoD HFACS will be discussed. **DISCUSSION:** The total number of Class A aviation mishaps and the overall Class A mishap rate increased from FY17, and the number of fatalities increased significantly. Human factors analysis reveals individual acts causing a preponderance of mishaps but organizational influences also played a significant role.

#### **Learning Objectives:**

1. The audience will know the overall trend in USAF mishaps and human factors contributing to current year mishaps in comparison with data from previous years.
2. The audience will know how human factors appear to have influenced the occurrence of these mishaps.

**[109] TRANSPORT CANADA: YEAR-IN-REVIEW 2018**

Tyler Brooks

Transport Canada, Ottawa, Ontario, Canada

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Transport Canada is the federal regulator responsible for policies and programs which promote safe, secure, efficient, and environmentally responsible transportation in Canada. This presentation will familiarize participants with the mission of the Civil Aviation Medicine (CAM) Branch of Transport Canada and highlight topics of interest arising in 2018.

**OVERVIEW:** The mandate of the CAM Branch of Transport Canada is to ensure aircrew and air traffic controllers are medically fit, to close gaps in scientific knowledge of Canadian aviation medicine, to promote health and safety in the field of aviation, and to prevent aircraft accidents due to medically related human factors. The CAM Branch will present an overview of notable civil aviation medicine issues encountered in 2018, including Transport Canada's early experience with the federal legalization of cannabis.

**DISCUSSION:** Aviation medicine practices and policy respond not only to changes in medicine, but also to changes in society and politics. The CAM Branch of Transport Canada shares its experience responding to a variety of issues in 2018, including the federal legalization of cannabis in Canada.

**Learning Objectives:**

1. Understand the mission of the CAM Branch of Transport Canada.
2. Understand Transport Canada's early experience in responding to the federal legalization of cannabis.

**[110] NASA 2018 YEAR IN REVIEW**

Tracy Dillinger

NASA, Washington, DC, USA

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** NASA gathers mishap, close-calls, and hi-visibility events each year. We will review occurrences for data, analysis, and trending for 2018. **OVERVIEW:** NASA collects Class A, B, C and D mishap information as well as close calls and hi-visibility events in an investigation data-base called NMIS (NASA Mishap Investigation System). NMIS data is reviewed and mapped into Human Factor codes using NASA's version of HFACS (Human Factors Analysis and Classification System). Both NMIS and NASAHFACS data, analysis and trending will be covered.

**DISCUSSION:** Review and understanding of mishap information, along with human factors and prevention efforts, constitutes a critical element for robust safety programs. Aerospace Medical, Safety and Human Performance professional should include annual Year in Review information in their future prevention and mitigation efforts.

**Learning Objectives:**

1. The audience will learn about NASA's mishap data collection system.
2. The audience will learn about NASA Human Factors coding system.

**[111] U.S. CIVIL AVIATION IN 2018**

Charles DeJohn, Richard Greenhaw

FAA Civil Aerospace Medical Institute, Oklahoma City, OK, USA

*(Original Research)*

**INTRODUCTION:** Trends in accident rates and performance data were analyzed for all types of civil aviation operations with emphasis on 2018 data. **METHODS:** U.S. civil aviation accident data was analyzed to determine trends from 1990 to 2018; whereas, safety performance measures were analyzed for various time periods, depending on available data. **RESULTS:** Fatal accident rates for all types of operations, except commuter airlines, significantly decreased for the period from 1990 to 2018 ( $p < 0.05$ ). During the same period, air carrier ( $p < 0.001$ ), air taxi ( $p < 0.05$ ), and general aviation ( $p < 0.01$ ) non-fatal accident rates decreased more rapidly than their respective fatal accident rates. The general aviation fatal accident rates (1.03, 0.91, and 0.84 per 100,000 hours) were below the target rates (1.04, 1.02, and 1.01 per 100,000 hours) for 2015 through 2017. Actual safety performance measure rates were all below their respective target rates for 2017. **CONCLUSION:** An analysis of accident rates between 1990 and 2018 and trends in safety performance measures for all types of operations indicated steady improvements in civil aviation safety.

**Learning Objective:**

1. The audience will learn about the trends in U.S. civil aviation accident rates over 2018 and previous years.

Tuesday, 05/07/2019

10:30 AM

Brasilia 4

**[S-24] PANEL: CARDIOVASCULAR DISEASE IN AIRCREW CONSENSUS GUIDELINES. NATO AVIATION CARDIOLOGY WORKING GROUP AND EACTS AVIATION MEDICAL COMMITTEE**

*Endorsed by: International Association of Military Flight Surgeon Pilots*

**Chair: Eddie Davenport****Co-Chair: Joanna d'Arcy**

**PANEL OVERVIEW:** The NATO Aviation Cardiology Working group was established in September 2015 and concluded in November 2018. This 10-country member group collaboration culminated in production of a consensus document for cardiovascular disease in aircrew which was recently published. The focus of this panel will be to present cardiac conditions likely to be encountered by the aerospace medicine physician and then use the recently published recently published Cardiovascular Disease in Aircrew document to guide treatment and disposition. An introduction on the development and use of the document will be discussed and made available to all in attendance. The panel will conclude with some late breaking topics in Cardiovascular Disease treatment and management and their implications for the future.

**[112] INTERNATIONAL CONSENSUS GUIDELINES FOR OCCUPATIONAL CARDIOLOGY**

Eddie Davenport<sup>1</sup>, Joanna D'Arcy<sup>2</sup>, Denis Bron<sup>3</sup>, Gary Gray<sup>4</sup>, Norbert Guettler<sup>5</sup>, Olivier Manen<sup>6</sup>, Rien Rienks<sup>7</sup>, Thomas Syburra<sup>8</sup>, Ed Nicol<sup>2</sup>

<sup>1</sup>USAF School of Aerospace Medicine, U.S. Air Force, Wright-Patterson AFB, TX, USA; <sup>2</sup>Royal Air Force, Clinical Aviation Medical Service, Henlow, United Kingdom; <sup>3</sup>Swiss Air Force, Aeromedical Center, Duebendorf, Switzerland; <sup>4</sup>Royal Canadian Air Force, Canadian Forces Environmental Medical Establishment, Toronto, Ontario, Canada; <sup>5</sup>German Air Force, Center of Aerospace Medicine, Fuerstenfeldbruck, Germany; <sup>6</sup>French Health Military Service, Percy Training Hospital of the Armies, Clamart, France; <sup>7</sup>Royal Netherlands Air Force, Military Hospital, Utrecht, Netherlands; <sup>8</sup>Swiss Air Force and Cardiac Surgery Department Luzerner Kantonsspital, Luzerner Kantonsspital, Switzerland

*(Original Research)*

**INTRODUCTION:** Military and civilian aircrew undergo regular clinical cardiovascular assessment to determine their continued fitness to fly. Determining the acceptability of cardiovascular disease in both civilian and military aviation is challenging given the paucity of evidence and limited number of military aviation cardiologists. There is a wide variation of clinical practice in military aviation cardiology and a need for international consensus on what to do in many cardiovascular disease processes. **METHODS:** In 2013 specialists in the fields of cardiology, cardiothoracic surgery, internal medicine, and aerospace medicine came together to form a NATO sponsored working group to develop consensus on disposition and return to flight for aircrew with cardiovascular disease. The 9-nation group was formed in June 2014 and concluding 2019. During this tenure, the group developed 10 consensus documents based on evidence. References included international published cardiology and aerospace literature as well as each individual country's data and evidence-based policy. **RESULTS:** A 10 paper consensus document was prepared and is pending publication. The documents cover the most common aspects of cardiovascular disease in aircrew. These topics include: An introduction to aviation cardiology; Risk assessment in aviation cardiology; The challenge of asymptomatic coronary artery disease in

aircrew; Heart muscle disease management in aircrew; Non-Coronary cardiac surgery and percutaneous cardiology procedures in aircrew; Contemporaneous management of valvular heart disease and aortopathy in aircrew; Congenital heart disease in aircrew; The management of established coronary artery disease in aircrew without myocardial infarction or revascularization; The management of established coronary artery disease in aircrew with previous myocardial infarction or revascularization; and The management of cardiac conduction abnormalities and arrhythmia in aircrew.

**DISCUSSION:** The new consensus documents formed by the NATO sponsored Aviation Cardiology Working Group should serve as the World's most complete and up to date aerospace cardiovascular resource for the cardiologist and aerospace physician. These documents represent the largest evidence-based aerospace cardiology resource ever written and can be applied to aircrew throughout the world.

**Learning Objective:**

1. The participant will learn how aircrew with common cardiac conditions should be diagnosed, treated, and possibly allowed to return to flight status.

**[113] THE CHALLENGE OF SCREENING AIRCREW AT HIGH RISK FOR CORONARY ARTERY DISEASE: A PRACTICAL APPROACH UTILIZING THE NATO-HFM 251 RECOMMENDED FLOW CHART**

Denis Bron<sup>1</sup>, Thomas Syburra<sup>2</sup>, Joanna D'Arcy<sup>3</sup>, Gary Gray<sup>4</sup>, Norbert Guettler<sup>5</sup>, Olivier Manen<sup>6</sup>, Edward David Nicol<sup>3</sup>, Rienk Rienks<sup>7</sup>, Eddie Davenport<sup>8</sup>  
<sup>1</sup>Swiss Air Force, Aeromedical Center Duebendorf, Duebendorf, Switzerland; <sup>2</sup>Heart Center, Luzerner Kantonsspital, Lucerne, Switzerland; <sup>3</sup>Royal Air Force, Clinical Aviation Medical Service, Henlow, United Kingdom; <sup>4</sup>Canadian Royal Air Force, Canadian Forces Environmental Medical Establishment, Toronto, Ontario, Canada; <sup>5</sup>German Air Force, Center of Aerospace Medicine, Fuerstenfeldbruck, Germany; <sup>6</sup>French Health Military Service, Percy Training Hospital of the Armies, Clamart, France; <sup>7</sup>Royal Netherlands Air Force, Military Hospital, Utrecht, Netherlands; <sup>8</sup>U.S. Air Force, Wilford Hall Ambulatory Surgical Center, San Antonio, TX, USA

*(Original Research)*

**INTRODUCTION:** Coronary artery disease (CAD) is a potentially dangerous disease with the impact of a sudden incapacitation. Primary preventive measures are necessary but sometimes difficult to implement. **METHODS:** Using the screening tool for asymptomatic CAD recommended by the NATO Cardiology Working Group HFM 251 we reviewed our collected data and monitored the laboratory data in air and ground crew done during their annual medical checkup.

**RESULTS:** A total of 4500 laboratory results were analyzed from 2014-2018. 1% showed an elevated AGLA Score of at least 7.5% or higher. Following the algorithm, we tried to convince the subjects to modify their risk factors (smoking, cholesterol, BP, weight) and in the case of even higher AGLA Scores to start statin therapy. One year later, a quarter of these subjects showed normal AGLA Score-levels.

Subjects with high AGLA Risk Score levels greater than 10% 10-year risk for asymptomatic CAD underwent further examination with coronary CT scan including a coronary calcium score. Surprisingly, most aircrew refused to undergo the coronary CT scans. On the other hand, those who were compliant showed high satisfaction and when applying specific preventive cardiovascular measures, they could see the drop in risk score. **DISCUSSION:** Primary CAD prevention is important and the HFM-251 flow chart is a good tool to evaluate if further screening is necessary. Although implementing all the received knowledge for the aeromedical examiner is difficult, the CAD screening process recommended by HFM-251 can serve as an efficient primary prevention strategy.

**Learning Objectives:**

1. Gain knowledge of the primary prevention of CAD.
2. Learn how to utilize an evidence based CAD screening approach.
3. Update the audience about the latest peer-reviewed literature on this topic.

**[114] LONG QT ECG IN AIRCREW**

Rienk Rienks<sup>1</sup>, Norbert Guettler<sup>2</sup>, Eddie Davenport<sup>3</sup>, Thomas Syburra<sup>4</sup>, Denis Bron<sup>5</sup>, Olivier Manen<sup>6</sup>, Gary Gray<sup>7</sup>, Joanna d'Arcy<sup>8</sup>, Ed Nicol<sup>8</sup>  
<sup>1</sup>Netherlands Royal Air Force, Utrecht, Netherlands; <sup>2</sup>German Air Force, Center of Aerospace Medicine, Fuerstenfeldbruck, Germany; <sup>3</sup>U.S. Air Force, Wilford Hall Ambulatory Surgical Center, San Antonio, TX, USA; <sup>4</sup>Swiss Air Force and Cardiac Surgery Department Luzern Kantonsspital, Luzern, Switzerland; <sup>5</sup>Swiss Air Force, Aeromedical Center, Duebendorf, Switzerland; <sup>6</sup>French Military Health Service, Percy Military Hospital, Clamart, France; <sup>7</sup>RCAF, Canadian Forces Environmental Medical Establishment, Toronto, Ontario, Canada; <sup>8</sup>Royal Air Force, Clinical Aviation Medical Service, Henlow, United Kingdom

*(Original Research)*

**INTRODUCTION:** Long QT syndrome (LQTS) is a genetic channelopathy that causes delayed repolarization and may cause ventricular tachycardia (Torsade de Pointes) and cardiac arrest due to ventricular fibrillation in individuals who were previously asymptomatic. The diagnosis is made by ECG (QTc = corrected QT interval > 440 ms) and genetic testing. However, not all patients with a long QT interval on ECG are at high risk for serious arrhythmias. At ECG examination in aircrew, the finding of a long QT interval raises the question whether the (candidate) aircrew can fly or not, and which restrictions may apply. **METHODS:** the risk stratification of long QT will be discussed on the basis of an asymptomatic pilot whose ECG showed a QTc of 450-480 ms on a resting ECG. Later and previous ECGs also showed normal QTc. Additional investigations (exercise test, Holter recording) were done, that showed a maximum QTc of 514 ms on Holter during bradycardia. There were no significant arrhythmias. There were no structural abnormalities. Family history was negative. Genetic testing did not reveal any specific genotype. **RESULTS:** The pilot was considered to have a low to intermediate risk of a major arrhythmic event and allowed to continue to fly OML (Operational Multipilot Limitation) on the basis of the risk calculation and the 3D matrix. The pilot was advised to avoid certain drugs that may prolong QT interval. **DISCUSSION:** For asymptomatic aircrew, a case-by-case decision should take into account all criteria for the aeromedical assessment, including the age of diagnosis, the type of LQTS (mutation identified, expected circumstances and triggers of arrhythmias, possible medical treatment), the duration and stability of QTc (Holter monitoring) and the type of aircraft and aircrew.

**Learning Objectives:**

1. To discuss the significance of long QT syndrome in aircrew, with emphasis on diagnostic problems and risk stratification.
2. To enable the flight surgeon to make a well documented decision about whether the aircrew may continue to fly and which restrictions should be applied.

**[115] THE USE OF PULSE WAVE ANALYSIS FOR THE EVALUATION OF APPLICANTS WITH ELEVATED SYSTOLIC BLOOD PRESSURE**

Norbert Guettler  
 German Air Force Center for Aerospace Medicine, Fuerstenfeldbruck, Germany

*(Original Research)*

**INTRODUCTION:** Arterial blood pressure is usually measured using the methods by Riva-Rocci and Korotkoff. According to EASA regulations, applicants with a systolic blood pressure consistently above 160 mmHg and/or a diastolic blood pressure above 95 mmHg are unfit for flying. The FAA blood pressure limit is 155/95 mmHg. Isolated systolic hypertension is well known in elderly patients. Prognosis and adequate treatment of isolated systolic hypertension, however, probably vary significantly between different age groups. Pulse wave analysis helps to evaluate the cause for systolic hypertension and to assess its prognostic relevance. **METHODS:** Non invasive pulse wave analysis can be used for the measurement of resting or 24 hours ambulatory blood pressure. Besides peripheral blood pressure of the brachial artery, central aortic blood pressure, central pulse pressure, pulse wave velocity, augmentation index and other parameters are indicated. In the German Air Force Center for

Aerospace Medicine a study has been launched to evaluate the mechanism of isolated systolic hypertension in young pilot applicants, to assess the percentage of its occurrence, and to examine its prognostic relevance with regard to organ damage. **RESULTS:** Isolated systolic hypertension in elderly people is caused by reflection and augmentation of the pulse wave due to increased arterial stiffness. Central aortic blood pressure is often higher than peripheral blood pressure. In young people, however, isolated systolic hypertension can be caused by amplification of the pulse waves due to high elasticity of the arteries. In literature, this phenomenon is often called "spurious systolic hypertension of youth" and mostly affects young, tall, and sporty males. Central aortic blood pressure is usually lower than peripheral blood pressure and often within normal limits. According to some authors it may have a benign prognosis, a treatment with antihypertensive drugs may not even be necessary. Two case reports are presented. The study initiated by the German Air Force Center for Aerospace Medicine will be explained. **DISCUSSION:** Pulse wave analysis is a useful method to evaluate isolated systolic hypertension in different age groups. In some young people it may be benign with a different prognostic relevance and different treatment requirements compared to elderly people. Depending on future study results, these differences may have to be considered for aeromedical assessment.

#### Learning Objectives:

1. Get to know pulse wave analysis for blood pressure measurement and its use for evaluating arterial hypertension in different age groups.
2. Get to know "spurious systolic hypertension of youth" and its underlying mechanism.
3. Learn the current scientific knowledge about prognosis and treatment requirements of "spurious systolic hypertension of youth" compared to other forms of arterial hypertension.

#### [116] AVIATION CARDIOLOGY: THE CARDIAC SURGEON'S VIEW

Thomas Syburra<sup>1</sup>, Jo d'Arcy<sup>2</sup>, Gary Gray<sup>3</sup>, Norbert Guettler<sup>4</sup>, Olivier Manen<sup>5</sup>, Denis Bron<sup>6</sup>, Ed Nicol<sup>2</sup>, Rienk Rienks<sup>7</sup>, Eddie Davenport<sup>8</sup>  
<sup>1</sup>Swiss Air Force, Luzern, Switzerland; <sup>2</sup>Royal Air Force, Clinical Aviation Medical Service, Henlow, United Kingdom; <sup>3</sup>Canadian Royal Air Force, Canadian Forces Environmental Medical Establishment, Toronto, Ontario, Canada; <sup>4</sup>German Air Force, Center of Aerospace Medicine, Fuerstenfeldbruck, Germany; <sup>5</sup>French Health Military Service, Percy Training Hospital of the Armies, Clamart, France; <sup>6</sup>Swiss Air Force, Aeromedical Center, Duebendorf, Switzerland; <sup>7</sup>Royal Netherlands Air Force, Military Hospital, Utrecht, Netherlands; <sup>8</sup>U.S. Air Force, Wilford Hall Ambulatory Surgical Center, San Antonio, TX, USA

(Original Research)

**INTRODUCTION:** Aircrew are responsible for safe and reliable aircraft operations. Cardiovascular disease accounts for 50% of all pilot licenses declined or withdrawn for medical reasons in Western Europe and is the most common causes of sudden incapacitation in flight. Aircrew retirement age is increasing and the burden of subclinical, but potentially significant, coronary atherosclerosis is still unknown in pilots above age 40. To fly as a pilot after cardiac surgery is possible; however, special attention to perioperative planning is mandatory. Choice of procedure is crucial for license renewal. Restrictions are likely to apply, particularly with regards to military aviation and high-performance aircraft. Coordination between the cardiac surgeon and the aviation medicine examiner is paramount. **METHODS:** Review of current aeronautical and related surgical literature was accomplished. Online anonymized survey over the global database of cardiac surgeons within the European Association for Cardio-Thoracic surgery was undertaken. **RESULTS:** In Europe, all cardiac surgery cases in pilots must be evaluated by an aviation medicine examiner alongside the operating surgeon and a cardiologist postoperatively. No return to flight duties will be considered earlier than 6 months postoperatively after full assessment. High +Gz environment and sustained Valsalva maneuvers as well as high cardiac output are to be taken into consideration. The indication for specific procedures needs to be weighed with regard to ethical considerations. In Europe, there is a proportion of cardiac surgeons who do not know requirements when operating on pilots. Surgical guidelines differ substantially from aeromedical regulations for flight crew licensing.

**DISCUSSION:** To fly as a pilot after cardiac surgery is possible, but special attention to perioperative planning is mandatory. Choice of procedure (e.g. full revascularization) and prosthetic material (e.g. stentless bioprosthesis) are crucial for license renewal. Unnecessary grounding due to ignorance needs to be avoided at all costs. Licensing restrictions are likely to apply, and the postoperative follow-up requires collaboration and close follow-up. Enhanced knowledge transfer between the surgical and cardiological societies and the aviation authorities ought to support future revisions of the medical regulations for flight crew licensing and cardiac surgery guidelines.

#### Learning Objectives:

1. Where are the pitfalls in cardiac surgery precluding further flight crew licensing?
2. Enhance the awareness of pilots: cardiac surgery isn't the death knell of a flying career.
3. Update the audience about the latest peer-reviewed literature on this topic.

Tuesday, 05/07/2019  
 Brasilia 5

10:30 AM

#### [S-25] PANEL: POSSIBLE EFFECTS OF AEROMEDICAL EVACUATION IN PRECLINICAL POLYTRAUMA RESEARCH MODELS

Endorsed by: Fellows Group, Aerospace Physiology Society, and Aerospace Nursing & Allied Health Professionals Society

Chair: Catriona Miller

Co-Chair: Timothy Webb

**PANEL OVERVIEW:** Aeromedical evacuation (AE) is often used as a rapid and effective way to evacuate patients. However, little is known about the effects of AE. In recent studies we investigated the effects of hypobaria during AE on systemic and neurologic physiology in several swine and rat injury models to include traumatic brain injury (TBI) alone or in combination with hemorrhagic shock (HS) or acute lung injury (ALI) only. A reoccurring observation was the significant reduction in brain tissue oxygenation and signs of increased inflammatory response in several tissue beds in animals exposed to hypobaria and or hyperoxia in a simulated flight. In this panel we provide further evidence of exacerbation of injury in various preclinical injury models of TBI, hemorrhagic stress and stress at three different laboratories.

#### [117] POSSIBLE EFFECTS OF AEROMEDICAL EVACUATION IN PRECLINICAL POLYTRAUMA RESEARCH MODELS

Melissa Mehalick<sup>1</sup>, Françoise Arnaud<sup>1</sup>, Yaron Dayani<sup>1</sup>, Carl Goforth<sup>1</sup>, Debra Malone<sup>2</sup>, Anke Scultetus<sup>1</sup>  
<sup>1</sup>Naval Medical Research Center, Silver Spring, MD, USA; <sup>2</sup>Walter Reed National Military Medical Center, Bethesda, MD, USA

(Original Research)

**INTRODUCTION:** In recent studies we investigated the effects of hypobaria during aeromedical evacuation on systemic and neurologic physiology in several swine injury models to include traumatic brain injury (TBI) alone (PMID: 26998778) or in combination with hemorrhagic shock (HS) (PMID: 29985235) or acute lung injury (ALI) only. A reoccurring observation was the significant reduction in brain tissue oxygenation and signs of increased inflammatory response in several tissue beds in animals exposed to hypobaria in a simulated flight. Here, we report results from our TBI+ALI arm of the study. **METHODS:** After fluid percussion TBI and ALI, anesthetized swine (n=6/group) were stabilized followed by a 4-hour aeromedical evacuation simulated in a hypobaric chamber with atmospheric pressure equivalent to an altitude of 8000 ft. (HYPO). Control animals were kept at normobaria. Systemic and neurophysiologic data were collected. Blood was analyzed for complete blood count, arterial gases, and electrolytes. Data were analyzed with repeated-measures ANOVA; p<0.05 was considered significant. **RESULTS:** Baseline parameters, including arterial oxygen pressures, were similar in both groups. Brain tissue oxygenation (% change over time) was significantly lower (p=0.0418) and arterial lactate was higher



in the HYPO group in the second half of the flight. **DISCUSSION:** In this study, prolonged hypobaria resulted in adverse neurologic physiology despite stable arterial partial pressures of oxygen. These data confirm our findings in previous studies, suggesting that hypobaric conditions have potentially additional detrimental effects on polytrauma patients during aeromedical evacuation. Further studies are indicated to simulate other en route care scenarios and possibly re-evaluate casualty evacuation guidelines.

**Learning Objective:**

1. The audience will learn about the specific pathophysiological changes that are occurring after polytrauma under hypobaric conditions in pre-clinical models of simulated aeromedical evacuation.

**[118] SIMULATED AEROMEDICAL EVACUATION IN A POLYTRAUMA RAT MODEL**

Francoise Arnaud<sup>1</sup>, Anke Scultetus<sup>1</sup>, Debra Malone<sup>2</sup>, Carl Goforth<sup>1</sup>  
<sup>1</sup>Naval Medical Research Center, Silver Spring, MD, USA; <sup>2</sup>Air Force Trauma Center, Bethesda, MD, USA

*(Original Research)*

**INTRODUCTION:** The aeromedical evacuation (AE) of critically wounded combat casualties from the battlefield to higher level of care may worsen their clinical stability, particularly if complicated with traumatic brain injury and hemorrhage. These problems could be enhanced in case of mass casualty and delayed evacuation. This study evaluated the impact of aeromedical evacuation in a polytrauma rat model. **METHODS:** Following instrumentation (t1), anesthetized Sprague-Dawley rats were either non-injured or injured with a 72-75 kPa blast and a 30% estimated-blood-volume controlled hemorrhage (polytrauma). After 15 minutes (t2), all rats were allowed resuscitation with normal saline. Rectal temperature, heart rate (HR), mean arterial pressure (MAP) and peripheral oxygen saturation (SpO2) were monitored throughout. Resuscitation was followed by simulated AE vs ground transport. During the simulated 3-hours AE in a hypobaric chamber at 2440 m (8000ft) heart rate (HR), temperature and oxygenation (SpO2) were recorded. Control animals underwent the same procedures followed by a simulated transport at sea level (normobaria). Rats were either euthanized immediately after evacuation (t3) or after 72hour recovery (t4). Hematology and metabolic levels were measured at t1, t2, t3 and t4. All rats were divided into sub-groups by block randomization and a SPSS software was used to perform 2-way ANOVAs to analyze independent variables (injury and transport). The study protocol was approved by the WRAIR/NMRC Institutional Animal Care and Use Committee **RESULTS:** Survival was 100% in sham animals and 83% in normobaria injured animals. However, under hypobaric evacuation, survival was reduced to 50% at t3 after AE. All animals that survived transport lived to 72 hours. This simulated evacuation setting caused HR, temperature and SpO2 in the animals under hypobaria to remain significantly lower after transport than those under normobaria (p<0.05). The reduced oxygen level (p<0.01) with the lower MAP (p<0.01) after injury was a critical factor for survival during evacuation. **DISCUSSION:** Physiological parameters were adversely affected during aeromedical evacuation and this was worsened when the animals were injured, particularly after a resuscitation regimen that was slightly hypotensive. Low mean arterial pressure caused low SpO2 in the hypobaric chamber and had a significant impact on mortality of severely traumatized rats.

**Learning Objectives:**

1. A small animal model is informative of the effect of air evacuation after injury.
2. The physiology of the injured is affected during the flight.
3. High mortality can occur during or soon after the flight.

**[119] HYPOBARIC CONDITIONS AGGRAVATE HISTOPATHOLOGICAL INJURY AND MODIFY INFLAMMATORY RESPONSE IN RATS EXPOSED TO BLAST OVERPRESSURE INJURY**

Yaron Dayani<sup>1</sup>, Joshua Stierwalt<sup>1</sup>, Andrea White<sup>1</sup>, Ye Chen<sup>1</sup>, Francoise Arnaud<sup>1</sup>, Michelle Jefferson<sup>2</sup>, Carl Goforth<sup>1</sup>, Debra Malone<sup>1</sup>, Anke Scultetus<sup>1</sup>

<sup>1</sup>Naval Medical Research Center, Silver Spring, MD, USA; <sup>4</sup>Walter Reed Army Institute of Research, Silver Spring, MD, USA

*(Original Research)*

**INTRODUCTION:** Aeromedical evacuation (AE) is often used as a rapid and effective way to evacuate patients. However, little is known about the effects of AE, which includes hypobaria, on patients with blast injuries. In the current study, we investigated the effects of hypobaria during AE on histologic injury and inflammatory response on rats exposed to blast overpressure injury. **METHODS:** Anesthetized male Sprague Dawley rats were exposed to blast overpressure of 110kPa, causing Trauma Brain Injury (TBI group). After 48hr, 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). Control animals underwent the same experiments but without blast (SHAM). All animals were euthanized 48 hours after flight, peripheral blood was sampled via cardiac puncture (for cytokine and inflammatory cell analysis) and animals were perfused and organs were quantitatively scored for histopathologic injury. **RESULTS:** Generally, TBI Animals demonstrated numerically higher histopathologic injury scores as compared to controls (lungs: p<0.01, brain: p<0.001, kidney: p<0.05, heart: p<0.001, intestine: p<0.01), which was elevated in animals exposed to hypobaria (lungs: p< 0.05). TBI animals exposed to normobaria exhibited a pro-inflammatory response compared to those that were not blasted (MCP-1: p<.05, Fractalkine: p<.01, leukocytes: p<.05), an observation that was not seen in TBI animals exposed to hypobaria. **DISCUSSION:** In rats exposed to blast, simulated AE in hypobaric condition showed increased evidence of histopathologic injury in contrast to NORMO group. The TBI HYPO inflammatory data imply a decreased ability of the immune system to mount a commensurate immunologic response to subsequent hypobaria post blast injury. This suggests 48-hour post-blast AE may lead to impairment in the inflammatory process and worse long-term outcomes. Other factors that may contribute to these observations are vibration, temperature and length of flight. These factors are currently under examination.

**Learning Objective:**

1. The effect of hypobaric condition on injury and inflammatory response.

**[120] HYPERHOMOCYSTEINEMIA-INDUCED PHYSIOLOGICAL STRESS EXACERBATES BLOOD BRAIN BARRIER DISRUPTION AND INFLAMMATION IN RATS WITH TRAUMATIC BRAIN INJURY**

Flaubert Tchanchou<sup>1</sup>, Gary Fiskum<sup>1</sup>, Catriona Miller<sup>2</sup>, Molly Goodfellow<sup>1</sup>

<sup>1</sup>University of Maryland School of Medicine, Baltimore, MD, USA;

<sup>2</sup>USAF School of Aerospace Medicine, Baltimore, MD, USA

*(Original Research)*

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. A total of 85 Male Sprague-Dawley rats (250-300 g; Envigo, Denver, CO) received daily 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 using Tukey-Kramer post-test analyses. The study was approved by the University of Maryland Institutional Animal Care and Use Committee. 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. HHCY exacerbates nitrotyrosine-induced astrogliosis and BBB permeability and promotes blood clotting and diffuse inflammation following mild TBI in rats. Note: We have ongoing experiments examining the effects of hypobaric exposure on homocysteine metabolism, oxidative stress and behavioral impairments.

### [121] MECHANISMS BY WHICH AEROMEDICAL EVACUATION-RELEVANT HYPOBARIA WORSENS MORTALITY FOLLOWING POLYTRAUMA

Gary Fiskum, Julie Proctor, Juliana Medina, Parisa Rangghran, Turhan Coksaygan, Rao Gullapalli, Rosemary Kozar  
*University of Maryland School of Medicine, Baltimore, MD, USA*

(Original Research)

**BACKGROUND:** Rats exposed to 6 h aeromedical evacuation-relevant hypobaric at 24 h following polytrauma (PT), consisting of traumatic brain injury (TBI) plus hemorrhagic shock (HS), exhibit greater 30-d mortality than those maintained under normobaric conditions. This study used magnetic resonance imaging (MRI) measurements of cerebral blood flow (CBF) and neurochemical levels during exposure to hypobaric to help understand the effects of hypobaric on brain injury and histologic measurements of inflammation in the brain, lung, gut, and kidneys to understand the effects on mortality. **METHODS:** Following controlled cortical impact TBI, rats were subjected to HS (mean arterial pressure 35-40 mmHg) for 30 min. Resuscitation used Hextend followed by blood reinfusion. At 24 h post-surgery, rats were placed in a "flight chamber" and exposed to either normobaric (sea level) or hypobaric (=8000 ft altitude) for 6 h under normoxic (21 or 28% O<sub>2</sub>) or hyperoxic (100% O<sub>2</sub>) conditions. Cerebral cortex lesion volumes were determined. Rats were also tested for inflammation and histopathology in the gut, lungs, and kidneys. Additional rats were placed in a flight chamber positioned within the bore of the MRI scanner, allowing for MRI and MR spectroscopy measurements before, during, and after exposure to hypobaric. **RESULTS:** Mortality was greatest following exposure to hypobaric under 100% O<sub>2</sub> and least in rats maintained under normobaric and normoxic conditions (28%). Histology performed with tissues obtained at 2-30 d post-injury indicated that inflammation in the gut, lung, and kidneys was greatest in the hypobaric/hyperoxia group. MRI measurements of CBF indicated that it was reduced in the rats exposed to hypobaric/hyperoxia compared to normobaric/normoxia. **CONCLUSIONS:** Exposure of rats after PT to 6 h of hypobaric or hyperoxia or both results in increased mortality. Based on histopathology, the cause for this increase is multiple organ dysfunction syndrome. The unique measurements of MRI and MR spectroscopy during exposure to hypobaric under hyperoxia indicate that CBF is reduced in comparison to that observed during normobaric and normoxia. Studies are in progress to determine if the reduction in CBF is due to elevated intracranial pressure. Such pressure differences in the brain and other organs could result in vascular leakiness, followed by inflammatory neutrophil and macrophage infiltration. Supported by U.S. Air Force FA8650-15-2-6D21 and FA8650-17-2-6H13.

#### Learning Objectives:

1. The audience will learn about the potential detrimental effects of exposure to air evacuation relevant hypobaric following traumatic brain injury.
2. The participant will be able to understand how hypobaric following polytrauma can increase mortality by promoting multiple organ dysfunction.
3. The audience will learn about MRI measurements performed with lab rats during exposure to hypobaric.

Tuesday, 05/07/2019  
Brasilia 7

10:30 AM

## [S-26] PANEL: SUPPLYING A PHARMACY FOR EXPLORATION SPACEFLIGHT: CHALLENGES AND CURRENT UNDERSTANDING

Chair: Rebecca Blue

Co-Chair: Tina Bayuse

**PANEL OVERVIEW: INTRODUCTION:** There is a paucity of evidence regarding pharmaceutical stability in the space environment, largely because this issue has not historically been a pressing concern for human spaceflight. **TOPIC:** Short-duration flights of the Mercury, Gemini, Apollo, and Space Shuttle eras minimized the need for prolonged medication shelf life, and the selection of healthy crewmembers minimized the need for ongoing medication provision for chronic disease. Careful maintenance of crew health and stringent flight rules regarding the more dangerous activities during spaceflight, such as extravehicular activity (EVA), have largely obviated the need for emergency medication provision. Even now, with missions to the International Space Station (ISS) lasting 6 months or longer, crews have been able to rely on medication availability through retirement of expired medications and frequent resupply rather than contending with questions of degradation, storage, and the impact of the space environment. As a result, investments in the systematic collection of data for the characterization of medication use, efficacy, side effects, pharmacokinetics, pharmacodynamics, and long-term stability have historically been a lower priority than other Health and Human Performance investments. **APPLICATION:** With the push for exploration missions to the moon and Mars, these questions have become a more pressing concern. Here we will present the current state of literature regarding pharmaceutical stability, metabolism, and effectiveness during spaceflight. In particular, we have attempted to highlight the gaps in current knowledge and the difficulties in translating terrestrial-based drug studies to a meaningful interpretation of drug stability, safety, and effectiveness in space. We hope to identify high-yield opportunities for future research that might better define and mitigate pharmaceutical risk for exploration missions.

### [122] THE USE OF PHARMACEUTICALS IN SPACEFLIGHT: A HISTORICAL REVIEW

Rebecca Blue<sup>1</sup>, Tina Bayuse<sup>2</sup>

<sup>1</sup>Geocontrol, Inc, Houston, TX, USA; <sup>2</sup>KBRwyle, Houston, TX, USA

(Education - Program / Process Review Proposal)

**INTRODUCTION:** Fifty years ago, man first walked on the moon. On this historical anniversary, we will review the role of pharmaceuticals over the course of human spaceflight, specifically reviewing the medications flown during historical missions and how pharmaceutical formularies have evolved over the years. **TOPIC:** This presentation will examine the ways in which onboard medications reflect medical concerns and evolving challenges in spaceflight, including changing mission parameters, goals and objectives, and crew makeup. We will additionally discuss the ways in which pharmaceutical reliance has changed as our space program has evolved from short duration missions to longer missions outside of low-Earth orbit to, most recently, establishing a permanent human presence in low-Earth orbit. **APPLICATION:** Historical precedent and experience provides insight regarding the challenges of an evolving formulary, including the introduction of new medications, the limitations in formulary testing during spaceflight and analogs, and the paucity of data collected over the past five decades regarding medication stability, efficacy, pharmacokinetics, pharmacodynamics, and unique threats of the space environment imposed by changing mission parameters.

#### Learning Objectives:

1. The audience will learn about historical use of pharmaceuticals over the span of human spaceflight history.
2. Historical review will provide education to the audience regarding the evolution of the spaceflight pharmaceutical formulary, the evidence supporting choice and use of medications in space, and the need for further review of practices to appropriately choose future formularies for evolving mission objectives.

**[123] LIMITATIONS IN UNDERSTANDING USE, STABILITY, AND EFFECTIVENESS OF MEDICATIONS DURING SPACEFLIGHT**Tina Bayuse<sup>1</sup>, Rebecca Blue<sup>2</sup>, Vernie Daniels<sup>1</sup>, Wendy Cory<sup>3</sup>, Ginger Wotring<sup>4</sup>, Erik Antonsen<sup>4</sup><sup>1</sup>KBRwyle, Houston, TX, USA; <sup>2</sup>Geocontrol, Inc, Houston, TX, USA;<sup>3</sup>College of Charleston, Charleston, SC, USA; <sup>4</sup>Baylor College of Medicine, Houston, TX, USA*(Education - Program / Process Review Proposal)*

**INTRODUCTION:** Medication use during spaceflight is not comprehensively monitored, largely due to conflicting crew time demands and a desire to avoid onerous tracking procedures for common medication use. **TOPIC:** While astronauts are encouraged to discuss symptoms, illness, or medication use with their flight surgeon, much of this discussion occurs without required documentation. Documentation that does occur is highly variable, physician-dependent, relies on crewmember recall potentially several days after medication use, and often lacks information such as specific medications consumed, dosage, indication, effectiveness, or any side effects. The need for careful inventory tracking or monitoring of drug consumption has been a low priority due to the historical capability to frequently resupply medication stock. Further, there is limited information regarding the stability of medications over time, or how effectiveness changes during the lifespan of pharmaceutical stock. **APPLICATION:** There is a paucity of information available regarding the frequency of medication consumption, the quantity of medications used over time, the stability of flown medications, or the mass and volume of pharmaceuticals that might be needed for a given reference mission. Here we will discuss these limitations and how they affect future challenges likely to be faced in longer-duration exploration missions.

**Learning Objective:**

1. The audience will learn about the current state of understanding of pharmaceutical stability in the space environment and be able to identify gaps in knowledge that present challenges for future long duration spaceflight.

**[124] LIMITATIONS IN UNDERSTANDING THE PHARMACOKINETICS AND PHARMACODYNAMICS OF MEDICATIONS IN SPACEFLIGHT**Virginia Wotring<sup>1</sup>, Tina Bayuse<sup>2</sup>, Rebecca Blue<sup>3</sup>, Vernie Daniels<sup>2</sup>, Wendy Cory<sup>4</sup>, Erik Antonsen<sup>1</sup><sup>1</sup>Baylor College of Medicine, Houston, TX, USA; <sup>2</sup>KBRwyle, Houston, TX, USA; <sup>3</sup>GeoControl Inc., Houston, TX, USA; <sup>4</sup>College of Charleston, Charleston, SC, USA*(Education - Tutorial Proposal)*

**INTRODUCTION:** There is limited knowledge regarding alterations of pharmacokinetics (body effects on the drug, such as absorption, distribution, metabolism, and excretion of a medication) and pharmacodynamics (drug effects on the body) in the space environment. **TOPIC:** As the human body undergoes significant physiological and metabolic changes during spaceflight, it stands to reason that the effects of pharmaceuticals on an astronaut may change during flight. Alterations of hepatic blood flow due to fluid shifts from gravitational unloading may lead to altered hepatic metabolism and variable enzyme activity. Delayed gastric emptying due to microgravity conditions, associated space motion sickness, or side effects of medications used to control spaceflight-induced nausea, perhaps in combination with variable intestinal wall edema caused by fluid shifting, may alter drug absorption in the gastrointestinal tract. Reduced total body water due to fluid shifting and renal excretion may alter the volume of distribution for consumed drugs. Variable protein expression, altered serum albumin levels, and altered renal blood flow may further affect drug absorption, distribution, metabolism, and excretion. However, research on the impact of spaceflight-induced physiological changes on pharmaceutical activity has largely been limited to observational reports and analog studies. **APPLICATION:** We will discuss the current state of understanding of pharmacokinetics and pharmacodynamics in the space environment, extrapolating potential challenges for future missions and addressing current gaps in addressing such challenges.

**Learning Objective:**

1. The audience will understand the current state of literature regarding pharmacokinetics and pharmacodynamics in spaceflight and the paucity of evidence supporting appropriate selection of medications for a long duration mission formulary.

**[125] LIMITATIONS IN PREDICTING RADIATION-INDUCED PHARMACEUTICAL INSTABILITY DURING LONG-DURATION SPACEFLIGHT**Rebecca Blue<sup>1</sup>, Tina Bayuse<sup>2</sup>, Jeffery Chancellor<sup>3</sup>, Vernie Daniels<sup>2</sup>, Virginia Wotring<sup>4</sup>, Erik Antonsen<sup>4</sup><sup>1</sup>Geocontrol, Inc, Houston, TX, USA; <sup>2</sup>KBRwyle, Houston, TX, USA;<sup>3</sup>Texas A&M University, College Station, TX, USA; <sup>4</sup>Baylor College of Medicine, Houston, TX, USA*(Education - Program / Process Review Proposal)*

**INTRODUCTION:** As human spaceflight seeks to expand beyond low-Earth orbit, NASA and its international partners face numerous challenges related to ensuring the safety of their astronauts, including the need to provide a safe and effective pharmacy for long-duration spaceflight. Historical missions have relied upon frequent resupply of onboard pharmaceuticals; as a result, there has been little study into the effects of long-term exposure of pharmaceuticals to the space environment. One potential risk to long-term pharmaceutical stability arises from prolonged exposure to the space radiation environment. **TOPIC:** While gamma radiation exposure has been used terrestrially for sterilization procedures in select pharmaceuticals, space radiation differs considerably from such practices because of differences in type of radiation, dose, dose-rate, and length of exposure. It is unclear whether long-term exposure to space radiation may affect stability, alter drug ingredients, or produce potentially toxic byproducts, particularly in drugs that have undergone degradation reactions. The long-term effects of space radiation on drug stability, especially as missions venture away from the protective proximity of the Earth, is a topic of increasing discussion. **APPLICATION:** This presentation will highlight the risk of space radiation to pharmaceuticals during exploration spaceflight, identifying the limitations of current understanding. We will further identify ways in which these limitations could be addressed through dedicated research efforts aimed towards the rapid development of an effective pharmacy for future spaceflight endeavors.

**Learning Objective:**

1. The audience will learn about the impact of space radiation on the stability of pharmaceuticals and the ways in which this impact may affect future formulary selection, effectiveness, and medical operations in long-duration spaceflight.

**[126] OPERATIONAL IMPACT OF AN ONBOARD PHARMACY: MISSION IMPACT AND RISK CONSIDERATIONS**Robert Mulcahy<sup>1</sup>, Tina Bayuse<sup>2</sup>, James Pattarini<sup>1</sup>, Rebecca Blue<sup>3</sup><sup>1</sup>NASA, Houston, TX, USA; <sup>2</sup>KBRwyle, Houston, TX, USA; <sup>3</sup>Geocontrol, Inc, Houston, TX, USA*(Education - Program / Process Review Proposal)*

**INTRODUCTION:** Pharmaceutical intervention is an essential component of risk management planning for astronaut healthcare during exploration spaceflight. However, there is limited understanding of current spaceflight pharmaceutical usage and effectiveness, drug stability, and altered pharmacokinetics and pharmacodynamics in the space environment. This limitation significantly constrains efforts to assemble an exploration formulary that is both comprehensive enough to prevent and treat anticipated medical events and chemically stable, safe, and robust enough to last the duration of the mission. **TOPIC:** The majority of operational interventions that address medical risks in spaceflight are likely to rely on pharmaceutical use. A current review of NASA's Human Research Roadmap identifies medication use as the primary countermeasure for prevention or management of most conditions. In an analysis of medical capabilities needed for a Mars transit mission, NASA's Exploration Medical Capability Element (ExMC) has preliminarily identified onboard medications as the largest single component of the complete medical capability, potentially accounting for more than a quarter of all medical interventions. This projection is

consistent with our limited experience on ISS. Medical kits aboard the ISS contain medications and supplies to help crewmembers cope with a variety of possible medical events including space motion sickness, sleep disruption, illnesses, injuries, and behavioral health problems. While medication usage reporting is not consistent, historical documentation indicates that more than 80% of crewmembers took medications at some time during Space Shuttle missions, further demonstrating our reliance upon pharmaceuticals to manage onboard health concerns.

**APPLICATION:** This presentation will discuss the operational impacts of an onboard pharmacy, specifically highlighting the risk associated with an inability to supply a safe, robust, and comprehensive formulary for long-duration spaceflight outside of low-Earth orbit and ways in which we can begin to address this risk.

**Learning Objective:**

1. This presentation will discuss the operational impacts of an onboard pharmacy, specifically highlighting the risk associated with an inability to supply a safe, robust, and comprehensive formulary for long-duration spaceflight outside of low-Earth orbit and ways in which we can begin to address this risk.

**Tuesday, 05/07/2019**

**10:30 AM**

**Miranda 5/7**

**[S-27] SLIDE: AE & LIFE SUPPORT SYSTEMS**

**Chair: Philip Buys**

**Co-Chair: Jami Buckley**

**10:30 AM**

**[127] CRITICAL CARE FLIGHT PARAMEDIC MEDICAL TASK SATURATION STUDY - UNCONSTRAINED ENVIRONMENT**

Amey Lloyd<sup>1</sup>, Rachel Kinsler<sup>1</sup>, Marcy Conti<sup>1</sup>, Khalid Barazanji<sup>1</sup>, George Hilderbrandt<sup>2</sup>

<sup>1</sup>U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA;

<sup>2</sup>U.S. Army Medical Evacuation Proponency Division, Fort Rucker, AL, USA

*(Original Research)*

**INTRODUCTION:** A recent study defined the minimum space for a critical care flight paramedic (CCFP) to perform enroute care tasks as 28 inches (in.) vertical separation, but did not define the number of trauma patients a CCFP was able to give care to in the ideal environment. This study examined the medical task completion rates when treating 1 to 2 simulated patients, in order to use quantitative metrics to define the ideal number of patients. The total duration for each medical task was measured to see which tasks took the most time to complete. **METHODS:** There were two groups of CCFP test participants (TP), either more (n=10) or less (n=9) experienced based on if they were more or less than 24 months away from their National Registry paramedics course successful completion date. The TPs performed medical tasks on simulated trauma patients (Laerdal Medical SimMan® 3G manikins). First each TP was asked to complete configuration (C1) with one urgent (S1) and one priority patient (S3). If they failed C1 they were given a configuration with one urgent patient (S7). The time data from the video taken during testing was evaluated to identify the retrieval time, preparation time, and application time for each task. All of the tasks were broken down into the following categories: Patient Assessment, Airway, Treatment, Fluid, Medication, and Cardiac tasks. **RESULTS:** The average total time the TPs spent on Patient Assessment tasks was S1=388.7 seconds (s), S3=342.0 s, and S7=867.2 s. The average number of Patient Assessment tasks completed by a single TP was 24.5, 20.8, and 43.1 tasks respectively for the scenarios. The average total duration for the administering fluid tasks are S1=245.7 s, S3=239.0 s, and S7=394.4 s. The average number of Fluid tasks completed by each TP which was 2.6, 2.7, and 4.4. **DISCUSSION:** The majority of TPs spent the most time on Patient Assessment tasks, likely due to high repetition rates. Fluid task took the longest to complete on average, the high completion time could be due to the higher preparation times. The high repetition rates and preparation times may be the largest contributing factors to the high failure rates. By identifying the most time-consuming medical tasks for the CCFPs, developers can

explore materiel solutions to reduce time and workload (ex. automated dispensing of correct medication doses).

**Learning Objectives:**

1. The audience will learn whether the duration of medical tasks affect the flight paramedics' ability to render critical care for more than one patient aboard a medical evacuation helicopter.
2. The audience will learn flight paramedics' average task the duration of specific medical procedures used on one-patient and two-patient configurations.

**10:45 AM**

**[128] MEDICAL SUPPORT TO COMBAT OPERATIONS IN A CHEMICALLY CONTESTED ENVIRONMENT**

Christopher Backus

U.S. Air Force, Montgomery, AL, USA

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** USA changed its Grand Strategy with the 2017 National Security Strategy (NSS) and aligned 2018 National Defense Strategy (NDS), pivoting to focus on near peer competitors. In recent conflicts, U.S. and allied militaries have enjoyed a record low died of wounds rate, but this effectiveness occurred in a setting of air dominance allowing rapid aeromedical evacuation to highly-capable facilities outside the combat zone and rapid resupply into the combat zone. Over the past several years at Air University (AU), members of the Air Force Medical Service (AFMS) have considered Medical Support for Combat Operations in a Denied Environment. Currently, a task force is considering a perceived gap given recent successes in casualty care in a setting of unfettered access to the combat zone but the knowledge that access could be contested by use of chemical weapons. **OVERVIEW:** This research considered existing Air Force preparation and whether it assured seamless medical operations in a chemically contested environment and finding gaps, considered a course of action to narrow that gap. **DISCUSSION:** Medical care and aeromedical evacuation in Iraq and Afghanistan reached record low died of wounds rates, but this depended on air dominance and a resulting permissive air mobility environment. Changes to this permissive environment, contesting flow into and out of a combat zone, heralded a threat to that success. U.S. Military chemical response was compared against similar medical response to organophosphate poisoning and this comparison highlighted the difficulty to establish a "gold standard" in low probability, historically rare, military specific medical concerns. All medics that might operate in a contested environment potentially benefited from this research. Analysis of current preparation not only helps military wounded of all services and all nations who might suffer in a system designed for permissive aeromedical evacuation and aerial resupply, but also serves to consider risks of highly efficient but specialized systems that may sacrifice adaptability. This question also serves as a model to consider military medical issues where level of evidence suffers due to lack of trials or even historical data, given the rarity of this threat.

**Learning Objectives:**

1. The audience will understand how current USA and coalition medical care has benefited from a permissive air mobility environment and how that could be threatened by chemically contesting access.
2. Participants will see one example of how evidence for military medical care can sometimes be limited to lower levels of the desired hierarchy of evidence through a comparison with a similar civilian standard of care.

**11:00 AM**

**[129] AIRCRAFT LIFE SUPPORT SYSTEM QUALIFICATION: WHY, HOW?**

Nicholas Green

RAF Centre of Aviation Medicine, Henlow, United Kingdom

*(Education - Tutorial Proposal)*

**INTRODUCTION:** To provide adequate physiological protection for aviators, and to minimize in-flight events, it is critical to understand why and how life support systems should be tested to recognized performance standards, before they are fielded on the front line. **TOPIC:** Aircraft

life support systems (and breathing systems in particular) will always be a compromise between performance, cost, reliability, physical size and complexity. Where this compromise lies will depend largely on the use to which the system is put (for example in transport aircraft vs fighters; the acceptability of these compromises is encapsulated in performance standards that are the result of years of research and operational experience. Typical documents include NATO STANAGs, AFIC Air Standards, U.S. DoD MIL-STDs and UK MOD Def Stans. A key feature of these standards is that they consider performance of the system as a whole, and so when requirements are examined in isolation they may appear overly demanding. However, when a series of requirements all achieve minimum acceptable performance, the whole system should still offer adequate physiological protection. For a breathing system, the fundamental goals are to deliver adequate flow of gas to meet respiratory demand, and for the composition of the gas delivered to the respiratory tract to be appropriate. To achieve this, we need adequate knowledge of the physiological demands likely to be made by the aviator, and what may happen to performance or flight safety if those demands are not met. For example, failure to meet breathing flow during stressful periods of flight in a fighter may lead to physiological symptoms that are not present when the system is tested under normal conditions. If performance-based specifications are used, care must be taken to ensure such issues are addressed. This presentation will highlight some of these performance requirements and give examples of real-life issues encountered in aircraft development programs. **APPLICATION:** The need for adequate life system support testing should be considered early during aircraft acquisition phases and can be improved by applying agreed standards to the requirement. Whole system tests are an essential component of this assurance.

#### Learning Objective:

1. The participant will be able to understand the critical role that aeromedical standards play in the assessment and delivery of safe and effective aircrew life support systems to front line military aircraft.

#### 11:15 AM

### [130] EXPLAINING THE INCREASE IN REPORTED PHYSIOLOGICAL EPISODES: PERCEPTIONS AMONG NAVAL JET AVIATORS

Brennan Cox, Panagiotis Matsangas, Lawrence Shattuck, Nita Shattuck

Naval Postgraduate School, Monterey, CA, USA

#### (Original Research)

**INTRODUCTION:** Since 2010, naval jet aviators have dramatically increased their reported experience of physiological episodes (PEs). Extraordinary efforts have been undertaken by numerous organizations (including the Navy, DOD, other federal agencies, and defense contractors) to determine root causes and work toward elimination of PEs. To provide structure to this process, PMA-265 and PMA-273 developed failure trees specifying several hundred unique systems requiring further investigation, ranging from aircraft components to aircrew behaviors. Our study asked aviators directly, based on their experience, what factors they consider to be responsible for the increase in reported PEs. **METHODS:** In January 2018, all active U.S. Navy and Marine Corps F/A-18 and T-45 aircrew and F/A-18 maintainers (~6,500 personnel) were invited via email to participate in an online survey regarding PEs and aircraft system performance. The survey consisted primarily of rating scale items addressing issues ranging from flight gear, to training procedures, to command culture considerations. The first and last questions of the survey, however, were open-ended, and asked specifically: "Based on your personal or second-hand knowledge of PEs, why do you think there has been a recent increase in reported episodes?" **RESULTS:** Valid data were received from 788 aviators and 435 maintainers (19% response rate). Among the respondents, 191 F/A-18 and 23 T-45 aviators had personally experienced a PE at some point in their careers. Content analysis of the open-ended data yielded 15 categories of response. The most common explanations for the increase in reported PEs included increased awareness and improved reporting procedures; aging/deteriorating airframes; changes to maintenance standards; inadequately designed

systems; and a hypersensitivity to report any physiological symptom as a PE. **DISCUSSION:** Our results provide insights into the beliefs and perceptions that are shared among naval jet aviators and maintenance personnel regarding the causal factors associated with PE reporting. Explanations for the increase in reported PEs vary, with some respondents indicating PEs have always existed and that aviators are just now more comfortable reporting them (increase in true positives), while others suggest aviators may be over-reporting events that are not PEs (increase in false positives). Applications and limitations to these data within the larger failure tree investigation will be discussed.

#### Learning Objectives:

1. The audience will learn about the reasons naval jet aviators and maintenance personnel attribute to the increased in reported physiological episodes.
2. The audience will be able to describe ways in which self-report survey data can and cannot be used to inform failure tree close-out processes.
3. The audience will learn about applications of human systems integration within the context of the physiological episodes.

#### 11:30 AM

### [131] DETECTION OF MULTIPLE LEVELS OF HYPOXIA THROUGH NOVEL FEATURE ANALYSIS AND MACHINE LEARNING

Chad Stephens<sup>1</sup>, Asher Saunders<sup>2</sup>, Kellie Kennedy<sup>1</sup>, Benton Calhoun<sup>2</sup>, Nicholas Napoli<sup>2</sup>

<sup>1</sup>NASA Langley Research Center, Hampton, VA, USA; <sup>2</sup>University of Virginia, Charlottesville, VA, USA

#### (Original Research)

Reliable and consistent induction of cognitive impairment is important to the experimental study of human operator performance (i.e., commercial aviation pilots). The specific purpose of this study was to investigate the use of normobaric hypoxia induction as a method to induce mild cognitive impairment in human operators. The current analyses examine the potential for improved prediction of hypoxia category. Professional pilots served as test subjects (n=57, 49 males) in the study involving simulated altitudes of sea level (21.0% O<sub>2</sub>) and 15,000 feet (11.2% O<sub>2</sub>) induced by an Environics, Inc. Reduced Oxygen Breathing Device. Each subject experienced both non-hypoxic and hypoxic exposures while performing three 10-minute tasks (computerized neuropsychology tests, computerized multi-tasking battery, and fixed-based flight simulation). The analyses of the physiological data (EEG, EKG, Respiratory Effort, GSR, pilot age, pilot BMI) recorded from the test subjects included statistical methods and machine learning techniques: Multinomial Logistic Regression, K-Nearest Neighbor (KNN), and Random Forest. Levels of hypoxia experienced were categorized based on peripheral SPO<sub>2</sub> as follows for ground truth labeling purposes: completely non-hypoxic state (100-95%), indifferent hypoxia (95-85%), compensatory hypoxia (75-85%), and critical hypoxia (<75%). Prediction Accuracy for the four levels of hypoxia using EEG features derived from activation complexity analysis was compared to traditional spectral power analysis. Analyses of features from activation complexity analysis of EEG resulted in higher classification accuracy (80.2%) of hypoxia category than features from traditional spectral power analysis of EEG (71.3% accuracy). Examining the implications of subject-specific models vs. general models of hypoxia classification indicated that accuracy was 80.2% and 51.8% respectively. These results indicate that improved classification accuracy for determining a subject's level of hypoxia can be accomplished using only EEG data through advanced feature engineering approaches that capture activation complexity. The contrast between classification accuracy for general models and subject-specific models indicates that models trained specifically for the test subject outperform the generally trained model. Further implications of these results, specifically analyses for classification of cognitive impairment due to the induced hypoxia, will be presented and discussed.

#### Learning Objective:

1. Discover how mild hypoxia exposure can impact operator performance.

11:45 AM

**[132] INCIDENCE OF ALTITUDE DECOMPRESSION SICKNESS (DCS) AMONG AIRCREW IN HYPOBARIC HYPOXIA TRAINING**Erdinc Ercan, Abdurrahman Engin Demir, Eda Sabaner  
University of Health Sciences, Eskisehir, Turkey

(Original Research)

**INTRODUCTION:** Aircrews are required to undergo periodic physiological trainings. Hypobaric chamber flight is one of these trainings in which the effects of changes due to hypobaric hypoxia and hypobarism itself on human physiology at altitude are demonstrated. During these trainings, the chamber was taken to a maximum altitude of 25,000 ft. to eliminate the risk of Decompression Sickness (DCS), denitrogenation (prebreathing) protocol is applied by breathing 100% oxygen for 30 minutes prior to the training. DCS is rarely seen during hypobaric trainings; but on the other hand it is one of the most hazardous results of decrease in cabin pressure during flight. Hyperbaric Oxygen Therapy (HBOT) is breathing 100% oxygen under increased atmospheric pressure in a chamber and is being successfully used in many indications, especially requiring urgent treatment, such as DCS, air-gas embolism, carbon monoxide poisoning etc. In this retrospective study, we aimed to determine the frequency of DCS events and its symptoms among aircrew during hypobaric chamber training. **METHODS:** Number of trainings and DCS cases occurred between January 2011 and September 2018 were determined by reviewing HBOT patient records. **RESULTS** were given as percentage and numbers. Each stage of the research was carried out on the basis of the Helsinki declaration and the ethics committee approval was granted by "Osmangazi University Clinical Research Ethics Committee". **RESULTS:** We evaluated 6 cases of DCS resulted from hypobaric chamber training in 6590 aircrew. The overall DCS incidence for aircrew was 0.091%. One session of HBOT was administered for each case. Over the period January 2011 to September 2018, HBOT was administered to 1965 patients and DCS was 0.305% of them. Considering Acute HBOT indications, HBOT was administered to 573 patients and altitude DCS was calculated as 1.04%. Most common symptom was shoulder pain.

**DISCUSSION:** Although rare, there is always a risk of DCS during hypobaric hypoxia trainings despite the 30-min prebreath prior to altitude exposure. It is of crucial importance to inform aircrew to be aware of warning symptoms for rapid diagnosis and treatment of DCS.

**Learning Objectives:**

1. It is important to keep in mind that hypobaric exposure poses a DCS risk.
2. HBOT is a primary treatment for DCS.
3. DCS signs and symptoms are as much important as hypoxia symptoms to be aware of.

Tuesday, 05/07/2019  
Brasilia 1

2:00 PM

**[S-28] PANEL: ADOPTING THE MILITARY FOR A RE-PARENTING EXPERIENCE: PSYCHOSOCIAL DEVELOPMENT WHILE SERVING IN THE ARMED SERVICES**

Chair: Daron Watts

**PANEL OVERVIEW: INTRODUCTION:** Currently 1.3 million uniformed members serve in the Department of Defense with an additional 41,000 in the USA Coast Guard. Active duty service has long been considered an attractive option for those with limited financial or educational prospects. Minorities and individuals with lower socio-economic backgrounds, academic performance, or a history of delinquency are more likely to enlist. Most recent recruits identified "Better my life" and nearly half included "To pay for future education" among their reasons for joining. **TOPIC:** Life in the armed services provides an opportunity for personal growth, which may be why adolescents from disrupted families or social networks are more likely to enlist. Most recruits reported gaining "Pride/self-esteem/honor" and "Develop Discipline" as motivating factors for signing up. **APPLICATION:** This panel will focus on the potential military

service has for impacting individual psychosocial development. The presenters will demonstrate how the military struggles to act as a surrogate parent and thereby affects many of the psychosocial stages of development. **RESOURCES:** Bachman JG, Segal DR, Freedman-Doan P. Who Chooses Military Service? Correlates of Propensity and Enlistment in the U.S. Armed Forces. *Military Psychology*, 2000; 12: 1-30. Elder GH, Wang L, Spence NJ, Adkins D, & Brown TH. Young men's pathways to the U.S. All-Volunteer Force. *Social Science Quarterly*, 2010; 91: 455-475. Erickson, EH. *The Life Cycle Completed*. W.W. Norton Inc, NY, 1997. Jackson JJ, Thoemmes F, Jonkmann K, Ludtke O, & Trautwein U. Military Training and Personality Trait Development: Does the Military Make the Man, or Does the Man Make the Military?. *Association for Psychological Science*, 2012; 23: 270-277. JAMRS, New Recruit Survey Wave 1 Findings (October 2012-March 2013) accessed at [https://timedotcom.files.wordpress.com/2016/03/new\\_recruit\\_wave1\\_briefing\\_final\\_7-23-2013.pptx](https://timedotcom.files.wordpress.com/2016/03/new_recruit_wave1_briefing_final_7-23-2013.pptx) on 29 August 2018 Johnson R, & Kaplan HBJ. Psychosocial predictors of enlistment in the all-voluntary armed forces: A life-event-history analysis. *Youth & Society*, 1991; 22: 291-317. Teachman J, & Tedrow L. Delinquent Behavior, the Transition to Adulthood, and the Likelihood of Military Enlistment. *Social Science Research*, 2014; 45: 46-55.

**[133] ADOPTING THE MILITARY FOR A RE-PARENTING EXPERIENCE: PSYCHOSOCIAL DEVELOPMENT WHILE SERVING IN THE ARMED SERVICES**

Daron Watts

U.S. Coast Guard, Alameda, CA, USA

(Education - Tutorial Proposal)

**INTRODUCTION:** Currently 1.3 million uniformed members serve in the Department of Defense with an additional 41,000 in the USA Coast Guard. Active duty service has long been considered an attractive option for those with limited financial or educational prospects. Minorities and individuals with lower socio-economic backgrounds, academic performance, or a history of delinquency are more likely to enlist. Most recent recruits identified "Better my life" and nearly half included "To pay for future education" among their reasons for joining. **TOPIC:** Life in the armed services provides an opportunity for personal growth, which may be why adolescents from disrupted families or social networks are more likely to enlist. Most recruits reported gaining "Pride/self-esteem/honor" and "Develop Discipline" as motivating factors for signing up. **APPLICATION:** This panel will focus on the potential military service has for impacting individual psychosocial development. The presenters will demonstrate how the military struggles to act as a surrogate parent and thereby affects many of the psychosocial stages of development. **RESOURCES:** Bachman JG, Segal DR, Freedman-Doan P. Who Chooses Military Service? Correlates of Propensity and Enlistment in the U.S. Armed Forces. *Military Psychology*, 2000; 12: 1-30. Elder GH, Wang L, Spence NJ, Adkins D, & Brown TH. Young men's pathways to the U.S. All-Volunteer Force. *Social Science Quarterly*, 2010; 91: 455-475. Erickson, EH. *The Life Cycle Completed*. W.W. Norton Inc, NY, 1997. Jackson JJ, Thoemmes F, Jonkmann K, Ludtke O, & Trautwein U. Military Training and Personality Trait Development: Does the Military Make the Man, or Does the Man Make the Military?. *Association for Psychological Science*, 2012; 23: 270-277. JAMRS, New Recruit Survey Wave 1 Findings (October 2012-March 2013) accessed at [https://timedotcom.files.wordpress.com/2016/03/new\\_recruit\\_wave1\\_briefing\\_final\\_7-23-2013.pptx](https://timedotcom.files.wordpress.com/2016/03/new_recruit_wave1_briefing_final_7-23-2013.pptx) on 29 August 2018 Johnson R, & Kaplan HBJ. Psychosocial predictors of enlistment in the all-voluntary armed forces: A life-event-history analysis. *Youth & Society*, 1991; 22: 291-317. Teachman J, & Tedrow L. Delinquent Behavior, the Transition to Adulthood, and the Likelihood of Military Enlistment. *Social Science Research*, 2014; 45: 46-55.

**Learning Objective:**

1. The audience will learn about the potential contribution the armed services make towards adult development.

**[134] ADOPTING THE MILITARY FOR A RE-PARENTING EXPERIENCE: A FAMILY SYSTEMS PERSPECTIVE**

John Heaton

USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

*(Education - Tutorial Proposal)*

**INTRODUCTION:** Systems thinking is understanding how different parts of a system can influence one another within a whole. Flight surgeons need to have a basic understanding of systemic thinking by considering the interpersonal context of problems their aviators bring into the office, as well as the effects those problems have on others and the mission. **TOPIC:** There are obvious benefits to life in the military. A steady paycheck, healthcare, advanced and specialty training, tax-free housing and food allowances, and educational benefits are the tip of the iceberg. On the surface, these recruitment incentives can be very attractive to those from lower socio-economic backgrounds where opportunities for financial stability, personal growth, career-broadening experiences, and hope extend beyond the confines of their family and community. Subconsciously, however, recruits may be seeking more unapparent needs like safety, stability, and structure which were previously unmet by their family of origin. Members who come from a lower socio-economic status often come with complicated histories and dysfunctional relationships, which in turn, can carry over into their relationships and interactions with others within the military (i.e. peers, supervisors, commanders, and family practitioner or flight doctor). Consequences can vary from communication problems, interpersonal conflicts, to boundary/authority violations that are often difficult to resolve without discipline and/or effective therapies. **APPLICATION:** By broadening their understanding of an aviator's background and interpersonal relationships, flight surgeons can provide support to airmen/aviators with difficult histories and relationships.

**Learning Objective:**

1. The audience will learn the systemic effects aviators personal backgrounds and interpersonal problems can have on others and the mission.

**[135] BIOPSYCHOSOCIAL BACKGROUND OF U.S. AIR FORCE AVIATORS**Ryan Peirson

USAF School of Aerospace Medicine, WPAFB, OH, USA

*(Education - Tutorial Proposal)*

**INTRODUCTION:** The psychological need to assign an institution or organization a significant role absent in one's development or current situation is complex and theoretical. An exploration of the background characteristics of U.S. Air Force aviators will be used to garner clues for future research and clinical utility. **TOPIC:** Although generally seen as resilient, aviators come from a range of circumstances and have diverse experiences. Pilots remain relatively homogenous in terms of intelligence and major personality characteristics, but other members of the crew have a wider array of experiences and vulnerabilities. Exposure to certain stressors during or after the developmental period may influence these vulnerabilities. Including bullying, physical or sexual trauma, neglect, and poor development of strong emotional ties, these experiences are possible determinants of future mental disorders and psychological dysfunction. Experiences of aviators seen at the U.S. Air Force Aeromedical Consultation Service and who identified with the possible psychodynamic need for a surrogate parental figure will be used to assert possible correlations with other reported determinants and background characteristics. **APPLICATION:** Understanding patients' potential risk factors and vulnerabilities will help the flight surgeon better care for aviators and anticipate referral needs.

**Learning Objective:**

1. The audience will learn about the psychosocial determinants of mental illness.

**[136] ADOPTING THE MILITARY FOR A REPARING EXPERIENCE: HOW CAN THE FLIGHT SURGEON HELP?**Kevin Heacock

USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

*(Education - Tutorial Proposal)*

**INTRODUCTION:** Most flight surgeons did not become doctors or join the military to become parents to their patients. However, a portion

of the military patient population, including some aviators, maintainers, fire fighters, and security forces personnel, seen in the flight medicine clinic may need guidance as they mature into their careers. **TOPIC:** While all people are created equally as described in the USA Declaration of Independence, not everyone who enters the U.S. military is raised in an equally nurturing environment. Some struggle and join the military out of a desperation to survive. Even if they make it through basic training and technical school, some may still be fighting their past. These difficulties often present themselves in the social interactions and occupational functioning in the day-to-day operations of a military unit. Flight surgeons are uniquely placed to identify these individuals with their own eyes at the squadron level or when supervisors and commanders consult for a medical explanation for their occupational challenges. A flight surgeon's capacity to care for others can be a unique asset when the military mission is impacted by the suffering of these individuals. **APPLICATION:** Attendees will be asked how they have handled scenarios in their own squadrons and clinics related to managing military members struggling to maintain operational duties. Techniques for flight surgeons to manage these scenarios on their own will be discussed. In addition, resources for how to direct their patients to appropriate care when the flight surgeon is unable to manage the situation will also be discussed.

**Learning Objectives:**

1. The audience will learn about the how some people join the military to improve their lives.
2. The participant will learn how flight surgeons are uniquely positioned to identify individuals with difficulty with occupational functioning.

**[137] ADOPTING THE MILITARY FOR A REPARING EXPERIENCE: TECHNIQUES TO HELP WITH DIFFICULT AVIATOR PERSONALITIES**Terry Correll

USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

*(Education - Tutorial Proposal)*

**INTRODUCTION:** Aviators are known to have unique personality styles and ways of viewing the world. These characteristics are mostly very adaptive to perform their assigned duties, but at times can cause difficulties in the rest of their lives. **TOPIC:** Life in the armed services provides an opportunity for personal growth, which may be why adolescents from disrupted families or social networks are more likely to enlist. A firm but supportive chain of command can provide psychological functions such as a "holding environment" and "emotional containment" for some while others perceive it as suffocating and controlling. The military esteems those who show creativity and are productive while working within a clearly defined structure. Too much initiative and autonomy, however, will not be tolerated. The interpersonal relationships within units can be incredibly intimate and nurturing, but some experience them as intrusive and phony. Extended military service provides some individuals with the ability to look back on a career that was well spent while others see themselves simply as replaceable cogs in an impersonal machine. The interactions among the individuals' personal history and stage of development, the unit that surrounds them, and the armed services' structure determine the valence and value of these experiences in the military. **APPLICATION:** Attendees will be asked to relate their experiences in the armed services or working with active duty/veteran patients (particularly aviators) to explore, confirm, or refute these concepts. This panel will focus on the potential military service has for impacting individual psychosocial development. The presenters will demonstrate how the military struggles to act as a surrogate parent and thereby affects many of the psychosocial stages of development. Techniques to help with difficult aviator personalities will be explored.

**Learning Objectives:**

1. The audience will learn about aviators' unique personality styles and ways of viewing the world.
2. Techniques to help with difficult aviator personalities will be explored.

Tuesday, 05/07/2019  
Brasilia 2

2:00 PM

### [S-29] PANEL: THIS IS YOUR BRAIN . . . THIS IS YOUR BRAIN ON OXYGEN (AND OFF OXYGEN)

Endorsed by: AsMA Science & Technology Committee and the Aerospace Physiology Society

Chair: Ryan Mayes

Co-Chair: Richard Arnold

**PANEL OVERVIEW:** This panel presents results from several recent studies investigating the impact of either high or low oxygen on neurophysiology. These studies are part of a broader effort to better characterize the environment for military high-performance aircraft; high oxygen levels are a constant exposure in tactical aviation, and low oxygen levels are a constant threat. The first presentation will describe the results of a study conducted by the Naval Medical Research Unit-Dayton and Wright State University in which neuroimaging with magnetic resonance imaging (MRI) was conducted over the course of hypoxic exposures. The second presentation by Naval Medical Research Unit-Dayton will explore brain function as measured using an event-related potential technique under hypoxic conditions. From this point, the focus will shift to high-oxygen exposures, all from a large study conducted by the U.S. Air Force School of Aerospace Medicine and Case-Western Reserve University. The third presentation will cover MRI-measured cerebral perfusion changes due to hyperoxic exposures, followed by a discussion on the tissue oxygenation implications of those cerebral perfusion changes. The final presentation will cover the functional outcomes of hyperoxic exposures, as measured by electroencephalography and cognitive testing. The panel will use these studies to compare and contrast MRI and electroencephalography results from hypoxic and hyperoxic exposures. Finally, the panel will discuss the physiologic implications of this research for high-performance aircraft pilots.

### [138] HEMODYNAMIC RESPONSE TO HYPOXIA: HYPOXIA-INDUCED INCREASES IN QUANTIFIED RESTING CEREBRAL BLOOD FLOW

Stephanie Warner<sup>1</sup>, Matthew Sherwood<sup>2</sup>, F. Eric Robinson<sup>1</sup>, Matthew Funke<sup>1</sup>, Todd Seech<sup>3</sup>, Jeffrey Phillips<sup>4</sup>, Aaron Madaris<sup>2</sup>, Jason Parker<sup>2</sup>, Katherine McEwen<sup>1</sup>  
<sup>1</sup>Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA; <sup>2</sup>Wright State University, Dayton, OH, USA; <sup>3</sup>U.S. Air Force Academy, Colorado Springs, CO, USA; <sup>4</sup>Institute for Human & Machine Cognition, Pensacola, FL, USA

(Original Research)

**INTRODUCTION:** Identification of the neurological substrates of hypoxia would improve the ability to differentiate it from similar respiratory insults experienced during flight and would ultimately aid in threat mitigation. Thus, the goal for the current effort was to induce hypoxia during magnetic resonance imaging (MRI) and to determine differences in the recovery profiles between the use of 100% and 21% oxygen as rescue gas concentrations. **METHODS:** Seven participants completed two experimental treatments consisting of three phases; a 12-minute baseline while breathing 21% O<sub>2</sub>, a 15-minute hypoxia exposure (9.7% O<sub>2</sub>), and a 12-minute recovery exposure with 21% or 100% O<sub>2</sub> administered during alternate visits. Neuroimaging conducted during all phases of the exposures included a structural image with whole brain cerebral perfusion to map cerebral blood flow (CBF) changes and blood oxygen level dependent (BOLD) images to map brain activation changes. **RESULTS:** A decrease in brain activation in regions tied to visuospatial and attentional processes, response inhibition, and sensory integration was observed during hypoxia exposure when compared to baseline. A difference was also observed in the recovery phase in areas involved with sensory and attentional processes. Perfusion measured during the 100% O<sub>2</sub> recovery visit, when compared to baseline, was found to be significantly greater during the hypoxia phase and then

significantly less when measured post-exposure. Alternately, during the 21% O<sub>2</sub> recovery visit, perfusion was not significantly different from the baseline phase when compared to the recovery phase. Upon transition from the hypoxia to the recovery phase, perfusion levels returned to those found during baseline faster during the administration of 100% O<sub>2</sub> when compared to 21% O<sub>2</sub>. However, the continuous inhalation of 100% O<sub>2</sub> caused perfusion to decline significantly below baseline levels when measured post-hypoxia exposure, whereas perfusion remained at baseline levels when 21% O<sub>2</sub> was administered during the same timeframe. **DISCUSSION:** Significant differences were found in brain activation and gray matter perfusion during and following hypoxia exposure between the 21% and 100% O<sub>2</sub> recovery gas treatments. These differences in recovery profiles suggest that further studies focused on tailoring recovery gas combinations are necessary to improve mitigation strategies and return to duty timelines.

#### Learning Objective:

1. The audience will begin to understand the brain's hemodynamic response to in-flight hypoxia.

### [139] IMPAIRED SENSORY PROCESSING DURING LOW-OXYGEN EXPOSURE: A NOVEL APPROACH TO DETECTING HYPOXIA

Kara Blacker<sup>1</sup>, Todd Seech<sup>2</sup>, Gregory Light<sup>3</sup>, Matthew Funke<sup>1</sup>  
<sup>1</sup>Naval Medical Research Unit - Dayton, Dayton, OH, USA; <sup>2</sup>U.S. Air Force Academy, Colorado Springs, CO, USA; <sup>3</sup>University of California San Diego; VISN-22 Mental Illness, Research Education and Clinical Center, VA San Diego Healthcare System, San Diego, CA, USA

(Original Research)

**INTRODUCTION:** Previous studies in operational medicine have demonstrated that exposure to reduced levels of breathable oxygen negatively impacts cognitive performance. However, the relationship between oxygen density in breathing air and task performance is inconsistent, and even paradoxical at times. The majority of studies have relied upon self-report and behavioral testing rather than measures of brain function. Recent advances in neuroscience provide a novel platform for non-invasively predicting and monitoring responses to physiological perturbations in real-time. Specifically, mismatch negativity (MMN) and P3a are event-related potential measures in the electroencephalogram (EEG) that are automatically evoked in response to unattended changes in background sensory stimulation. The MMN/P3a complex is passively elicited, requires no overt behavioral response or awareness on the part of the participant, and reflects the brain's ability to efficiently detect changes. Here, we assessed the extent to which low-oxygen exposure impacts the brain's ability to efficiently process sensory information and concurrent behavioral performance. **METHODS:** Participants performed a continuous visuomotor tracking task while EEG was recorded. In addition to the tracking task, a series of "standard" auditory tones was presented while occasional "oddball" tones were infrequently presented. The MMN/P3a was assessed in response to the oddball compared to the standard stimuli. Participants completed two sessions: one at a simulated altitude of 17,500 ft (i.e., hypoxia) and one at sea-level (i.e., normoxia). **RESULTS:** Findings demonstrated a deficit in tracking performance during hypoxia vs. normoxia exposure. Importantly, the MMN/P3a signal complex was sensitive to hypoxia, showing a significantly reduced amplitude during hypoxia exposure compared to normoxia. Reductions in MMN/P3a were evident prior to detectable deterioration in tracking performance. **DISCUSSION:** Our results suggest that during low-oxygen exposure the ability to detect environmental changes and process sensory information efficiently through predictive coding is impaired. The MMN/P3a may represent an early and reliable predictor of sensory and cognitive deficits during hypoxia exposure, which may be of great use in objectively detecting impairment in low-oxygen environments. These findings may provide a method for defining personalized thresholds for performance deterioration under hypoxic conditions.

#### Learning Objective:

1. The audience will learn about how event-related brain potentials can be used to assess sensory deficits during low-oxygen exposure.



**[140] HARBOR SEALS AND PILOTS: THE IMPACT OF HIGH OXYGEN LEVELS ON CEREBRAL PERFUSION**Ryan Mayes<sup>1</sup>, Michael Decker<sup>2</sup>, Elizabeth Damato<sup>2</sup><sup>1</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA; <sup>2</sup>Case-Western Reserve University, Cleveland, OH, USA*(Original Research)*

**INTRODUCTION:** High oxygen levels are an omnipresent exposure in tactical aviation. High-performance aircraft typically deliver an aggressive oxygen schedule to pilots to protect against the threat of hypoxia. However, the physiologic and cognitive implications of hyperoxic exposures in this environment are not well-understood; this study seeks to fill that gap. **METHODS:** This effort used a pharmacodynamics study design and utilized 30 military and civilian subjects under room air (21% fraction of inspired oxygen [FiO<sub>2</sub>]) and a sustained hyperoxic exposure (100% FiO<sub>2</sub>) to determine cerebral perfusion (cerebral blood flow [CBF]) and associated physiologic sequelae. Subjects experienced both levels of oxygen while undergoing magnetic resonance (MR) imaging assessment; electroencephalogram, arterial blood gases, cognitive testing, and ventilation were contemporaneously measured. CBF was measured by MR pulsed arterial spin labeling. MR scans were processed to provide measures of brain gray matter, white matter, ventricular volumes, as well as total volume of 105 specific brain regions. **RESULTS:** Exposure to 100% FiO<sub>2</sub> within our MR scanner led to a rapid, significant, and sustained reduction in CBF. Compared to CBF during room air, CBF under 100% FiO<sub>2</sub> decreased dramatically, quickly, and continuously. After approximately 30 min of 100% oxygen, CBF values fell to 63% of the baseline values. Gender, age, and brain size were not predictive of change in CBF values. **DISCUSSION:** This is the most comprehensive study of CBF under hyperoxia performed to date; previous studies have had small sample sizes and have been limited to male subjects. The implications for tactical aviation physiology are clear and concerning; CBF decreased dramatically within a very short time frame and continued to decrease throughout the exposure. The physiologic outcomes are not dissimilar to those observed with mammalian diving reflex; however, the stimulus accompanying that reflex was not observed in this study. This phenomenon is not well studied or understood, and the mechanism underlying this response is unexplored.

**Learning Objective:**

1. Understand the impact of high inspired oxygen levels on cerebral perfusion.

**[141] PARADOXICAL HYPEROXIA: THE FIFTH TYPE OF HYPOXIA?**Michael Decker<sup>1</sup>, Elizabeth Damato<sup>1</sup>, Ryan Mayes<sup>2</sup>, Aemilee Ziganti<sup>1</sup>, Tod Flak<sup>1</sup>, Alireza Abdollahifar<sup>1</sup>, Joseph LaManna<sup>1</sup>, Kingman Strohl<sup>1</sup>, Chris Flak<sup>1</sup><sup>1</sup>Case Western Reserve University, Cleveland, OH, USA; <sup>2</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*(Original Research)*

**INTRODUCTION:** Arterial blood oxygenation, consciousness, and life itself require continuous exposure to hyperoxic gas mixtures during high-altitude flight. Albeit beneficial during short-term use, prolonged exposure to hyperoxia induces vascular remodeling within the central nervous system. To define hyperoxia-induced changes in cerebral oxygen delivery (DaO<sub>2</sub>), which could evoke vascular remodeling, we calculated DaO<sub>2</sub> using magnetic resonance (MR) pulsed arterial spin labeling (PASL) and arterial blood gases (ABGs) measured while breathing room air (21% fraction of inspired oxygen [FiO<sub>2</sub>]) and again while breathing 100% FiO<sub>2</sub>. **METHODS:** Thirty military and civilian subjects exposed to 21% FiO<sub>2</sub> received an arterial puncture with ABG analyses, followed by MR anatomical scans. Cerebral perfusion (cerebral blood flow [CBF]) was measured using sequential MR-PASL sequences. Following MR imaging, and while exposed to 100% FiO<sub>2</sub>, subjects received a second arterial puncture with ABG analyses; 24 subjects had successful MR imaging and ABGs. CBF and ABG results were combined using an established formula to calculate DaO<sub>2</sub>. MR images were three dimensionally reconstructed to provide measures of brain gray matter, white matter, ventricular volumes, and incidental findings. **RESULTS:**

Whole brain DaO<sub>2</sub> was significantly reduced by 22% (p=0.001) during 100% FiO<sub>2</sub>. We found no significant sexual dimorphisms in brain volumes with the exception of white matter volume, which was greater in males. The absence of substantive neuroanatomical differences and neuropathology suggests that our subjects were somewhat homogenous and healthy, with regard to overall brain structure. **DISCUSSION:** DaO<sub>2</sub> may indeed be lower during 100% FiO<sub>2</sub> than at 21% and evoke a "paradoxical cerebral hypoxemia." This could initiate vascular remodeling; however, future studies are needed to confirm this. Hyperoxia-induced reductions in CBF and DaO<sub>2</sub> were not tempered by increased partial pressure of arterial carbon dioxide levels (PaCO<sub>2</sub>). During 100% FiO<sub>2</sub>, subjects experiencing increased PaCO<sub>2</sub> ≥ 3 mmHg (n=14) showed the same reduction in DaO<sub>2</sub> as did subjects who experienced decreased PaCO<sub>2</sub> ≤ 3 mmHg. This suggests that the mechanism(s) through which 100% FiO<sub>2</sub> decreased CBF, and potentially DaO<sub>2</sub>, also suppressed mechanisms through which increased PaCO<sub>2</sub> levels induce cerebral vasodilation.

**Learning Objective:**

1. Understand that high inspired oxygen levels may significantly reduce oxygen delivery to neuronal tissue.

**[142] FLIGHT, THEN FIGHT: HYPEROXIA AND INCREASED COGNITIVE FUNCTION**Elizabeth Damato<sup>1</sup>, Tod Flak<sup>1</sup>, Michael Decker<sup>1</sup>, Aemilee Ziganti<sup>1</sup>, Ryan Mayes<sup>2</sup>, Alireza Abdollahifar<sup>1</sup>, Joseph LaManna<sup>1</sup>, Kingman Strohl<sup>1</sup>, Chris Flak<sup>1</sup><sup>1</sup>Case Western Reserve University, Cleveland, OH, USA; <sup>2</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*(Original Research)*

**INTRODUCTION:** Heightened levels of cognitive performance are a prerequisite to piloting high-performance aircraft. Administration of high fractional levels of inspired oxygen (FiO<sub>2</sub>) to minimize risk of hypobaric-hypoxia during flight coincidentally enhances cognitive performance. However, high FiO<sub>2</sub> significantly reduces cerebral perfusion (cerebral blood flow [CBF]), a physiologic response counterintuitive to enhancing brain performance. To provide insight into this paradox, we characterized cognitive performance and overall cortical activity during baseline levels of CBF at 21% FiO<sub>2</sub> and during reduced CBF induced by 100% FiO<sub>2</sub>. **METHODS:** Cognitive performance and cortical electroencephalographic (EEG) activity were measured and recorded in 30 military and civilian subjects during exposure to 21% FiO<sub>2</sub> and again at 100% FiO<sub>2</sub>. A 64-channel EEG system facilitated simultaneous measurement of electrical activity over 11 cortical regions. Following 3 min of quiet-state EEG recording, assessment of cognitive performance was achieved with a test measuring nine cognitive domains. **RESULTS:** At 21% FiO<sub>2</sub>, the majority of study subjects scored within the range of "average" cognitive performance in each of the nine cognitive domains. At 100% FiO<sub>2</sub>, significant improvements (P<0.001) occurred in the domains of General Cognitive Functioning, General Cognitive Proficiency, Information Processing Speed, Information Processing Accuracy, Reasoning/Calculation, Memory, and Spatial Processing. There were no differences in Attention/Mental Control (P=0.777) or Reaction Time (P=0.138). No difference in EEG spectral power emerged between quiet-state recordings at 21% and 100% FiO<sub>2</sub>. However, during cognitive testing at 100% FiO<sub>2</sub>, alpha spectral power, considered a marker of vigilance and overall cortical activation, revealed greater desynchronization (increased activity) across three of seven brain regions. Beta activity also suggested increased activity in two brain regions. Theta activity did not differ between cognitive testing during 21% and 100% FiO<sub>2</sub>. **DISCUSSION:** Enhanced cognitive performance with corresponding EEG markers of increased vigilance emerged during exposure to 100% FiO<sub>2</sub>, a stimulus that reduces CBF. We suspect this dichotomy represents a homeostatic flight or fight enhancement in brain activity. This could offset unintended reductions in vigilance that accompany enhanced vagal tone, which occurs during a hyperoxic state.

**Learning Objective:**

1. Understand that cognitive performance and vigilance are quantifiably enhanced during short-term exposure to 100% FiO<sub>2</sub>.

Tuesday, 05/07/2019  
Brasilia 3

2:00 PM

### [S-30] SLIDE: RUNNING ON FUMES

Chair: Kathryn Hughes

Co-Chair: Rob Monberg

2:00 PM

#### [143] HUMAN BIOMONITORING AFTER "FUME AND SMELL EVENTS" – REQUIREMENTS FOR ANALYTICS AND CONCLUSIONS

Joerg Hedtmann<sup>1</sup>, Christoph Caumanns<sup>1</sup>, Ulrich Metzendorf<sup>1</sup>, Christian Felten<sup>1</sup>, Barbara Schindler<sup>2</sup>, Stephan Koslitz<sup>3</sup>, Thomas Bruening<sup>3</sup>, Tobias Weiss<sup>3</sup>  
<sup>1</sup>BG Verkehr (Statutory Accident Insurance of the Transport Industry), Hamburg, Germany; <sup>2</sup>Lufthansa Medical Services, Frankfurt, Germany; <sup>3</sup>IPA - Institute for Prevention and Occupational Medicine, Bochum, Germany

(Education - Program / Process Review Proposal)

**BACKGROUND:** Scientific remarks proposed that "Fume and Smell Events" in aircraft cabins (FuSE) may be associated with an elevated level of VOC and organophosphates or their metabolites in blood and urine. Nevertheless, the known and published exposure data do not make the assumption plausible, that exposure to VOC or organophosphates may be a reason for long term symptoms. Also, this does not correspond to low concentrations of hazardous substances during cabin air exposure measurements. In a former study we could show, that metabolites of tricresylphosphate isomers (TCP) were not elevated in the urine of exposed flight crews. Knowing the source for organophosphates quite well, however, we still have no plausible explanation as to why VOC should be significantly elevated in body fluids after flights with or without FuSE. So, it is necessary to rule out misinterpretations caused by irregularities in pre-analytics and to set standards in sampling and measuring. **OVERVIEW:** To provide reliable scientific data for the current discussion we offered exposed flight crews a standardized examination including biological monitoring of blood and urine, that covers nearly all compounds under discussion. By testing disinfection fluid and collection tubes we had to rule out exogenous contamination of blood and urine samples. This led to the implementation of a standard pre-analytic protocol. Blood and urine samples were transferred to gas tight glasses immediately after donation. In every case the sampling was accompanied by a personal and a technical questionnaire. **DISCUSSION:** In preparation of the analytic methods we could show, that n-hexane as one of the discussed VOC is able to contaminate the biological material in some of the test tubes and disinfection fluid may influence the results of VOC measurements. This indicates the necessity of standardized methods for sample collection and analysis. First results confirm familiar findings on elevated but still low dose organophosphate exposure. Only using standardized pre-analytic protocols we will be able to contribute to the discussion, whether cabin air may lead to relevantly elevated levels of toxins in blood or urine.

#### Learning Objectives:

1. The audience will learn about the low concentrations of hazardous substances during cabin air exposure measurements and human biomonitoring as a method to uncover possible exposure.
2. The audience will learn about the necessity of standardized pre-analytic protocols to rule out exogenous contamination of blood and urine samples.

2:15 PM

#### [144] ONBOARD FUME EVENTS: SHORT TERM HEALTH CONSEQUENCES IN AIRCREW

Michel Klerlein<sup>1</sup>, Maxime Loizeau<sup>2</sup>  
<sup>1</sup>Air France, Roissy CDG, France; <sup>2</sup>Service de Pathologies Professionnelles et Environnementales de l'Hôtel-Dieu, Paris, France

(Original Research)

**INTRODUCTION:** Fume event is a rare but stressful aeronautical event for aircrew, and is suspected to lead to a variety of health consequences. Despite numerous toxicological studies, few data are available to describe the reality of these clinical effects in aircrew. We present a one year survey of aircrew exposed to a fume event. **METHODS:** All aircrew of a major airline involved in an onboard fume event were sent an ad-hoc online questionnaire within a short delay after the incident, entirely managed by the occupational health service and therefore covered by medical confidentiality. We used classic descriptive statistics and multilevel logistic regression to estimate the healthcare use determinants. All subjects were informed of the medical confidentiality of their answers. **RESULTS:** From March 2017 to March 2018, 81 flights with an onboard fume event were included, involving 610 aircrew. 376 (61.6 %) answers have been received, from which 354 (58 %) were included. Answers were provided by 101 (28.5 %) flight crew and 253 (71.5 %) cabin crew. The mean delay for answer was 11 days (IQR: 5-27). The main fume type was isolated odors, described as wet socks odor (27.2%), burning odor (23.5%), solvent smell (19.8%) and acrid smell (18.5%). When present, main symptoms were ENT irritation (33.9%), headaches (21.6%) and dyspnea (16.3%). In 185 answers (51.8%), no symptom were felt. Only 53 (14.8%) crew sought help from a healthcare provider, mainly the airport medical service (6.7%), the airline occupational health service (4.8%) or the GP (2%). Multivariate analysis showed significant odds-ratio for predicting health care use for presence of headache and ENT irritation, for at least one crew disembarked or for using oxygen mask in the flight deck. **DISCUSSION:** In our study, fume events were moderately associated with mild health short term consequences. Despite important concerns about potential neurotoxic poisonings, we had no report of neurologic signs in this short term delay, except few cases of lightheadedness. The occupational medicine service records all the fume events exposures in the aircrew medical file, in a purpose of traceability and adaptation of the medical follow-up of our aircrew in the event of an onset of a chronic disease.

#### Learning Objectives:

1. Understanding the reality of health consequences of exposure to a fume event.
2. Learning from the experience of an occupational health setting about managing exposure to fume events.

2:30 PM

#### [145] REVIEW OF A FUME EVENT AND SYMPTOMS IN AN AIRLINE PILOT

Lothar Bressemer  
GAF Center for Aerospace Medicine, Fuerstenfeldbruck, Germany

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This case report describes a civil airline pilot, who experienced a fume event in short final before landing. **BACKGROUND:** Military and civil professional pilots repeatedly reported symptoms during flight in coincidence with fume events. Very often the toxicological work up did not show conclusive findings. In this case blood and urine samples were taken immediately after landing and the toxicology showed evidence of oil or fuel vapor exposure. During this case report the toxicology findings are presented. The primary toxicology in a university lab was repeated with frozen samples of the pilot in the military specialized unit of the GAF Center of Aerospace Medicine. Similar fume events in military transport aircraft were investigated with the toxicological work up of cabin and cockpit air samples. **CASE PRESENTATION:** The subject pilot is a 35-yr old German airline pilot with 1500 hours of professional flight experience. During short final for landing in bad weather conditions the cockpit and cabin crew noticed a bad smell and continued the landing without using oxygen masks. Shortly after landing the cockpit and cabin crew reported dizziness, headaches and coughing. The pilot underwent repeated lung function tests which showed decreased values. The oxygen diffusion tests showed results below normal. Psychological performance tests were below standards after the event. **DISCUSSION:** This case demonstrates a clear relationship between severe symptoms of aircrew members during flight and fume events. In this case the exposure to oil or fuel vapors has been proven. The investigation of fume events in military transport aircraft has shown that due to the construction of most modern jet aircraft the bleed air for the air conditioning and the OBOGS is taken from the compressed air in the engines. While this is a convenient technical solution in high altitude

with low outer pressure, this also produces the risk of contamination of the bleed air due to pressure changes in the jet engines. These pressure changes may occur by drastic changes in power settings or by flight through rough or turbulent air during low power settings, for example during approach and landing. Better technical solutions are on the market, taking the air for the air conditioning and OBOGS from ports on the fuselage.

#### Learning Objectives:

1. The audience will learn about the possibility to prove the exposure of air crew members to toxic substances during fume events with modern toxicologic methods.
2. The period for full recovery varies greatly and may take between several months to one year.

#### 2:45 PM

##### [146] RELATIONSHIP OF NASAL CONGESTION TO THE AGE OF THE INTERNATIONAL SPACE STATION

Daniel Weinberg<sup>1</sup>, Richard Cole<sup>2</sup>, Christopher Coble<sup>2</sup>, Sara Mason<sup>2</sup>, Mary Wear<sup>2</sup>, Millennia Young<sup>2</sup>

<sup>1</sup>Naval Medical Center Portsmouth, Portsmouth, VA, USA; <sup>2</sup>National Aeronautics and Space Administration, Houston, TX, USA

#### (Original Research)

**INTRODUCTION:** Nasal congestion has been a frequent complaint of astronaut crews throughout the history of the International Space Station (ISS). While congestion has traditionally been attributed to fluid shifts, congestion still continues to be reported despite fluid equilibrium being reached during the first week of spaceflight. The authors' previous work showed an association between CO<sub>2</sub> levels and nasal congestion complaints. Our current study compares an expanded congestion data set to the age of ISS. **METHODS:** ISS data was gathered for U.S. Operating Segment (USOS) astronauts from March 14, 2001 to February 16, 2018. These dates spanned expeditions 2 to 53 and included 79 astronauts. The first 7 days of an astronaut's stay on the ISS was excluded to eliminate congestion symptoms caused by initial fluid shifts while adapting to microgravity. Congestion symptoms were obtained from astronaut Private Medical Conferences (PMCs) and Space Medicine Operations Team (SMOT) meetings. Associations were investigated using a mixed modeling approach incorporating subject-specific random intercepts with robust standard errors to adjust for the repeated measures over time for this observational study. Specifically, logistic regression was used to model the yes/no outcome of congestion reports at each reporting opportunity (PMC or SMOT). **RESULTS:** Age of ISS had a statistically significant association with reports of congestion in this study. For every year the ISS ages, there is a predicted 24.6% increase in the odds of congestion ( $p=0.0024$ ) after adjusting for CO<sub>2</sub> level as a covariate. **DISCUSSION:** This study demonstrates a clear correlation between age of the ISS and congestion. While we cannot prove causation, several environmental variables could be contributing to the congestion that astronauts experience during their ISS stay. These include particulate load, toxic contaminants, animal dander, and fungal and bacterial hypersensitivities. Age of ISS and elevated CO<sub>2</sub> levels have both been shown to contribute to congestion complaints during spaceflight. Interestingly, the age of ISS and CO<sub>2</sub> are inversely related as the allowable CO<sub>2</sub> limits have periodically decreased as the ISS has aged. Regardless of cause, CO<sub>2</sub> levels may need to be further reduced each year to counter rising congestion symptoms expected from an aging ISS.

#### Learning Objectives:

1. Understand there is a relationship between age of the ISS and complaints of nasal congestion and examine several variables that may play a role.
2. Understand there is a relationship between CO<sub>2</sub> levels and complaints of nasal congestion.

#### 3:00 PM

##### [147] THE CHARACTERIZATION OF A STANDARDIZED BREATH SAMPLING DEVICE FOR OFF-LINE TD-GC-MS ANALYSIS

Sean Harshman<sup>1</sup>, Rhonda Pitsch<sup>1</sup>, Michael Brothers<sup>1</sup>, Maomian Fan<sup>1</sup>, Nicole Schaeublin<sup>1</sup>, Grant Slusher<sup>1</sup>, Sharon Rose<sup>1</sup>, Leslie Drummond<sup>2</sup>, Jennifer Martin<sup>1</sup>

<sup>1</sup>711th Human Performance Wing, Wright-Patterson AFB, OH, USA;

<sup>2</sup>Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, USA

#### (Original Research)

**INTRODUCTION:** Exhaled breath bags have been the standard method for off-line breath collection. However recently, the Respiration Collector for In Vitro Analysis (ReCIVA) was developed for versatile exhaled breath collection directly onto adsorptive material. The ReCIVA is designed to eliminate sources of variability associated with off-line exhaled breath collection. While potentially beneficial, very little has been done to characterize the overall performance of the ReCIVA breath sampler.

**METHODS:** Immediately prior to and following collection via the ReCIVA device, participants filled 1L ALTEF polypropylene bags with exhaled breath, functional residual capacity. Breath was concentrated onto conditioned thermal desorption (TD) tubes. Additionally, exhaled breath was simultaneously collected directly onto TD tubes, either Tenax TA (n=6) and Tenax/Carbograph 5TD (n=6), in duplicate utilizing the lower airway settings on the ReCIVA sampler. Mask background was evaluated using a cleaned glass head. Following the initial collections and background, all ReCIVA masks were cleaned and the breath collection protocol was repeated. All TD tubes were analyzed by TD-GC-MS using 70keV electron impact ionization. **RESULTS:** Overall the quantified results from the ReCIVA sampler yield significantly less isoprene than those obtained from the breath bags ( $p<0.0001$ ). Additionally, the ReCIVA samples collected on Tenax/Carbograph 5TD tubes yielded significantly lower isoprene results compared to those collected on Tenax TA. The exhaled breath data illustrates individual variability in the results obtained from both the exhaled breath bags (29.8% RSD) and ReCIVA breath sampler (45.9% (STD)). Manual inspection of the chromatograms shows large contaminant peaks. Washing the masks was able to remove 77.3% to 99.9% of individual background contaminants. **DISCUSSION:** The results from these experiments suggest variability in in exhaled breath volatiles using the ReCIVA breath sampler and standard gas bags. Additionally, these data provide evidence for cleaning and reuse of the ReCIVA sampler masks.

#### Learning Objective:

1. The audience will learn about exhaled breath sampling strategies for biomarker discovery and diagnostic purposes.

#### 3:15 PM

##### [148] A CASE REPORT: TOTAL EXPOSURE HEALTH AND NEUROLOGICAL SYMPTOMS IN AN AIRCRAFT FUEL SYSTEM REPAIR TECHNICIAN

Jean-Felix Cyriaque

USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA

#### (Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This case report describes an aircraft fuel system repair service member (with 14 yr of service) with complaint of chronic neurological symptoms that he perceived to have resulted from chronic fuel exposures at work. **BACKGROUND:** Capturing the environmental and lifestyle exposure history of aircraft workers significantly improves the confidence of determining if a condition or symptoms experienced by the individuals are related to their work. **CASE PRESENTATION:** A 36-yr-old fuel system repair technician presented with complaints of forgetfulness and mental fogging, which he stated began 7 yr prior. The member attributed his symptoms to exposures to jet fuel and other chemicals in the workplace associated with fuel systems repair, such as hydrazine, methanol, methyl ethyl ketone, and toluene. He reported that he played hockey consistently over the last 20 yr and suffered multiple injuries, including at least two significant sports-related concussions. Both incidents were managed in the emergency room with no reported long-term effects. His other lifestyle activities included skateboarding. The service member was temporarily removed from fuel system repair operations pending further evaluation. Liver and renal function tests were normal. An occupational health risk assessment was completed, including air sampling, and revealed no evidence of overexposure to process hazards. **DISCUSSION:** This case report illustrates the importance of taking into account both environmental and lifestyle factors, i.e., total exposure health, in determining if individual symptoms or conditions are work related. The service member experienced multiple sports-related concussions, which are a risk factor for cognitive impairment and mental health problems in some individuals. New studies are emerging that underscore the importance of recognizing these symptoms early, not only in football players, but also in other sports such as ice hockey. Studies have associated low-level chronic jet fuel exposures with neurological health effects. However, human studies are

scarce. Animal studies have investigated the effects of jet fuel on several neurological end points; however, the dose-response relationships are not well characterized. More studies are needed and some are emerging to better characterize the effects of low-level exposures to jet fuel. Based on the available evidence, the fuel system repair technician's symptoms are more likely not work related.

**Learning Objective:**

1. This case report will illustrate the importance of taking into account both environmental and lifestyle factors, i.e., total exposure health, in determining if individual symptoms or conditions are work related.

Tuesday, 05/07/2019

2:00 PM

Brasilia 4

## [S-31] PANEL: NAVY RAM GRAND ROUNDS

**Chair: Nathaniel Almond**

**PANEL OVERVIEW:** This panel is aerospace medicine resident grand rounds to include case reports by the residents.

### [149] A CHALLENGING EVALUATION OF DIZZINESS IN A STUDENT NAVAL AVIATOR

Kimberly Everett, Jason Bernhard, Charles Reese  
Naval Aerospace Medical Institute, Pensacola, FL, USA

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** This case report describes a military Student Naval Aviator (SNA) who experienced chronic, worsening disequilibrium and lightheadedness. **BACKGROUND:** The evaluation and diagnosis in cases of dizziness (non-spinning vertigo) has historically been ill defined. In the past, diagnoses such as phobic postural vertigo, space-motion discomfort, visual vertigo, and chronic subjective dizziness have been used to describe a similar constellation of symptoms of dizziness, unsteadiness, and disequilibrium without a clear etiology. Recently, the diagnosis of Persistent Postural-Perceptual Dizziness (PPPD) was established, combining the previously described presentations into a single condition with standard diagnostic criteria and treatment recommendations. **CASE PRESENTATION:** The subject is a 25-year-old male SNA who presented at the onset of flight training with a 1.5-year history of lightheadedness and disequilibrium starting shortly after two root canals. His symptoms were initially mild and intermittent, and he was able to complete ground military training. His symptoms progressed and he constantly felt slightly "off" and complained of increased disequilibrium with position changes, exercising, and moving through complex visual environments. He felt true room-spinning vertigo only intermittently when he rolled over in bed. Initial workup included normal audiology testing, laboratory evaluation, imaging, and cardiac monitoring. Vestibular testing initially demonstrated findings consistent with right horizontal canal benign paroxysmal positional vertigo. The patient was started in vestibular therapy and taught the canalith repositioning maneuver, which resolved his intermittent vertigo but not his constant disequilibrium. He was diagnosed with PPPD. He was removed from flight training, placed on a limited duty status, continued on vestibular therapy, and sent for psychiatric evaluation. **DISCUSSION:** This case highlights the diagnosis of PPPD, a recently identified diagnostic term for a chronic maladaptive response of the vestibular system and brain. All forms of dizziness and vertigo are important to recognize in the aviator due to the impact on flying performance. PPPD has been recognized as a common syndrome amongst specialty clinic patients and likely exists unrecognized in primary care populations, including aviators. Its subtle nature and subjective but potentially treatable symptoms make it important to recognize.

**Learning Objectives:**

1. The participant will be able to recognize the constellation of symptoms concerning for persistent postural-perceptual dizziness and understand the diagnostic criteria.
2. The participant will learn about treatment approaches and outcomes for persistent postural-perceptual dizziness.
3. The participant will be able to apply concepts of aviation safety and human performance to determine an aeromedical disposition in this case of persistent dizziness.

### [150] VERTIGO IN A FIGHTER PILOT: CAREER ENDER?

Carlos Navarro, Karl Kingry  
Naval Aerospace Medical Institute, Pensacola, FL, USA

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** This case reports describes a military fighter pilot who experienced acute onset vertigo four days after his last flight. **BACKGROUND:** Acute onset vertigo has a broad differential that includes life threatening illnesses as well as chronic disease processes that are incompatible with aviation duties. Even in young pilots with no risk factors, an extremely conservative approach must be taken as the recurrence of symptoms in flight can be catastrophic. **CASE PRESENTATION:** We discuss the case of a 33-year-old USMC male F/A-18C pilot with acute onset, non-remitting vertigo and gait instability. He had no major risk factors for cardiovascular disease and a non-contrast head CT in the ED was not suggestive of a stroke or other intracranial process. He denied any migrainous symptoms, eustachian tube dysfunction or recent barotrauma, change in hearing, tinnitus, or aural fullness. Of note, the patient had not flown in 4 days because of an upper respiratory illness that the patient had just recovered from. His exam revealed no focal neurological deficits but was remarkable for a horizontal and rotational nystagmus in addition to an obvious inability to ambulate without assistance. A screening audiogram did not show a threshold shift. The patient was diagnosed with vestibular neuritis and given a 10-day course of oral steroids along with supportive medication to be followed by vestibular rehabilitation exercises. Two weeks later, the patient was symptom free and six weeks after that returned to flight status. **DISCUSSION:** The typical course of vestibular neuritis is characterized by 1-2 days of severe symptoms followed by a gradual improvement. Non-specific symptoms may persist for months, however, and a favorable aeromedical disposition requires at the very least a period of observation free from residual effects. The U.S. Navy Aeromedical Reference and Waiver Guide considers vestibular neuritis not disqualifying if it is associated with a viral illness, brief in duration, and results in a complete recovery with no recurrence of symptoms during a period of observation lasting at least four weeks.

**Learning Objective:**

1. Understand how to diagnose and treat vestibular neuritis and appreciate its prognosis.

### [151] NON-COMPACTION CARDIOMYOPATHY

David Andres, Eric Carroll  
Naval Aerospace Medical Institute, Pensacola, FL, USA

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** This case report describes a case of non-compaction cardiomyopathy in a soon to graduate fleet replacement pilot with abnormal EKG and endorsed heart palpitations. **BACKGROUND:** The importance of this condition in the aeromedical arena revolves around the possibility of incapacitation while conducting flight profile and duties. This is of concern in a platform that is used for personnel transport even with the setup for dual piloted aircraft. **CASE PRESENTATION:** Designated Naval aviator presenting for five-year long form flight physical presents with abnormal EKG tracing with positive endorsement recently of symptomatic heart palpitations. EKG demonstrated a PVC load of 17% and service member was promptly referred to cardiology for workup per the Navy Aeromedical Reference and Waiver Guide. Member's workup included the standard items in the waiver guide, but a decision based on the volume of PVCs and symptoms led to a Cardiac MRI. The MRI demonstrated one segment of hypertrebeculation of the ventricular wall. Member was started on carvedilol for PVC load. After a lengthy period of follow ups and a grounding period, Cardiology had recommended a stop to the carvedilol and the patient was cleared for waiver consideration. Patient continued to endorse no further episodes of palpitations or symptoms to suggest acute decompensation due to his heart. Waiver was submitted in early summer of 2018 and as of recently waiver was not recommended. Currently it appears member is attempting to resubmit after further workup with cardiology. **DISCUSSION:** This case highlights the concern of a potentially significant underlying medical condition when it comes to weighing safety versus operational commitments and

demands. This case involves a designated naval aviator still in student status near completion of the syllabus to report to his squadron. There is something to learn from this case both medically and administratively.

**Learning Objectives:**

1. To understand the pathophysiology of a little known medical condition in the general practice setting.
2. To discuss its relevance within the flight environment and the concern involved.
3. To weigh the administrative burden on not only military aviators but also those that are civilian flyers.

**[152] DID NEUROCYSTICERCOSIS END HIS FLYING CAREER?**

Gabriel Gizaw<sup>1</sup>, Jean G. Mathurin<sup>2</sup>, Edwin Y. Park<sup>2</sup>

<sup>1</sup>U.S. Navy, Pensacola, FL, USA; <sup>2</sup>Naval Aerospace Medical Institute, Pensacola, FL, USA

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** Focal neurological signs can mimic any neurological pathology. Our vigilance, systematic approach and a detailed neurological exam will give us the clue as to the differential. **BACKGROUND:** Adult seizure among developing countries is associated with neurocysticercosis (1). The cases we see in the U.S. originate in endemic regions around the globe (2). The least common symptoms may be the reason for doctor visits in the developed nations. **CASE DESCRIPTION:** A 34-year-old male naval flight officer with no prior medical history who presented for multifocal sensory symptoms over a period of several months. His main visit to see his flight surgeon was due to a few days of new onset of headache, and left sided facial pain followed by numbness and blurry vision. His neurological exam finding was negative, except slight nystagmus in horizontal end-gaze bilaterally, and reduced sensation left side on trigeminal nerve with V2 and V3 distribution. His gait and Romberg were normal. A trial of anti-inflammatory and antiviral agents without improvement of symptoms continued to persist. MRI and Neurology consult in place. MRI of the brain findings were consistent with multiple non-enhancing lesions in the cerebellar vermis measuring up to 1cm in size, some of which were well-circumscribed. However, the incidental finding of a lesion in the cerebellar vermis did not correlate with patient's symptoms. Additional studies showed positive serum Cysticercosis antibody. Confirmation of diagnosis from the CDC was indicated using enzyme-linked immunoelectrotransfer blot assay (EITB) with better sensitivity and specificity over commercial lab serology (3). EITB confirmed negative finding. This testing demonstrated that the commercial lab serology (simple and rapid) was a false positive. This, and the atypical MRI of the brain made it unlikely that the patient has cysticercosis. **DISCUSSION:** Untreated neurocysticercosis symptoms range from seizures, headaches, focal neurologic symptoms, visual disturbance, confusion, psychiatric disturbance, to ataxia (4). Any of these symptoms impact flight and the pilot needs to be grounded for the duration of the treatment. MRI findings and serology may provide a clinical diagnosis of neurocysticercosis. However, understanding the limitations of the diagnostic analysis is imperative as is consultation with field experts for a final diagnosis. The importance of multispecialty input refines the diagnosis as we have seen in this case study.

**Learning Objectives:**

1. Adult seizure among developing countries is associated with neurocysticercosis in endemic regions (White, 2018). The cases we see in the U.S. originate in endemic regions around the globe (Garcia, 2000).
2. Untreated neurocysticercosis symptoms range from seizures, headaches, focal neurologic symptoms, visual disturbance, confusion, psychiatric disturbance, to ataxia (Nash, 2018). The CDC based enzyme-linked immunoelectrotransfer blot assay (EITB) has better sensitivity and specificity over commercial lab serology (Sloan, 1995).
3. Dog tapeworm should be in the differential for patients who have not travelled to cysticercosis endemic regions. The cysts can be similar in neuro imaging; however, serology can be false positive for cysticercosis due to the cross reactivity in *ochinococcus* (Van Doorn, 2007).

**[153] ACUTE ONSET BLURRY VISION IN A STUDENT PILOT**

Sean Haight

Naval Aerospace Medicine Association, Pensacola, FL, USA

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** This case report describes a student pilot who experienced acute unilateral blurred vision in his left eye for four days. **BACKGROUND:** Blurry vision has a broad differential that includes media, retinal, and neural etiologies. Acute vision loss is a frightening experience for patients and has the potential for long-term consequences. The many causes of acute vision loss and the time-sensitive need for evaluation and treatment pose diagnostic and therapeutic challenges. **CASE PRESENTATION:** We discuss the case of a 25-year-old USN male student aviator with acute onset, painless, left sided blurry vision 4 days prior. He denies any history of trauma, foreign body, pruritis, or tearing. He has never experienced this before and he is otherwise healthy. Patient was unable to read the main "E" on the Snellen chart and upon further evaluation of his vision, his visual acuity was determined to be OD 20/20 and OS 20/400. Fundoscopic exam of the left eye demonstrated a classic "blood and thunder" appearance. The patient was diagnosed with central retinal venous obstruction and sent to see a retinal specialist and started on intravitreal injections of ranibizumab. Coagulation panels were obtained (all within normal limits) and over six months his vision eventually improved to 20/50 OS. Unfortunately, naval air crew all require vision correctable to 20/20 ou and he was still requiring periodic intravitreal injections. **DISCUSSION:** While this case deals specifically with a rare cause of vision loss in a young adult it does give an excellent opportunity to review the retinal causes of vision loss. These include retinal detachment, retinal vein occlusion, retinal artery occlusion, and acute maculopathy. The U.S. Navy Aeromedical Reference and Waiver Guide considers these conditions on an individual case with most being disqualifying for aviation applicants (except for specific cases of retinal detachment) and considers them on a case by case basis for designated personnel.

**Learning Objectives:**

1. Understand the different retinal causes of acute vision loss.
2. Understand how to diagnosis and appropriate triage the different retinal causes of acute vision loss.

**[154] DELAYED HYPERBARIC OXYGEN THERAPY FOR CENTRAL RETINAL ARTERY OCCLUSION RESULTING IN CLINICALLY SIGNIFICANT RETINAL HEALING AND VISUAL RECOVERY**

Leisa Deutsch<sup>1</sup>, Carlos Navarro<sup>2</sup>, Joseph LaVan<sup>2</sup>

<sup>1</sup>Navy Medicine Operational Training Center, Pensacola, FL, USA;

<sup>2</sup>Naval Aerospace Medical Institute, Pensacola, FL, USA

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** A case of a retired military helicopter pilot who experienced a central retinal artery occlusion (CRAO) during a routine retinal procedure is described. Hyperbaric oxygen therapy initiated 17 days after the insult resulted in significant visual improvement. **BACKGROUND:** CRAO is one of the fourteen Undersea and Hyperbaric Medical Society approved indications for clinical hyperbaric oxygen therapy (HBOT). Traditionally, therapy is initiated as soon as possible but no later than twenty-four hours after visual loss after which there is thought to be no benefit. There is increasing evidence that patients with remote ischemic events may benefit from HBOT with clinically and functionally significant improvements in neurologic deficits. **CASE PRESENTATION:** This patient was a 73-year-old male retired helicopter pilot with a history of hypertension, hyperlipidemia, non-insulin dependent diabetes mellitus, and a remote history of prostate cancer. He was a non-smoker, with no prior cardiopulmonary or stroke history. He presented with a CRAO of his left eye after a routine retinal procedure by an experienced retinal specialist. He had subsequent imaging which showed sluggish flow and continued to have minor spontaneous visual improvements during an extended evaluation. He had no signs of infection or other neurologic deficits and was on no blood thinners at the time of presentation. The ischemia was thought to be due to increased intraocular pressure resulting in arterial obstruction, rather than thrombus. After undergoing twenty rounds of HBOT, he exhibited both subjective and objective visual improvement and retinal healing. **DISCUSSION:** This case highlights the potential benefit of delayed HBOT in cases of CRAO, even though, historically, there was thought to be no benefit. This patient experienced clinically significant visual field improvement both peripherally and centrally, allowing him to continue to work and drive independently resulting in

improved quality of life. There was objective evidence of retinal healing on imaging by his retinal specialist that matched the subjective charting done by the patient throughout the course of his treatment. Though he did not fully recover his vision, this case shows that in certain cases it is reasonable to initiate a trial of hyperbaric oxygen in the period between twenty-four hours and seventeen days after an ischemic event that could offer hope in a previously near hopeless diagnosis.

**Learning Objective:**

1. Recognize presenting symptoms of a central retinal artery occlusion and appreciate some indications for HBOT.

**Tuesday, 05/07/2019**  
**Brasilia 5**

**2:00 PM**

**[S-32] PANEL: MORAL AND ETHICAL ISSUES  
FOR HEALTHCARE PROVIDERS IN AIR  
EVACUATION TRANSPORT**

*Endorsed by: Aerospace Nursing & Allied Health  
Professionals Society*

**Chair: Melissa Wilson**

**PANEL OVERVIEW:** Providers in air evacuation transport may experience difficulties in delivering the best care due to moral and ethical situations encountered during patient care in austere environments. These situations put the providers at risk for developing frustration, burnout, anxiety, depression, and post-traumatic stress disorder. This well-established phenomenon in civilian healthcare is called moral distress. This occurs when a provider knows the right action to take but, due to an external or internal barrier, is unable to act in a way that is consistent with his/her belief and moral integrity is compromised. Few studies have examined moral distress within the military healthcare population. The concept of moral injury is better known to the military population but has not been applied to the military healthcare population. If moral and ethical issues are not addressed in care delivery, suffering results. The purpose of this panel is to deliver an overview of the concept of moral distress and moral injury, describe the experience in a military healthcare provider, identify contributing factors, and explore potential interventions to mitigate the impact of the experience. The completed work will include representation of an interdisciplinary team from tri-service Department of Defense and Veteran's Administration enterprises. This panel will present the fundamental concepts associated with moral and ethical encounters of providing healthcare in austere conditions as well as potential interventions for mitigation of the harmful effects of not adequately managing moral distress/injury. The first presentation, on the state of the evidence of moral distress in military healthcare providers, provides a synthesis of literature pertaining to the concept with a contrast to similar concepts such as moral injury and their applicability to the military air transport environment. The second presentation describes the behavioral health symptoms identified in the en route care deployed nurse. The third presentation establishes the phenomenon of moral distress in Critical Care Air Transport nurses and describes the experience. The final presentation explores novel interventions aimed at improving moral injury. The work presented will help to guide the future of this research trajectory for developing interventions in military en route care critical care nurses.

**[155] THE STATE OF THE EVIDENCE OF MORAL DISTRESS AND  
ITS APPLICATION TO MILITARY EN ROUTE CARE CRITICAL  
CARE NURSES**

Melissa Wilson

*USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Moral distress is a well-established phenomenon in civilian healthcare. It occurs when healthcare providers encounter a moral or ethical issue and do not act, act in a manner contrary to their beliefs, or are prevented from acting in a manner consistent with their beliefs and distress results. Depending on the intensity of a single encounter or frequency of encounters, moral distress can arise, resulting

in suffering. Moral distress results in poor patient clinical outcomes, burnout, employment turnover, and increased healthcare expenses. **OVERVIEW:** Hundreds of qualitative, quantitative, and theoretical articles have been published since moral distress was first defined in the 1980s. There has been a lack of harmony between theoretical clarity and empirical understanding on the topic, making its application to policy, education, and practice challenging. Blurring the concept further has been the emergence of similar terms such as moral injury, compassion fatigue, and burnout as they relate to the healthcare provider. Concepts such as moral injury have been traditionally used in the context of a warfighter and not applied to the military healthcare provider. But for a military critical care nurse practicing in austere conditions such as the en route care environment, they are simultaneously healthcare providers and warfighters, which may pose situations where both of these concepts are applicable. This presentation will include a synthesis of the current state of literature on moral distress, relevant similar terms, application to military en route care nurses and other healthcare professionals across Department of Defense and Veteran's Administration enterprises, future work for a moral distress tool for the military nurse, and interventions to address the deleterious effects of this phenomenon. **DISCUSSION:** Understanding the current evidence of moral distress and similar relevant terms is key to developing evidence-based interventions that will address this phenomenon in critical care en route care nurses. As a warfighter and caregiver, it is essential that we understand this experience and learn from previous work in warfighter and civilian moral distress nursing research. Then we may be able to immediately respond with an evidence-based intervention to mitigate the negative effects of this detrimental outcome of providing care in this challenging environment.

**Learning Objectives:**

1. The participant will describe the current definition of moral distress.
2. The participant will identify gaps in the literature related to presentation topics.
3. The participant will describe similar relevant terms related to moral distress in military healthcare providers.

**[156] MORAL DISTRESS IN THE CRITICAL CARE AIR  
TRANSPORT NURSE**

Kayla Eaton<sup>1</sup>, Melissa Wilson<sup>1</sup>, Col Nicole Armitage<sup>1</sup>,  
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<sup>1</sup>*USAF School of Aerospace Medicine/FHE, Wright-Patterson AFB, OH, USA;* <sup>2</sup>*Cutcliffe Consulting, Amherstview, Ontario, Canada*

*(Original Research)*

**INTRODUCTION:** Critical Care Air Transport (CCAT) nurses provide world-class patient care in austere environments. These environments can leave them vulnerable to multiple physical and psychological stressors, such as fatigue, multiple traumas, lack of resources, and ethical dilemmas. These stressors put the providers at risk for developing anxiety, depression, and post-traumatic stress disorder. Moral distress occurs when a nurse knows the right action to take but, due to an external or internal barrier, is unable to act in a way that is consistent with his/her belief. The phenomenon of moral distress has been explored in previous research in the civilian sector, but few studies have been completed within the military population. This study aims to explore moral distress in the CCAT nurse by describing the lived experience of moral distress and by identifying the themes described by CCAT nurses during moral distress situations. **METHODS:** An interpretative phenomenological method was utilized. Data collection was accomplished through in-person interviews conducted by the study principal investigator. Being a CCAT nurse and having completed one or more deployments were inclusion criteria for participation. Four team members completed data analysis of all transcribed interviews. Data analysis began once the first interviews were completed. Each member completed an individual analysis of the data, then the team met collectively to discuss the findings and establish meaning from the interviews. Emerging themes developed, highlighting the lived experience of moral distress in CCAT nurses.

**RESULTS:** Fifteen interviews were completed. Moral distress was present and described in the CCAT nurse population. At the completion of data analysis, seven themes of CCAT nurses' lived experience of moral distress were identified: 1) Not Prepared; 2) Agent of Healing, Agent of Harm; 3) Live or Let Die; 4) Robbing Peter to Pay Paul; 5) Ever-Decreasing Circles; 6) Cultural Dissonance; and 7) Incongruence with Colleagues. **DISCUSSION:**

While moral distress has been established in the civilian population, research completed on it is limited in the military environments. This study established the presence of moral distress in the CCAT nurse population. The seven themes described highlight the unique moral issues that CCAT nurses encounter. These themes provide insight into the realities of providing care in the air evacuation setting and its contrast to civilian nursing care.

#### Learning Objectives:

1. Describe the lived experience of moral distress in the Critical Care Air Transport Nurse.
2. Describe the themes of moral distress identified by the Critical Care Air Transport Nurse.
3. Define Moral Distress.

### [157] EMPIRICALLY SUPPORTED INTERVENTIONS FOR MORAL INJURY

Jeanette Irene Harris

*Minneapolis VA Health Care System, Minneapolis, MN, USA*

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** Moral injury and moral distress are related constructs dealing with situations in which individuals experience conflict related to moral or spiritual beliefs. Moral injury is usually considered as a consequence of combat or first responder duties, whereas moral distress is usually considered in health care providers. This presentation outlines the research on treatment for moral injury. Theories and techniques used in moral injury may be applicable to moral distress as well. Moral injury is associated with more severe and chronic mental health challenges, as well as increased suicide risk; as such, it is a high priority concern in the ASMA community. **OVERVIEW:** Research in moral injury is still in emergent stages; gold standards for definitions and measurement of moral injury are still in development. This presentation will review current theories of etiology and related treatment approaches, while evaluating the empirical evidence for each. Topics will include the exposure theory vs. developmental theory of moral injury. A large number of recently developed treatments in use in the Veterans Health Administration and the Department of Defense will be reviewed, with an emphasis on the three manualized treatments that have been subjected to randomized controlled trials. These will include Adaptive Disclosure, The Impact of Killing in War, and Building Spiritual Strength. After reviewing the evidence for each, we will discuss clinical considerations in selecting a treatment for an individual based on individual clinical needs and institutional context. **DISCUSSION:** 1. Operational Significance: Moral injury contributes to the mental health sequelae of combat and first responder service, by exacerbating symptoms of PTSD, depression, and substance abuse, and increasing suicide risk. Understanding the etiology and treatment of moral injury is essential to maintain force readiness in both military and first responder workforces. 2. Advancement of Aeromedicine/Human Performance: Understanding the etiology of moral injury can help to inform prevention from both an individual employee management perspective, and from an organizational management perspective. Awareness of treatment options for moral injury can help to get individuals effective treatment and reduce the mental health sequelae of moral injury. 3. Cross Service/Military/Civilian implications: Moral injury affects those in both military combat and civilian first responder/medical services.

#### Learning Objective:

1. Participants will be able to describe at least 3 treatments for moral injury.

### [158] BEHAVIORAL HEALTH IN MILITARY NURSES WHO PROVIDED EN ROUTE CARE WHILE DEPLOYED

Angela Simmons<sup>1</sup>, Felecia Rivers<sup>2</sup>

<sup>1</sup>U.S. Army, JBSA Fort Sam Houston, TX, USA; <sup>2</sup>U.S. Army, Knoxville, TN, USA

*(Original Research)*

**INTRODUCTION:** Since 2003, over 8400 nurses deployed to Iraq or Afghanistan in support of Operations Iraqi Freedom, Enduring Freedom, and New Dawn. A subset of those nurses provided enroute care delivering life-saving nursing care on various platforms. The volume of trauma they witnessed and the severity of injuries often left

imprints that paralleled those experienced by the Soldiers in combat units. The purpose of this exploratory, mixed methods study was to examine factors that influenced the behavioral health of military nurses who provided enroute care while deployed to Iraq or Afghanistan, focusing specifically on perceptions of behavioral health symptoms and the process of seeking assistance. **METHODS:** Roy's Adaptation Model was used to guide the quantitative portion using five instruments: a demographic and personal military characteristics instrument, the Centers for Epidemiologic Studies Depression Scale, the Generalized Anxiety Disorder-7 Scale, the Post-Traumatic Stress Disorder Checklist-Military, the Post-Deployment Readjustment Inventory, and the Post Traumatic Growth Inventory. These surveys were administered either electronically using Survey Monkey or hard copy, returned via mail. The results were analyzed using SPSS 21 and 22 and Pearson bivariate correlation analyses. Existential phenomenology was the method used for the qualitative portion of this study. **RESULTS:** 119 nurses completed the surveys and twenty-two interviews were conducted either via Skype, face-to-face, or by phone. The interviews lasted an average of 75 minutes, were recorded and transcribed. The majority of those who completed the surveys were male (51%), serving in the Air Force (55%) and 79% had deployed two or more times to Iraq or Afghanistan. The qualitative findings validated key findings of the quantitative arm of the study, which detailed elevated levels of anxiety and depression. Qualitative findings revealed seven themes: Terror of war, Here is my suffering, You have to have a team, This is my purpose, I am not prepared, I do not fit in, and Leadership matters. **DISCUSSION:** The findings speak to the importance of mixed methods research designs. The results from the surveys did not provide details on certain issues, such as spirituality. However, the qualitative data clearly detailed spirituality as an influencer of nurses behavioral health. Further research is needed to discover ways to better support military nurses before, during, and after returning from deployment.

#### Learning Objectives:

1. The participant will be able to identify three factors that influenced the behavioral health of enroute care nurses.
2. The participant will be able to discuss the role leadership plays in influencing the behavioral health of enroute care nurses.
3. The participant will be able to identify two ways to assist enroute care nurses upon return from deployment to mitigate issues with anxiety and depression.

**Tuesday, 05/07/2019**

**2:00 PM**

**Brasilia 7**

### [S-33] PANEL: ESAM CLINICAL SPACE MEDICINE

*Sponsored by European Society of Aerospace Medicine (ESAM)*

**Chair: Jochen Hinkelbein**

**Co-Chair: Matthieu Komorowski**

**PANEL OVERVIEW:** This session is provided by the European Society of Aerospace Medicine and the Space Medicine Group (ESAM-SMG). It covers clinical aspects of Emergency Medicine in space for future space missions.

### [159] AIRWAY MANAGEMENT IN MICROGRAVITY – A SYSTEMATIC REVIEW

Jochen Hinkelbein<sup>1</sup>, Tobias Warnecke<sup>2</sup>, Jan Schmitz<sup>3</sup>, Steffen Kerkhoff<sup>1</sup>, Matthieu Komorowski<sup>4</sup>, Christopher Neuhaus<sup>5</sup>

<sup>1</sup>Department of Anesthesiology and Intensive Care Medicine, University Hospital of Cologne, Cologne, Germany; <sup>2</sup>Department of Anesthesiology and Intensive Care Medicine, Evangelisches Klinikum Niederrhein, Duisburg, Germany; <sup>3</sup>German Society of Aerospace Medicine, Munich, Germany; <sup>4</sup>Department of Surgery and Cancer, Imperial College London, London, United Kingdom; <sup>5</sup>Department of Anesthesiology, University Hospital of Heidelberg, Heidelberg, Germany

*(Original Research)*

**INTRODUCTION:** In the near future, space programs will shift their focus towards long-duration interplanetary missions, in particular to the Moon and Mars. These exploration missions will unavoidably be associated with an increased risk of acute medical problems, which will need to be handled by an autonomous crew operating in extreme isolation. An important skill in emergency medicine is represented by airway management, which is a key component in the management of numerous medical conditions as well as for general anesthesia. Many airway devices are available, and it is unclear which one would be the most suitable in the context of a space mission. The aim of this systematic review is to analyze the existing literature on airway management in the special situation of weightlessness during space missions. **METHODS:** We performed a standardized review of published literature on airway management in spaceflight and analogue environments using the database PubMed. **RESULTS:** We identified a total of 3,111 publications of which 3,039 were initially excluded after evaluation. The literature screening identified three randomized comparative manikin studies, two of them in parabolic flights, one in a submerged setup. Under free-floating conditions, the insertion success rate of supraglottic airway devices (SGA) was excellent (91%-97%). The administration of artificial ventilation could be successfully achieved in weightlessness with supraglottic devices, without the need to restrain patient or operator. The success rate of conventional laryngoscopy under free-floating conditions fluctuated between 15-86%. No study has evaluated modern video laryngoscopes or intubation under partial gravity conditions. **DISCUSSION:** It appears possible to safely manage the airway in weightlessness, provided that certain conditions are ensured, such as restraining the patient and operator for conventional orotracheal intubation. If airway protection is required in microgravity with endotracheal intubation, both the operator and the patient should be restrained.

**Learning Objectives:**

1. Airway Management in space is done with two analogues (parabolic flight, underwater).
2. Success rate for ETI in space is significantly lower.
3. Concepts for airway Management in space are urgently needed for Long-term missions.

### [160] IMPROVING SUCCESS OF OROTRACHEAL INTUBATION BY NOVICE OPERATORS IN MICROGRAVITY WITH VIDEO-LARYNGOSCOPY

Clément Starck<sup>1</sup>, Seamus Thierry<sup>2</sup>, Cécile Isabelle Bernard<sup>3</sup>, Yvon Thomas<sup>2</sup>, Yoann Le Mer<sup>2</sup>, Thierry Morineau<sup>3</sup>, Pascal Chapelain<sup>3</sup>, Matthieu Komorowski<sup>4</sup>

<sup>1</sup>Brest University Hospital, Brest, France; <sup>2</sup>Bretagne Sud General Hospital, Lorient, France; <sup>3</sup>University of Bretagne Sud Laboratory of Psychology, Cognition, Communication and Behaviour, Vannes, France;

<sup>4</sup>Imperial College London, London, United Kingdom

*(Original Research)*

**INTRODUCTION:** In the near future, space programs will shift their focus toward long-duration interplanetary missions, in particular to the Moon and Mars. During these exploration missions, an autonomous crew may have to perform emergency care without real-time telemedical support. Many scenarios require advanced airway management skills. Therefore, safe and reliable airway management strategies are mandatory, especially for operators with limited expertise. Modern video-laryngoscope devices allow higher success rate of orotracheal intubation in lay operators but were never tested in microgravity. The aim of this parabolic flight study was to evaluate the success rate of two intubation techniques (direct or video-assisted laryngoscopy) in normogravity and microgravity, comparing novices and experts in intubation. **METHODS:** Six subjects, 3 experts (with an experience of more than 1000 intubations) and 3 novices (with less than 10 intubations), performed oro-tracheal intubation on a mannequin with difficult airway due to swollen tongue and a cervical collar in restrained condition. 90 intubations attempts were performed with direct laryngoscopy (DL) (45 in normogravity and 45 in microgravity) and 90 using a MacGrath® video-laryngoscope (VL) (45 in normogravity and 45 in microgravity). Success rate and confidence score of successful insertion (on a scale of 1 to 10) were recorded. **RESULTS:** The success rate of novice operators in microgravity was higher with VL compared with DL

(VL 20/25 (80%) successful intubations versus DL 8/20 (40%),  $p < 0.006$ ). Gravity condition and the type of device did not affect the success rate of experts, which was consistently very high (Microgravity : DL 24/25 (96%) versus VL 19/20 (95%)  $p = 0.87$  ; Normogravity : DL 21/25 (84%) versus VL 16/20 (80%)  $p = 0.72$ ) Overall, the use of VL led to higher confidence scores of successful insertion, when compared with DL in all scenarios (VL 10/10 versus DL 7/10 in microgravity,  $p < 0.001$  and, VL 9.9/10 versus DL 6.1/10 in normogravity,  $p < 0.001$ ). **DISCUSSION:** VL is associated with a higher intubation success rate for novice operators in microgravity. It may represent a viable technique for advanced airway management during long duration spaceflight.

**Learning Objectives:**

1. The participants will learn about oro-tracheal intubation in parabolic flight, used as a model for weightlessness during space travel.
2. The participants will discover which intubation device is associated with higher success rate in this experiment, in novice hands as well as expert hands, in both normogravity and microgravity.

### [161] CORRELATION BETWEEN HEMODYNAMICS AND THE CENTRAL NERVOUS SYSTEM IN MICROGRAVITY

Jan Schmitz, Steffen Kerkhoff, Jochen Hinkelbein  
Uniklinik Köln, Cologne, Germany

*(Original Research)*

**BACKGROUND:** There is limited evidence that the space environment and especially microgravity may induce anatomical structure alterations in the central nervous system by influencing intracranial pressure homeostasis. **METHODS:** Retrospective analysis. Recent data was gathered by using the MEDLINE® database. **RESULTS:** In the 14 studies analyzed, a total of 105 subjects were investigated. Significant changes were investigated. **CONCLUSIONS:** In recent studies, the most likely mechanisms of spaceflight-induced increased ICP include a cephalic shift of body fluids and venous outflow obstruction and these changes in turn may provoke structural remodeling and altered cerebral autoregulation.

**Learning Objective:**

1. The audience will learn about correlations between hemodynamics and the central nervous System in microgravity. Investigation of underlying causes will be an important subject of future medical aerospace research – especially in the light of long-term missions.

### [162] DEVELOPMENT OF A GUIDELINE FOR CPR IN MICROGRAVITY

Steffen Kerkhoff<sup>1</sup>, Matthieu Komorowski<sup>2</sup>, Christopher Neuhaus<sup>3</sup>, Jan Schmitz<sup>1</sup>, Jochen Hinkelbein<sup>1</sup>

<sup>1</sup>University Hospital of Cologne, Cologne, Germany; <sup>2</sup>Imperial College London, London, United Kingdom; <sup>3</sup>Heidelberg University Hospital, Heidelberg, Germany

*(Original Research)*

**INTRODUCTION:** Considering future space exploration missions and the arising space tourism with more humans staying for longer periods in space, medical emergencies become more and more likely to happen. So far, no severe medical emergency has happened in space – especially no cardiac arrest. Although evidence-based and proven guidelines for cardiopulmonary resuscitation (CPR) on Earth exist there is no guideline for its application under the special circumstances of spaceflight. **METHODS:** In the beginning, a taskforce was created to develop a guideline for CPR in microgravity, based on the members clinical and scientific background. After a brainstorming phase PICO-questions were developed to guide the systematic literature research. The literature research was then carried out using "MEDLINE". There were 4,356 abstracts identified in the first place, that were consecutively screened by at least two reviewers. The 265 selected papers were then rated using the GRADE-method. There were 15 subtopics identified for the guideline and for each subsection at least 2 taskforce members proposed recommendations based on the retrieved literature. Afterwards the proposed recommendations were subject to the structured consensus finding process using a two round DELPHI-method. **RESULTS:** We recommend a differentiated approach to CPR in microgravity with a division into basic life support (BLS) and advanced



life support (ALS) similar to the Earth-based guidelines. In immediate BLS, the chest compression method of choice is the Evetts-Russomano method (ER), whereas in an ALS scenario, with the patient being restrained on the Crew Medical Restraint System, the handstand method (HS) should be applied. Airway management should only be performed if at least two rescuers are present, and the patient has been restrained. A supraglottic airway device should be used for airway management where crew members untrained in endotracheal intubation (ETI) are involved. **DISCUSSION:** CPR in microgravity is feasible and should be applied according to the Earth-based guidelines of the AHA/ERC in relation to fundamental statements, like urgent recognition and action, focus on high-quality chest compressions, compression depth and compression-ventilation ratio. However, the special circumstances presented by microgravity and spaceflight must be considered concerning central points, such as rescuer position and methods for the performance of chest compressions, airway management and defibrillation.

#### Learning Objectives:

1. The participant will be able to understand the basic principles of cardiopulmonary resuscitation under the conditions of microgravity.
2. The audience will learn about the process of the development of an evidence-based guideline for cardiopulmonary resuscitation in microgravity.

#### [163] EXTRATERRESTRIAL CPR AND ITS APPLICATIONS IN TERRESTRIAL MEDICINE

Christina Mackaill<sup>1</sup>, Lucas Rehnberg<sup>2</sup>, Elliot Brown<sup>3</sup>,  
Thais Russomano<sup>4</sup>

<sup>1</sup>Ninewells Hospital, Dundee, United Kingdom; <sup>2</sup>University Hospital Southampton, Southampton, United Kingdom; <sup>3</sup>Luton and Dunstable University Hospital, Luton, United Kingdom; <sup>4</sup>King's College London, London, United Kingdom

(Education - Program / Process Review Proposal)

**BACKGROUND:** Cardiopulmonary resuscitation (CPR) is a well-known method used in cardiac arrest, aiming to achieve the return of spontaneous circulation (ROSC). Several CPR methods have been trialled in environments simulating microgravity and hypogravity. Although the chances of a cardiac arrest in space are low, there is a possible increased risk in longer microgravity exposures, less screening medical criteria for commercial space flight, and during a trip to Mars. Therefore, a well-defined CPR protocol for both microgravity and hypogravity is necessary to avoid a potentially fatal incident. **OVERVIEW:** There are currently three proposed methods for both CPR in microgravity (Handstand (HS), Reverse Bear-Hug (RBH) and Evetts-Russomano (ER)) and hypogravity (Terrestrial, SeAL and Mackaill-Russomano (MR)). When comparing these methods against 2015 Resuscitation Council guidelines, some would appear to be more effective at achieving ROSC than others, especially when they are applied in microgravity or hypogravity. These methods are yet to be combined with airway management to establish an effective extraterrestrial CPR protocol, as well as be evaluated in environments with sustained microgravity and hypogravity. **DISCUSSION:** The efficacy of extraterrestrial CPR methods may be influenced by training and the rescuer's size and weight, which must be considered for the establishment of an efficient protocol. In hypogravity, the MR method may be more applicable to lighter space travelers, as it adds more stability to the rescuer. In microgravity, the HS method may be more applicable to taller crewmembers, who can push their legs against the spacecraft ceiling. By studying extraterrestrial CPR, we can learn about CPR on Earth in relation to the impact of size and weight differences between rescuers and patients. If a child or weaker adult performing CPR on a patient in an out of hospital cardiac arrest adopts the MR method, it may increase stability of the rescuer, improving the CPR outcome. Similarly, a lighter or weaker healthcare professional performing CPR on a larger patient, especially in the presence of a lung disease that increases chest diameter, must flex and extend their elbows to compensate for the lack of weight between themselves and the patient. This will improve the effectiveness of CPR by increasing the depth of chest compressions, as it has been shown in studies conducted in microgravity and hypogravity simulations.

#### Learning Objectives:

1. The audience will learn about extraterrestrial CPR methods in microgravity and hypogravity, and the importance of establishing a CPR protocol for these environments.
2. The audience will learn about the terrestrial applications of studying extraterrestrial CPR.
3. The audience will learn about gaps in current research, and what future research needs to be done to establish an extraterrestrial CPR protocol for microgravity and hypogravity.

Tuesday, 05/07/2019

2:00 PM

Miranda 5/7

#### [S-34] SLIDE: BRAIN PERFORMANCE

Chair: Chris Front

Co-Chair: Eric Friedman

2:00 PM

#### [164] THE EVIDENCE FOR NEUROCOGNITIVE TESTING FOR FITNESS TO FLY

Elilis Boudreau, Cynthia Davis-O'Reilly, Tamara Cheney, Annette Totten

Oregon Health & Science University, Portland, OR, USA

(Original Research)

**INTRODUCTION:** Neurocognitive functioning is critical for safely piloting an aircraft. Injury or illness may temporarily or permanently impair pilot function so regulatory agencies commonly request neurocognitive assessment in determining medical certification of fitness to fly. However, optimal methods for making this determination remain controversial. This project was designed to start by describing the published evidence that evaluates neurocognitive assessment for pilots, rigorously exam the applicable research, then identify gaps in the evidence and create a framework for future research. **METHODS:** Systematic review methods to identify research literature evaluating tests for assessment of neurocognitive fitness to fly in pilots were used. We formed a stakeholder-technical expert panel representing regulatory authorities, pilot representatives, neuropsychologists, and aerospace medicine experts. This panel provided input on the key questions, scope of the review and inclusion-exclusion criteria. A research librarian constructed a search strategy for biomedical literature published between 1980 - January 2018. Abstracts were dual reviewed with questions being resolved by consensus. Characteristics and results of studies included were described and summarized in order to assess the state of the literature. **RESULTS:** The stakeholder group agreed the review would include all types of pilots (military, commercial and civilian) and created a list of frequently used neurocognitive tests. The search resulted in 845 citations; of these 73 full text articles were pulled for further review; and 19 met the inclusion criteria. Most of the excluded studies assessed the wrong population or evaluated tests outside the review scope. Studies included 5 with samples of 100 or more pilots, most were general aviation and compared the test in question to simulator performance. **DISCUSSION:** The published literature does not provide extensive evidence evaluating current neurocognitive assessments for fitness to fly. Supplementing this search with grey literature (unpublished or not peer reviewed) including meeting abstracts, technical reports, and manuals for psychometric tests in the next phase will provide a broader assessment of the evidence. The identified gaps in the current evidence provide a framework for a prioritized research agenda.

#### Learning Objectives:

1. The audience will understand how the process of systematic review can be used to evaluate relevant literature for aeromedically significant questions.
2. The participant will be able to identify the most commonly used tests for evaluating pilot neurocognitive fitness to fly.
3. The participant will be able to identify which neurocognitive tests used for determination of fitness to fly have the strongest supporting evidence.

2:15 PM

**[165] PSYCHOPHYSIOLOGICAL CORRELATES OF WORKLOAD AND PERFORMANCE**Amanda Kelley, Kathryn Feltman, Ian Curry  
U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL, USA*(Original Research)*

**INTRODUCTION:** A promising method for monitoring workload in real time is through the use of psychophysiological recording devices. Some of the commonly used psychophysiological measurements of workload include electroencephalogram (EEG) for measuring brain activity (Borghini et al., 2014), electrocardiogram (ECG) for cardiovascular measures [e.g., heart rate, heart rate variability, blood pressure (Stuiver et al., 2014)], electrooculography (EOG) to record eye movements (Wickens & Hollands, 1999), and to a lesser extent, respiration (Veltman & Gaillard, 1996). Such measures are able to provide indications of the mental or physical engagement of the individual that correspond to changes in task demands. Wickens (2002, 2008) Multiple Resource Model postulates that the relationship between workload and performance is driven by the degree of overlap in resources required across four dimensions. To apply this framework to aviation, we refined description of these four discrete domains to be more directly representative of the categories encountered during aviation: visual, auditory, cognitive, and physical. **METHODS:** In Phase 1, 16 healthy adults (3 females, mean age = 31.25) completed an auditory discrimination task at three validated workload levels (low, medium, high). In Phase 2, 23 healthy, U.S. Army rated aviators completed both low and high workload levels of a 10-minute flight maneuver with requiring auditory attention. **RESULTS:** Phase 1 results revealed changes in frontal alpha activity between workload conditions in the auditory discrimination task ( $F(2,22) = 5.67, p = 0.01, \eta^2 = 0.34$ ). Similarly, Phase 2 results showed a relationship between frontal alpha activity and perceived level of workload ( $r(22) = 0.43, p = 0.04$ ) and flight performance ( $r(22) = 0.44, p = 0.04$ ). Further, performance correlated with perceived workload ( $r(22) = 0.50, p = 0.02$ ). **DISCUSSION:** Taken together, these findings provide preliminary support for validity of these measures as indices of workload by task domain (specifically, the auditory domain) and are consistent with previous work using cognitive tasks. Specifically, these findings suggest attenuation of frontal alpha activity during high workload conditions during an auditory attention task consistent across a basic cognitive task and complex flight maneuver task.

**Learning Objective:**

1. The audience will learn about the utility of real-time psychophysiological monitoring of workload by task domain (e.g., auditory, visual).

2:30 PM

**[166] EXECUTIVE FUNCTIONS AND DECISION MAKING IN UAV OPERATORS**Alexander Diaz<sup>1</sup>, Camila Rodriguez<sup>1</sup>, María Corzo<sup>1</sup>, Jose Saavedra<sup>1</sup>, Ivette Falla<sup>1</sup>, Christian Mahecha<sup>2</sup><sup>1</sup>Colombian Air Force, Bogotá, Colombia; <sup>2</sup>Colombian Air Force, Barranquilla, Colombia*(Original Research)*

**INTRODUCTION:** UAV operational issues have concerned different disciplines. For Psychology is important to identify how UAV operator think during different missions. Because of that this original research analyze how is the neuropsychological function and how decision making works on UAV operators and to establish differences related with previous flight activities. **METHODS:** Iowa Gambling Task 2 and the neuropsychological battery of executive functions and frontal lobules (BANFE 2) were applied to 17 UAV operators. They were divided in four groups according to their hours of experience in Scan Eagle. Protocol was approved by Postgraduate School of Colombian Air Force ethics committee. **RESULTS:** It was observed that performance was better in operators who have higher number of hours in Scan Eagle (group 4 mean: 195) than those of group 1 (mean=191) in the test that evaluated executive function specifically orbito-medial area. Banfe 2 results that are associated to the pre-frontal dorsolateral area of group 1 operators were better than group 4 (group 1 = 215; group 4 = 207). **DISCUSSION:** UAV operators with little experience require more cognitive sources such as planning, organization and integration of sensory information than those

with more experience. Thus, those with more experience react to emergencies in an intuitive way. Also, a better cognitive process in decision making process was observed in group 4, that is related to emotion and reward processing mechanisms.

**Learning Objective:**

1. Understand executive functions and decision making process in UAV operators.

2:45 PM

**[167] AUTONOMOUS MULTIMEDIA STRESS MANAGEMENT AND RESILIENCE TRAINING FOR NASA FLIGHT AND MISSION CONTROLLERS**Raphael Rose<sup>1</sup><sup>1</sup>University of California, Los Angeles, Los Angeles, CA, USA*(Original Research)*

**INTRODUCTION:** Stress and anxiety-related problems are among the most common and costly behavioral health problems in society, and for those working in operational environments (i.e. astronauts, flight controllers, military) it can seriously impact performance, safety, and wellbeing. Technology-based interventions are effective for treating behavioral health problems and can significantly improve the delivery of evidence-based health care. SMART-OP (Stress Management and Resilience Training for Optimal Performance) is an autonomous, multimedia, computer-based stress management training program, developed for NASA, to help autonomously train users to manage stress and build resilience. SMART-OP is an evidence-based resilience training program that teaches skills that address, physiological and emotion regulation, cognitive flexibility, and effective behavioral responses.

**METHODS:** The present study evaluated SMART-OP's effectiveness in a randomized controlled trial with NASA-JSC flight/mission controllers and instructors (N=45) in comparison to a wait list control (WLC) group. Pre-post assessments consisted of self-report questionnaires about stress, resilience, sleep, and mood. Participants completed a standardized stress/frustration task, a neuropsychological battery, and biomarker stress data (salivary and urinary cortisol and  $\alpha$ -amylase), and heart rate data was collected. Participants received 6 weekly SMART-OP sessions or waited for 6 weeks (WLC) between pre-post assessments. **RESULTS:** Participants in the SMART-OP group reported significantly greater reductions in perceived stress (PSS-10) as compared to the WLC group from pre- to post-assessment (SMART-OP  $M = 10.48$  ( $SD=4.65$ ), WLC  $M = 15.53$  ( $SD=4.90$ ),  $\chi^2(1) = 4.08, p = .043$ ). For the Stress and Perception of Control Scale (SPOCS) and Connor-Davidson Resilience Scale (CDRS) scales, the SMART-OP group approached statistical significance at the  $p < .05$  level as compared to WLC. Post-hoc power analyses suggest that the sample was underpowered by 1-2 participants. SMART-OP received high ratings of system usability, usefulness, and working alliance. **DISCUSSION:** This study provides initial support for the efficacy, acceptability, and usefulness of autonomous behavioral health training among NASA employees who work in operational settings. Our presentation will address limitations of the study as well as recommendations on future research and implementation approaches.

**Learning Objectives:**

1. To understand about the use and content of digital autonomous behavioral health/resilience training programs.
2. To understand the findings from a randomized controlled trial of an autonomous stress management and resilience training program with flight and mission controllers at NASA-Johnson Space Center.

3:00 PM

**[168] IMPACT OF 24 HOURS ISOLATION AND CONFINEMENT EXPOSURE (ICE) ON PSYCHOLOGICAL STATE OF HEALTHY HUMAN VOLUNTEERS**

Sudhanshu Mohapatra

Institute of Aerospace Medicine, Bengaluru, India

*(Original Research)*

**INTRODUCTION:** Some studies have found that isolated individuals could suffer from anxiety, mood swing and discrepantly enhancement of negative emotions which in conjunction with the physiological offsets adversely affect the crew performance. The identification of adverse

effects arising from isolation and confinement not only allows the crew to prepare better but also help them to get adapted quickly and effectively during the space explorations in future. **METHODS:** State-Trait Anxiety Inventory (STAI), Positive and Negative Affect State (PANAS) and Profile of Mood State (POMS) in the existing Isolation cum Group Confinement Laboratory of IAM. A multifactorial ANOVA was carried out to find out the statistical significance of the changes which may have appeared in the psychological parameters as the period of isolation and confinement progresses. **RESULTS:** There was a momentary increase in anxiety level during early period of Isolation and Confinement exposure (ICE). But the anxiety level returned to pre-exposure level within 24 h. Similarly, the level of positive emotions among the experimental group was significantly lower in comparison to the control group. Though insignificant, a fluctuation in the level of positive emotions was observed in comparison to a more or less steady level maintained in the control group. Over the period of 24 hours of isolation and confinement, neither the experimental group nor the control group did show statistically significant changes in the Total Mood Disturbance (TMD). None of the groups showed any significant changes in any of the POMS sub-scales i.e. Anger-hostility, Confusion-bewilderment, Depression-dejection, Fatigue-inertia, Tension-anxiety Except for Vigor-activity. **DISCUSSIONS:** On exposure to isolation and confinement, the experimental group exhibited a higher level of State anxiety and lower level of positive emotions in comparison to the control group. While the anxiety level return to pre-exposure level within 24 h, the state of positive emotions progress through an insignificant fluctuation during 24 hours period of isolation and confinement in comparison to a more or less steady level of positive emotions observed in the control group. Towards end of the isolation period (24 h), the subject group exhibited a significant decrease in the level of negative emotions. There was no significant change in the Mood state in the study group as well as in the control group.

**Learning Objectives:**

1. Audience will learn effect of 24 hours Isolation/ Confinement on psychological states of healthy human subjects.
2. Audience will learn various psychological tests used during an Isolation/ Confinement study.

**3:15 PM**

**[169] "PILOT IN THE LOOP" - ENHANCING AEROMEDICAL DECISION MAKING BY BRINGING THE AVIATOR ONBOARD**

Vivianne Fonne, Anthony Wagstaff

*Institute of Aviation Medicine, Oslo, Norway*

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** The quality of any aeromedical decision making (ADM) process to medically certify aircrew has an obvious impact on both efficiency and safety in aviation at large. Current standards have been developed with this in mind, and a multitude of efforts developed to ensure the highest quality in ADM. A well-recognized challenge in ADM processes is ensuring disclosure of all relevant health related information from the aircrew member in question. A general skepticism towards disclosing personal information due in large to dreaded consequences for fitness to fly, still seems to pose a challenge. In an attempt to further improve the ADM algorithm, the RNOAF has recently implemented a new regulatory practice in their ADM process, ensuring mandatory involvement from the aircrew member in question in the decision process. The aim is to increase pilot involvement in issues regarding own health, in addition to involving operational and risk mitigating factors as a basis for ADM processes. **OVERVIEW:** The Pilot-In-The-Loop concept (PITL) has been developed gradually over several years. The central part is an ADM algorithm which includes formal participation from the aircrew member in the process. From 2017, this participation has also been included in RNOAF regulations. PITL involves one or more meetings where the ADM board chairperson, relevant clinical specialist and aviation psychologist participate in addition to the aircrew member and his/her base flight surgeon. The discussion includes review of the medical case, operational duties, possible mitigation of risk, and alternative duties if applicable, and forms a basis for the final aeromedical decision. The aircrew member is made aware that any decision may be reviewed at a later date. **DISCUSSION:** It could be argued that high quality judgements might benefit from the perspective of the aircrew member in addition to the perspective of trained aeromedical professionals. While this ADM

algorithm is written from a military aviation perspective and refers to an aviation medical certification process, it is highly applicable to other regulatory spheres and can be used to assess any fitness for duty determination.

**Learning Objectives:**

1. The audience will learn about enhancing aeromedical decision making by including the aviator in the process.
2. The audience will learn about the RNOAF regulated ADM algorithm which forms the basis for their aviation medical certification process.

**Tuesday, 05/07/2019**

**4:00 PM**

**Brasilia 1**

**[S-35] PANEL: BLUE FORCES: COMPLEX PROBLEMS AND NOVEL SOLUTIONS FROM JUNIOR AND FUTURE FLIGHT SURGEONS LEADING INNOVATION**

**Chair: William Timberlake**

**Co-Chair: Bryant Martin**

**PANEL OVERVIEW:** The diverse missions of aviators, special duty operators, and trainees across the USA Air Force present complex operational medicine problems. This panel features junior Flight Surgeons from various installations 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 have one central 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. In the spirit of being in Las Vegas near Nellis AFB where the famed RED FLAG exercises take place, this panel is named "BLUE FORCES" in homage to the friendly forces leading the fight against the enemy. As such, our Junior Flight Surgeons in this panel are showcasing their fight against disease and disability on a daily basis in efforts to keep our flyers in the fight.

**[170] EJECTION SEAT BLAST TO THE FACE: A CASE STUDY AND REVIEW OF BURN EMERGENCIES**

Zackary Powers

*U.S. Air Force, Columbus, MS, USA*

*Endorsed by: Society of U.S. Air Force Flight Surgeons*

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** The Field Response Team was activated after the rear cockpit ejection seat inadvertently fired, injuring the three maintainers who were inspecting it. **BACKGROUND:** Aviation brings a wide spectrum of risks, including trauma and burns, prompting extensive precautionary measures and emergency response capabilities. This case report describes a consequence of an ejection seat malfunction resulting in significant burns and trauma. Appropriate evaluation and response to burn injuries by flight medicine can make the difference in a burn victim's outcome. **CASE PRESENTATION:** A T-38 was found to have an issue with the rear ejection seat. The aircraft was able to land safely and the pilot egressed without injury. The ejection seat was inadvertently activated while two maintainers were inspecting the seat. The two maintainers were blasted off of their ladders approximately two feet from the ground resulting in burns to 10-30% TBSA. A third maintainer was struck by an unknown object resulting in minor injuries. **DISCUSSION:** Effectively responding to multiple burn/trauma patients requires a coordinated effort from multiple disciplines. Proficiency in basic skills save lives. Triage with the primary and secondary survey with re-evaluation are paramount in prioritizing limited resources and arranging transportation. Burns have many nuances outside of the basics during initial response with common pitfalls. Advanced Burn Life Support is an available course that addresses the array of burn variety and was crucial in managing the patients in this scenario.

**Learning Objectives:**

1. The audience will understand the possibility of burn emergencies in flight medicine.
2. The audience will learn some details of emergency burn care as it pertains to blasts.
3. The audience will learn about other possible burn emergencies including IED blasts, electrical burns, etc.

### [171] ELEVATED SERUM IRON AND SERUM TRANSFERRIN CONCENTRATION (TIBC) IN AN AIR TRAFFIC CONTROLLER: A CASE REPORT

Kenneth Taylor

Columbus AFB, MS, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This case report describes a military air traffic controller who presented with bilateral metacarpophalangeal joint (MCP) pain and was found to have elevated serum iron and serum transferrin concentration (TIBC). Initially he was believed to have hemochromatosis, but after consultation with hepatology, his alcohol use was found to be causal. **BACKGROUND:** Hepcidin is a crucial element in iron metabolism. With increased levels of hepcidin, iron absorption in the small intestine is downregulated and macrophages are signaled to increase their iron stores. These regulatory mechanisms work in concert to decrease serum iron concentrations in inflammatory states such as anemia of chronic disease. In other conditions such as chronic alcohol use, hepcidin is downregulated, causing increased iron absorption in the small intestine, decreased macrophage iron uptake, and thus increased serum iron and TIBC. **CASE PRESENTATION:** The subject air traffic controller is a 39-year-old Caucasian male with no significant past medical history who smokes 1 ppd for 20 years, donates 1 unit of blood at the local blood bank every 60-90 days for 15 years, consumes alcohol 2-4 times a month, and takes no medications. He presented to flight medicine complaining of bilateral knee pain and bilateral MCP pain. On presentation, aspartate aminotransferase was 88 U/L, alanine aminotransferase was 80 U/L, serum iron was 156 mcg/dL and TIBC was 328 mcg/dL, all representing elevations from normal values. C282Y and H63D genotypes were obtained, which were homozygous for normal human hemochromatosis protein (HFE) alleles. Though at initial screening the member reported only social alcohol use, upon more direct questioning, he confirmed drinking 300-500 mL of hard liquor per day for the last 20 years. The patient was advised to discontinue alcohol use, and after 2 months, his liver function tests and iron studies had normalized. **DISCUSSION:** Increased serum iron and serum transferrin concentration with increased liver enzymes in a middle-aged male with MCP pain is classically associated with the diagnosis of hemochromatosis. However, excessive ethanol consumption is another cause of this laboratory finding that may go unrecognized without a careful history. Prompt diagnosis of individuals with alcoholic hepatitis is imperative to maintain a fit and healthy force and to decrease patients' long-term risk of developing irreversible hepatic cirrhosis.

**Learning Objectives:**

1. The participant will be able to list the differential diagnoses for iron overload.
2. The participant will be able to understand the role of hepcidin in iron metabolism.
3. The participant will be able to understand the diagnostic roles of serum iron, serum transferrin concentration, total transferrin saturation, and serum ferritin.

### [172] PULLING MORE THAN Gz: A CASE OF RHABDOMYOLYSIS IN A USAF FIGHTER PILOT

Brooke Organ, Andrew Pellegrin

Eglin Family Medicine Residency, Eglin AFB, FL, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This case report describes an otherwise healthy USAF F-35 pilot with a case of severe exercise-induced rhabdomyolysis, as well as the implications of this diagnosis as it relates to aircrew readiness and performance. **BACKGROUND:** Rhabdomyolysis is a condition resulting from muscle cell death and the release of intracellular

constituents such as creatine kinase into the circulation. Mild cases produce symptoms such as muscle pain, edema, and dark urine. Severe cases can cause life-threatening electrolyte abnormalities and acute renal failure, requiring inpatient treatment with intravenous fluids and close monitoring. As high-intensity exercise programs increase in popularity, especially among the active duty population, we have noticed an increase in cases of rhabdomyolysis in these otherwise young, healthy individuals. **CASE PRESENTATION:** A 45-year-old active duty fighter pilot with no significant past medical history presented to his flight surgeon with severe back pain following a strenuous workout two days prior. He was initially diagnosed with muscle spasm and treated with ibuprofen, hydrocodone with acetaminophen, and cyclobenzaprine. He presented again the next day with continued back pain and progressively darker urine. Subsequent labs showed a creatine kinase elevation to 96,000 U/L. He was admitted to the hospital inpatient service for aggressive intravenous hydration and electrolyte monitoring. Over a four-day admission he steadily improved and his labs normalized, and he was discharged home with close outpatient follow up. **DISCUSSION:** With growing numbers of the active duty population participating in high-intensity exercise programs, the risk of rhabdomyolysis may have a more significant impact on aircrew mission readiness. Beyond just the duty days lost for treatment of the acute illness, those with multiple episodes of rhabdomyolysis require a full work-up, formal medical evaluation board, and flying waiver before they are able to return to duty. Physical exertion, dehydration, and heat exposure are risk factors for rhabdomyolysis that are frequently encountered in military training and especially in the deployed setting, so it is imperative for flight surgeons to have a high degree of suspicion for rhabdomyolysis and to be skilled in its management. Further, prevention of rhabdomyolysis by educating our members on mitigating the risk factors is of invaluable importance to prevent lost duty time and keep our aviators flying.

**Learning Objectives:**

1. Understand the risk factors and common presentation of rhabdomyolysis to maintain a higher index of suspicion in vulnerable populations.
2. Reinforce clinical skills for prevention and treatment of rhabdomyolysis.
3. Discuss the implications for rhabdomyolysis in aircrew readiness.

### [173] PARSONAGE-TURNER SYNDROME IN A KC-135 PILOT

Brian Hanshaw<sup>1</sup>, Isaac Yourison<sup>2</sup>

<sup>1</sup>JB Elmendorf-Richardson, Anchorage, AK, USA; <sup>2</sup>Hill AFB, Salt Lake City, UT, USA

(Education - Case Study: Clinical / Human Performance)

**INTRODUCTION:** This case report describes a military tanker pilot who experienced Parsonage-Turner Syndrome (Neuralgic Amyotrophy) after fall injury. **BACKGROUND:** Military pilots are highly trained assets capable of performing complex neuromuscular tasks to complete a variety of aviation missions. These responsibilities are highly susceptible to detriment from numerous factors, including acute neurologic injury. Parsonage-Turner Syndrome is considered to be an inflammatory disorder of the brachial plexus; its pathology is speculative but hypothesized to be an immune-mediated process. The potential for adverse outcomes from neurologic palsies are substantial, and the risks to aviators need to be recognized. **CASE PRESENTATION:** 41-year-old, male, KC-135 ANG pilot presented to the flight medicine clinic with neck pain, left upper extremity paresthesia, and radial nerve palsy after a fall while ice climbing. He had presented to the ED where a CT of the C-spine and T-spine showed mild cervical spondylosis, but otherwise unremarkable. The member was referred for MRI studies including the brain, left brachial plexus, and left elbow, which all returned normal. Specialist consultations were pursued including Neurosurgery, Neurology, and Pain Management. After EMG studies and specialist visits, the consensus was the diagnosis of Parsonage-Turner Syndrome. His left upper extremity radial nerve palsy symptoms were severe and left him with complete loss of wrist extension and associated finger extension. An MRI of the left upper arm was later obtained revealing swelling of the radial nerve, which was not seen on previous imaging. A corticosteroid injection at the area of radial nerve swelling was performed and the member reported significant improvement in his symptoms. This along with continued PT and OT treatments, his neuromuscular function gradually improved. At this time, he is at

roughly 80% of his baseline strength after 9 months since symptom onset. **DISCUSSION:** This case highlights the significant risks to both military pilots and aircraft mission from a rare case of Parsonage-Turner Syndrome. This is a difficult condition to diagnose or prevent, and the pathology is not well understood. This illustrates the need for prompt medical care and referral for pilots suffering from symptoms of acute neurologic impairment, in order to prevent permanent deficit and loss of a trained Air Force asset.

#### Learning Objectives:

1. The audience will learn how to recognize symptoms consistent with Parsonage-Turner Syndrome and the approach to diagnosis, treatment, and prevention of further neurologic decline.
2. The audience will learn about aeromedical considerations regarding Parsonage-Turner Syndrome and its impact on the flyer and the mission.

#### [174] F-35 RAMP HEAT MITIGATION: AN OCCUPATIONAL MEDICINE SUCCESS STORY

Quinton Keigley, Kenneth Kirk II, David Duval  
56th Medical Group, Luke AFB, AZ, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** The F-35 presence has rapidly expanded at Luke Air Force Base over the years as more training squadrons are established and the inventory continues to grow. These aircraft were initially parked in the same spots previously used for F-16s, without consideration of their much larger exhaust plume. Consequentially, maintenance and pilot personnel reported thermal injury to exposed skin on the face, neck, ears, and fingertips. **OVERVIEW:** Our team conducted field studies to investigate the risk of heat injuries from F-35s operating on Luke's ramp. Our goal was to determine adequate spacing between F-35 aircraft to mitigate risk of thermal injury. We collected air temperatures, exhaust speeds, and skin temperatures downwind from the jet to evaluate for occupational hazards caused by F-35 exhaust. **DISCUSSION:** Our results indicated that F-35 airframes operating in the F-16 parking configuration at Luke put military personnel at an increased risk for thermal injury and chemical exposure. At an ambient temperature of 106°F (typical during the summer months in AZ), exposed skin temperature may exceed 133°F with current aircraft spacing of 120 feet. This potentially could result in work loss due to significant pain, superficial burn injuries, or partial thickness burn injuries. The execution of a "one-for-one" F-16/F-35 swap while using Luke's legacy infrastructure for aircraft parking highlighted the need for additional spacing and blast deflectors to promote safe F-35 operations. Data suggest that a minimum of 200 feet between aircraft is required to mitigate risk. Plans valued at \$18 million are currently underway to reconfigure the ramp at Luke to prevent thermal injuries. In the meantime, the Wing has implemented administrative controls to stagger parking rows and redirect the flow of taxiing aircraft.

#### Learning Objective:

1. Discuss practical implementation of occupational medicine principles to prevent health hazards and solve unanticipated issues on the flightline after introduction of a new airframe.

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4:00 PM

Brasilia 2

#### [S-36] PANEL: 711TH HUMAN PERFORMANCE WING'S RESPONSE TO THE T-6A UNEXPLAINED PHYSIOLOGIC EPISODES

Chair: David Burch

**PANEL OVERVIEW:** The T-6A, a primary pilot training platform for the U.S. Joint Forces, experienced a significant rise of unexplainable physiologic episodes (UPEs) during 2017 and 2018. These episodes, which resulted in a 48-hour operational pause during 2018, prompted the USAF to rally flight safety, system program offices, and research entities to investigate the issue. A dedicated Flight Test plan led by the T-6 System Program Office, executed by the 412th Test Wing, and supported by the 711th Human Performance Wing, evaluated the aircraft's air quality and air systems' performance over the course of 52 sorties. The two aircraft

were instrumented with a total of 261 sensors, including both commercial sensors to monitor component inlet and outlet pressures, temperature, and humidity, as well as prototype sensor systems for monitoring contaminants, flow, oxygen concentration, and aircrew blood oxyhemoglobin saturation. This resulted in nearly 1 billion data points over the course of the Flight Test program, which the 711th Human Performance Wing then analyzed to determine what, if anything, could help explain the UPEs experienced during the T-6 training flights. The methods, results, conclusions, and lessons learned that the 711th Human Performance Wing generated from the T-6 Flight Testing are presented, in the hopes that they may inform future UPE-related investigations.

#### [175] 711TH HUMAN PERFORMANCE WING OVERVIEW AND CAPABILITY TO SUPPORT UNEXPLAINED PHYSIOLOGIC EPISODE INVESTIGATIONS

Nathan Maertens, David Burch

U.S. Air Force Research Laboratory, Wright-Patterson AFB, OH, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** 711th Human Performance Wing (711 HPW) leads the development, integration, and delivery of Airman-centric research, education, and consultation enabling the Air Force to achieve responsive and effective global vigilance, global reach, and global power now and in the future. Established under the Air Force Research Laboratory, the 711 HPW is comprised of the Airman Systems Directorate (RH), the USA Air Force School of Aerospace Medicine (USAFSAM), and the Human Systems Integration Directorate (HP). **OVERVIEW:** The 711HPW's mission of advancing human performance in the aerospace environments makes it uniquely capable to investigate the complexities of the unexplained physiologic episode (UPE) problem in Air Force and Navy fighter, attack, and trainer aircraft. These capabilities include the new manned centrifuge and research altitude chambers, state of the art technology to monitor aircrew in even the most challenging of environments, experts in diversity of fields from aerospace physiology, flight medicine, toxicology, life-support system engineering, data analytics, and aerospace operational consultation. **DISCUSSION:** The 711HPW has been involved with every USAF and USN-led UPE investigation, and with the recent T-6 investigation, had the opportunity to advance both the capability to address the issues, as well as the understanding of what research gaps are the immediate priority moving forward. These advances, along with the capabilities at Wright Patterson AFB, will help to usher in a new and exciting time for aerospace medical research.

#### Learning Objective:

1. The audience will learn about the USAF 711th Human Performance Wing's capabilities, resources, and expertise related to aerospace medical research and unexplained physiologic episodes.

#### [176] T-6A TEST DATA ANALYTICS TEAM OVERVIEW

Brian Geier, Benjamin Clapp, Christopher Dooley, Anthony Turner, Zachary Smith

711th Human Performance Wing, Air Force Research Lab, Wright-Patterson AFB, OH, USA

(Original Research)

**INTRODUCTION:** A T-6A engineering test event performed between April – June 2018 at Edwards Air Force Base generated several million in-flight data points per flight hour of OBOGS and oxygen system parameters that required immediate aeromedical review to monitor safety risk to aircrew. An efficient data pipeline was necessary to confront the volume, veracity and variety of sensor feeds recorded in-flight in a manner that was collaborative between subject matter experts, engineers, flight surgeons and pilots. **METHODS:** Review of the data was performed on a by-flight basis in an integrative fashion by combing sensor feeds across independent sensor systems in a manner that logically followed OBOGS system operation. Matlab and the Tex type setting language was used to automate signal extraction, perform limit checks, and build reports with great on-the-fly customization necessary to manage competing requirements of subject matter experts and engineers. The data review product was compiled daily, coined 'Quick Look Reports' or QLR's, for subject matter expert review. The QLR was used to monitor for any potential physiological threat on a daily basis. In

the longer term, analysis was performed by comparing the performance of the life support system to established standards, and general guidelines provided by SMEs for safe operation of the T-6A in-flight.

**RESULTS:** Quick Look Reports were judged sufficient to provide aeromedical oversight of the test flights and provided subject matter experts with individual flight insights that led to a hypothesis generation process. **DISCUSSION:** The nature of ad-hoc and post-hoc analysis engendered by a high-urgency operation require a systematic approach to digest data and draw meaningful conclusions. Scalable analytical pipelines are necessary to allow rapid reorganization of data as dictated by a confluence of stakeholder requirements during a test event. This is especially true when examining multi-factorial complex environments, which are common in the aerospace environment.

**Learning Objective:**

1. The audience will learn about methodology to wrangle large amounts of data generated by fully instrumented aircraft.

**[177] IN-FLIGHT CHARACTERIZATION OF T6-A LIFE SUPPORT SYSTEMS IN RESPONSE TO UNEXPLAINED PHYSIOLOGIC EVENTS**

Christopher Dooley<sup>1</sup>, David Burch<sup>1</sup>, Brian Geier<sup>2</sup>, George Miller<sup>2</sup>  
<sup>1</sup>USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA; <sup>2</sup>USAF Medical Center, Wright-Patterson AFB, OH, USA

*(Original Research)*

**INTRODUCTION:** Aircraft life support system (LSS) performance has been identified as a potential contributor to the physiologic episodes (PEs) reported in multiple fighter, attack, and training platforms, including recently the T-6A. In response to those events, the 412<sup>th</sup> Air Force Test Center and the 711<sup>th</sup> Human Performance Wing instrumented two T-6A aircraft with sensors, including prototype systems still in development, to more completely characterize the in-flight LSS performance. **METHODS:** The 412<sup>th</sup> Air Force Test Center installed 1 gas flow, 13 pressure, 5 temperature, and 2 humidity sensors at key inlet and outlet points throughout the two T-6A aircraft. Twenty-one total test pilots from the 416<sup>th</sup> and Air Education and Training Command instructor pilots flew 52 sorties that encompassed four different flight profiles used during flight training and four different units of the 105 model oxygen concentrator that varied in age and involvement with reported PE incidents. From these data, LSS component performance and breath profile data were calculated and analyzed for each sortie. **RESULTS:** LSS performance varied significantly over the sorties, with the different concentrator units being statistically a large driver of that variance. Brief periods of LSS performance issues shorter than a few minutes were observed over the course of 77 h of flight tests; however, the frequency of occurrence was overall insufficient to correlate these events to any observed symptomatology. Other issues with sensor performance and the lack of comprehensive instrumentation of the LSS limited the scope of the analysis. **DISCUSSION:** The characterization of the LSS performance for the sorties flown found no evidence supporting the theory that hypoxic hypoxia is the root cause for the T-6A PEs, nor does the evidence support any hypothesis of a poor LSS performance that is sustained throughout a sortie. However, the caveats and limitations of these flight tests do not refute that aircrew breathing regulation, momentary fluctuations of breathing gas supply, hyperoxia, and hypo- or hypercapnia, either as a singular effect or when combined, are plausible contributors to the PEs in the T-6A. Further testing is needed to provide conclusive evidence on these factors.

**Learning Objectives:**

1. The audience will gain an awareness and understanding of the recent efforts made to address unexplained physiologic events including some lessons learned and challenges.
2. The audience will learn about the current state of the art for in cockpit sensing in high performance aircraft.

**[178] CHARACTERIZATION OF T-6 PILOT BREATHING AIR DURING GROUND ENGINE RUNS**

Christin Duran, Danielle McKenzie-Smith, Dan Reilly, Converse Griffith, John Frazey, Darrin Ott  
 711th Human Performance Wing, Wright-Patterson AFB, OH, USA

*(Original Research)*

**INTRODUCTION:** Hazardous chemicals in pilot breathing air have been cited as a potential contributor to physiological episodes. However, there is a limited amount of measurement data available. The goal of this series of studies was to complete comprehensive characterization of pilot breathing air during engine ground runs for both incident and non-incident T-6 aircraft. **METHODS:** A breathing air sampling system was designed to encompass a suite of real-time and collection techniques for combustion gases, volatile organic compounds, and ultrafine particles. The breathing air sampling system was designed to sample from two locations simultaneously and connected directly to the pilot breathing line. Each engine run consisted of a series of changes in engine thrusts and on-board oxygen generation system regulator settings. **RESULTS:** Chemicals sampled were present at varying quantities in different aircraft. None of the chemicals identified were present at levels that exceeded military or industrial-based occupational exposure limits. **DISCUSSION:** The data suggest that there may be a relationship between the presence of chemicals in the pilot breathing air and incidents; however, the data are not yet conclusive. The findings have driven follow-on investigation into chemical classes not characterized using current strategies and development of improved methodologies to reduce user-interaction required to execute air quality assessments.

**Learning Objectives:**

1. Chemical contaminants detected in T-6 pilot breathing air included carbon monoxide, ultrafine particles and volatile organic compounds. The concentrations of these chemicals were often well below industry and military exposure limits.
2. There are chemical classes that have not been sampled in pilot breathing air due to lack of available sensors.
3. Chemical sensors used for real-time sampling often have nonlinearity and cross-sensitivity issues. Therefore, correction factors must be developed under the expected environmental conditions.

**[179] PROCEDURE FOR SYMPTOMOLOGY ANALYSIS FOR UNEXPLAINED PHYSIOLOGIC EVENTS TESTING PROTOCOL**

Anthony Turner<sup>1</sup>, Dara Regn<sup>2</sup>, Benjamin Clapp<sup>2</sup>, Christopher Dooley<sup>2</sup>, David Burch<sup>2</sup>, Brian Geier<sup>2</sup>  
<sup>1</sup>U.S. Air Force, Muskegon, MI, USA; <sup>2</sup>U.S. Air Force, Wright-Patterson AFB, OH, USA

*(Original Research)*

**INTRODUCTION:** The 711<sup>th</sup> Human Performance Wing supported the T-6 Systems Program Office request to perform an investigation examining the life support systems of the T-6 at Edwards Air Force Base. The investigation generated a tremendous amount of physiological data inspiring an operational epidemiologic approach for attempting to analyze and determine any potential threats to aircrew. **METHODS:** Cases were identified by dynamic inclusion and exclusion criteria from a post-sortie questionnaire that was completed by each Instructor Pilot and Test pilot. There were 52 sorties, so there was a total of 104 post-sortie questionnaires that were completed by the pilots involved with the investigation. The questionnaire consisted of a listing of symptoms with a Likert rating scale for each one. It also included mission type, life support configuration and personal history questions. Anecdotal accounts were also collected from the questionnaire as well as the flight report filed after each sortie. Confirmation of a diagnosis was not possible. In this situation, there is an unknown cause leading to undefined outcome. This also leads to difficulty determining a formal "case definition" due to the outcome being unknown and undefined. **RESULTS:** Collected data points show symptoms experienced by aircrew include cough, flush, fatigue, nausea, headache, lightheadedness, color vision change, tingling in extremities, and mental lapses. These symptoms were self-reported through the questionnaire or through the flight report. **DISCUSSION:** Due to the tremendous self-selection sample bias as well as the subjective nature of the questionnaire, it would be inappropriate to make broad conclusions about the data that were collected. However, the questionnaire did provide additional data points that acknowledge the different symptomatic outcomes experienced by aircrew.

**Learning Objective:**

1. The participant will be able to understand the importance of data collection during physiologic events.

Tuesday, 05/07/2019  
Brasilia 3

4:00 PM

### [S-37] SLIDE: SAFETY IN MILITARY AVIATION

Chair: Scott Shappell

Co-Chair: Leonid Hrebien

4:00 PM

### [180] AEROMEDICAL ANALYSIS OF UK MILITARY ACCIDENT INVESTIGATIONS 2007-2017

Joseph Britton, Matthew Lewis

Royal Air Force, Henlow, United Kingdom

(Original Research)

**INTRODUCTION:** Service Inquires (SIs) are convened following UK Military aircraft accidents to “investigate the circumstances... and to make recommendations to prevent a recurrence”. This study aims to analyze how aeromedical factors have affected accidents across manned airframes and to investigate for themes that, if addressed, may reduce future risk.

**METHODS:** A gov.uk search for SIs involving the Military Aviation Authority (MAA) revealed 27 reports (since Aug 07). 4 were discounted (3 x UAV, 1 x parachuting). The remaining 23 were analyzed for causation, outcome, the incidence and level of aeromedical factors and the use of existing safety systems. **RESULTS:** The most frequent cause of accident was mechanical failure (22%), followed by errors during take-off and landing (17%). Only 1 incident was primarily caused by an aeromedical factor. However, such factors were found in 96% of reports and were ‘contributory’ in 83%. Human factors affected or possibly affected 91% of accidents. Other factors included aircraft design (52%), vision (52%), aircrew equipment or life support systems (35%), medical history (22%), fatigue (22%), disorientation (17%), medication (9%), and +Gz (n=1). 86% of SIs noted that existing safety systems (i.e safety protocols, audio-visual warnings or aircraft equipment) were not utilized. 50% of SIs reported that a relevant safety system existed but was not available during that incident. In 64% a present safety system was not utilized correctly or at all. **DISCUSSION:** In the majority of accidents, one or more of the many highly varied factors that lead to the outcome are aeromedical in nature. This study supports previous evidence regarding the ubiquity of human factors in aircraft accidents. Other themes are noted in proportions that fit with trends seen in incident reporting. It suggests that early involvement of aviation medicine specialists during aircraft design may be able to reduce the risk of accidents. Failure to utilize existing safety systems did not directly contribute to the incident in the majority of cases but was frequently noted as an increased risk for future accidents. This may occur partly due to a ‘safety overburden’ in which the large number, variety and duplication of safety procedures in modern aviation makes the perfect completion of these tasks increasingly difficult. It is suggested, therefore, that new safety tasks be analysed for duplication and workload burden.

#### Learning Objectives:

1. To learn about the UK Service Inquiry process for aviation accidents.
2. To gain an understanding of the Aviation Medicine input to UK Accident Investigations.
3. To gain an awareness of the aeromedical themes across a range of Service Inquiries.

4:15 PM

### [181] ANALYZING THE EFFECTIVENESS OF MILITARY AVIATION SAFETY RECOMMENDATIONS

Andrew Miranda, Shari Wiley

Naval Safety Center, Norfolk, VA, USA

(Original Research)

**INTRODUCTION:** After an accident, safety investigation teams inevitably provide a collection of safety recommendations to avoid a similar event from recurring. Though current resources exist to aid safety professionals with developing safety recommendations (e.g. Human Factors Intervention Matrix), empirical research supporting the effectiveness of specified recommendations is lacking, particularly those intended to address “human error.” We begin to address this gap by analyzing a

collection of recommendations generated from U.S. Naval aviation ground-related mishaps. **METHODS:** A collection of 1,359 mishap recommendations (MISRECs) obtained from 507 Class C aviation ground-related mishaps occurring from 2012 through 2017 were analyzed. A Latent Class Analysis was conducted on the unstructured text of MISRECs, enabling the statements to be grouped into clusters of similar types. Four categories were observed: Administrative, Procedural, Training, and Technology. Two Poisson regression models were run to test if MISREC type significantly predicted mishap counts. **RESULTS:** The results of the initial MISREC classification found that the substantial proportion of the MISRECs generated from Class C investigations were Administrative in nature (44.44%). The results of the first regression model, which included flight hours as an interaction term, revealed MISREC types Administrative (rate ratio=1.11, 95% CI 1.02 to 1.21,  $p<.05$ ) and Procedural (RR=1.27, 1.15 to 1.40,  $p<.01$ ) were significant predictors for increased mishap occurrences, though these effects were reduced when flight hours were excluded (each  $RR<1.04$ ,  $p<.01$ ). Furthermore, Technology MISRECs were significantly associated with reduced mishap events (RR=0.40, 0.25 to 0.63,  $p<.01$ ), whereas in the second model, the conjunction of Procedural and Training MISRECs were diminutively associated with reduced mishap occurrences (RR=1.00, 0.998 to 0.999,  $p<.01$ ). **DISCUSSION:** Administrative MISRECs that focus on enhancing awareness of existing hazards and risks (e.g. “Brief this event”) rather than addressing substantive aspects of the work experience appear to have no impact on reducing the likelihood of future mishaps. Second, the findings that Technology and the conjunction of Procedural and Training MISRECs were moderately associated with reduced likelihood indicates a possible greater need to address the underlying human factors deficiencies likely going unaddressed by current MISRECs formulation.

#### Learning Objective:

1. Understand the importance of astutely crafted safety recommendations that intend to address underlying human factors issues involved in aviation mishaps.

4:30 PM

### [182] DYNAMIC RESPONSE INDEX IN UNDERBODY BLAST AND AIRCRAFT EJECTION – INTERFACE RESEARCH IN BIOENGINEERING

Edward Spurrier<sup>1</sup>, Jon Clasper<sup>2</sup>, Spyros Masouros<sup>2</sup>

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(Original Research)

**INTRODUCTION:** Improvised Explosive Device (IED) attacks on vehicles have been a significant feature of recent conflicts, causing severe injuries to the spine and limbs. The Dynamic Response Index (DRI) was developed for predicting spinal injury in aircraft ejection and is widely used in ejection seat design, though its validity is unproven. It has been adopted for testing vehicles in under-body blast as the mechanisms of injury in blast and aircraft ejection had been presumed to be similar. Recent papers suggest that DRI is not accurate in blast conditions. This paper reviews the validity of DRI in blast and considers the utility of collaboration and crossover research between aviation medicine and blast bioengineering. **METHODS:** The literature was reviewed to identify the distribution of spinal fractures in aircraft ejection and under-body blast incidents. A Joint Theatre Trauma Registry search identified victims of under-body blast with spinal fractures. The distribution of injuries in ejection and blast were compared; if DRI is suitable for use in both environments, the distribution of injuries should be similar. **RESULTS:** 329 fractures were identified in ejector seat incidents; 1% cervical, 84% thoracic and 16% lumbar. 245 fractures were identified in victims of mounted blast; 16% cervical, 34% thoracic and 50% lumbar. There was no significant similarity between the two ( $p=1$ ), and the incidence of a given fracture was statistically significantly different at each level and in each spinal region. **DISCUSSION:** The clinical difference between blast and ejection injury patterns suggests that injury prediction models for ejection should not be extrapolated to blast mechanisms. New models are being developed for blast injury modelling and injury prediction as understanding of DRI’s unsuitability evolves. While this model has been shown not to transfer from aviation medicine to blast injury modelling, opportunities for collaboration and crossover research exist and we will consider ways of exploiting them in future.

**Learning Objectives:**

1. Dynamic Response Index is used in modelling injury risk in both blast and aircraft ejection, because underbody blast has been presumed to involve similar risks and mechanisms to aircraft ejection.
2. The validity of DRI is unproven. Underbody blast and aircraft ejection do not share common mechanisms or injury patterns.
3. Collaboration between blast injury and aircrew injury research may support future innovation and aircrew health in novel ways.

**4:45 PM****[183] DYNAMIC IMPACT TESTING OF REAR TROOP SEATS AND HIGHER MASS OCCUPANTS**

Matthew Lewis<sup>1</sup>, Paul Parker<sup>2</sup>, Sarah Day<sup>2</sup>, Richard Butcher<sup>3</sup>  
<sup>1</sup>RAF CAM, Baldock, United Kingdom; <sup>2</sup>QinetiQ, Farnborough, United Kingdom; <sup>3</sup>DSTL, Porton Down, United Kingdom

*(Original Research)*

**INTRODUCTION:** The trial investigated the injury risk to occupants of aircraft accidents seated in non-energy attenuating side facing seats who exceed the design boarding masses. Typically, rear seats are designed and qualified to accommodate seat occupants of 50<sup>th</sup> percentile masses (77kg). Seat occupant masses can exceed these limits; operationally all up masses of 170kg are possible. The testing aimed to establish the crash performance of tube and fabric troop seats. **METHODS:** 12 rear side facing seats were tested on a deceleration sled facility, at impact velocities of 15, 22.5, 30, 40Gz and 15, 30Gz with Hybrid III occupant masses of 113, 135 and 173kg representing the masses of crewmen and infantry users of aircraft. Testing occurred at impacts (peak acceleration and velocity change) that were credible and survivable in terms of occupiable cabin space post impact. Injury risk was assessed by consideration of standard Injury Assessment Reference Values (IARV).

**RESULTS:** At 15Gz impact and 113,135kg masses the seat remained intact, but with 173kg there was catastrophic failure of the seat, as there was at 30Gz with 113kg. The aluminum tubing which makes up the seat pan or supporting leg structure failed completely; exposing the dummy occupant to potentially injurious contact with sharp metal tubing parts and would expose the occupant to a high risk of injury or fatality, regardless of the spinal loads experienced. For all Gz tests, where failure occurred, the seat structure exhibited similar failure modes. For Gz impacts a large amount of sideways motion of the dummy occurred due to the lack of restraint provided by the lap belt harness. For the 30Gz test vertical and lateral loading of the seat caused the seat pan side arms to fail at the attachment to the seat pan front beam. Due to these structural seat failures, the test matrix was adapted to include an impact at 15Gz and 152kg; this test showed seat deformation, but no catastrophic failure. For all impacts the spinal IARV were below those to cause serious injury.

**DISCUSSION:** For impacts of 15Gz the upper limit of seat occupant mass is approximately 152kg, but the testing demonstrated that at impacts between 15 to 22.5Gz seat failures were likely at masses of 113kg. Although the seat failures would be likely to cause serious lacerations and contact injuries, the deforming and fracturing of the seat limited the spinal loads as the seats' collapse attenuated the impact energies.

**Learning Objective:**

1. Understand the injury risk associated with increasing boarding mass for occupants of side-facing aircraft cabin seats.

**5:00 PM****[184] USA AIR FORCE FLIGHT SURGEON INVOLVEMENT IN A MISHAP ENCOMPASSING THE USA ARMY AND THE KINGDOM OF SAUDI ARABIA NATIONAL GUARD**

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*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** This case report describes a mishap investigation involving an international military helicopter and international pilot as well as a U.S. military pilot. **BACKGROUND:** Mishaps are an unfortunate constant of aviation. However, aviation mishaps do create opportunities for improvements in safety of flight. Flight Surgeons need to be prepared for mishap investigation in any type of environment whether it be in their home country or when stationed abroad. **CASE**

**PRESENTATION:** The mishap in question was a Class A aviation mishap that occurred on 6 Sep 2018. The mishap involved an AH-6i Light Attack Helicopter owned by the Ministry of the National Guard (MNG) for the Kingdom of Saudi Arabia (KSA). The helicopter was being piloted by a KSA Rated Student Pilot (RSP) and a USA (US) Army Instructor Pilot (IP). While performing routine training maneuvers over Khashm Al An Airfield outside of Riyadh, KSA the AH-6i crashed resulting in the death of the IP and significant injury to the RSP. The mishap crew were tended to by Contract Flight Line Crash/Fire/Rescue and MNG medics. The U.S. Air Force (USAF) Flight Surgeon in KSA was notified of the mishap approximately 2 hours after the crash and responded to the MNG hospital. The next day an MNG mishap investigation board was convened, which included members from MNG with corresponding advisors from the U.S. military. Several days later a team was sent to KSA from the U.S. Army Combat Readiness Center (CRC) to conduct an independent mishap investigation as it related to the IP. The USAF Flight Surgeon was a component of both mishap investigation boards.

**DISCUSSION:** This mishap highlights the need for Flight Surgeons to be prepared for any type of mishap in any location and involving any service. The USAF deals predominantly with fixed-wing aircraft, but USAF Flight Surgeons may be called upon for U.S. Army mishaps involving rotary-wing aircraft. Mishap plans in the U.S. are pretty straight forward for U.S. military Flight Surgeons, but these become immensely more complicated when operating outside of the US. The different branches of the U.S. military have different instructions, guidelines, and forms relating to mishap investigation. And, in an international setting, the host nation military may not have a well-established plan for mishap investigation in place. This mishap case exemplifies the importance of preparedness for mishaps that is outside of the normal preparedness for one's given branch of service.

**Learning Objective:**

1. The audience will learn about the challenges encountered and lessons learned in mishap investigation between military branches and different countries.

**5:15 PM****[185] AIRCRAFT MAINTENANCE MANNING, MORALE AND SAFETY CULTURE AS EACH RELATES TO MISHAP RATES IN THE USAF**

Nancy DeLaney, Rachael Falcon  
 USAF Safety Center, Albuquerque, NM, USA

*(Original Research)*

**INTRODUCTION:** Research has established the relationships between worker morale and job performance and workplace safety culture and accidents. The U. S. Air Force (USAF) is a unique organization, in that its workers are largely an Active Duty (AD) population with limited ability to choose where they work, what time of day they report, and how much overtime they accomplish. In addition, this workforce does not have the option to quit, or select out of employment if conditions become unfavorable. These unique aspects of the USAF work environment may have impact on the morale and safety culture of AD aircraft maintainers, which may contribute to aviation mishaps. This abstract contributes to the Air Force Safety Center's research using the Air Force Combined Mishap Reduction System (AFCMRS) and Air Force Safety Automated System (AFSAS). **METHODS:** Squadron morale and safety culture measures were drawn from AFCMRS, an anonymous, web-based, safety culture survey. Mishap data were drawn from AFSAS, a tool for recording, evaluating, and analyzing Air Force mishap investigations. **RESULTS:** Multilevel models were used to account for the hierarchical structure of the data – individuals nested within squadrons. Self-reported morale, quality of manning, and overall safety culture are significantly lower in maintenance squadrons than support or operations squadrons (all  $p < .05$ ), though the results for quantity of manning are mixed. **DISCUSSION:** USAF AD aircraft maintainers report relatively lower morale, and safety culture, than other USAF personnel. These intangibles may be influenced by aspects of the work environment over which AD maintainers have little control, such as work hours and location. Given established relationships between morale, safety culture, and job-related errors, measures to improve the work situation of AD USAF maintainers may not only improve their well-being, but also the safety of the aircraft they maintain.



**Learning Objective:**

1. The audience will know how USAF aircraft maintainers compare to other USAF personnel on aspects of safety culture.

**Tuesday, 05/07/2019**

**4:00 PM**

**Brasilia 4**

### [S-38] PANEL: NERVOUS GAMBLING - NEUROLOGIC DISEASE RISKS

**Chair: Roger Hesselbrock**

**PANEL OVERVIEW:** Neurologic conditions are commonly seen in aviators. Particularly worrisome aeromedical risks include potential for sudden incapacitation, operational distraction, and unrecognized subtle functional impairments. Some neurologic disorders have well-established evidence-based risk data that are applicable to aviators. However, many neurologic conditions do not have relevant evidence-based future risk information, which makes certification analysis and recommendations challenging. This panel will present information on aeromedical risk for several neurologic conditions commonly encountered in aviators. Conditions to be presented include movement disorders (focused on essential/familial tremor and Parkinson's disease), traumatic brain injury, migraine, stroke, and multiple sclerosis. Audience participation and discussion are encouraged and expected.

#### [186] MIGRAINE RISKS

Roger Hesselbrock

*USAF School of Aerospace Medicine, Wright-Patterson AFB, OH, USA*

*(Education - Case Study: Clinical / Human Performance)*

**INTRODUCTION:** Migraine is a common paroxysmal neurological disorder with significant aeromedical risks. **TOPIC:** Migraine affects approximately 12% of the general population, with highest prevalence in the 25-55 age group. Migraine attacks vary in intensity, duration, frequency of occurrence, and in their associated features. Aeromedical risk determinations are challenging due to lack of well-established evidence-based risk data. **APPLICATION:** Migraine is disqualifying for aviation duties, but with appropriate management, many aviators with migraine are able to be returned to flight duties. Aeromedical concerns with migraine include impact on operational safety from the migraine attack itself, medication effects, and risk of recurrence. Aeromedical disposition of migraine is based on attack severity, frequency, absence or presence of associated symptoms such as aura or neurologic deficits, and effects of treatments used for management. Future migraine risks are imprecisely predictable, making aeromedical dispositions challenging. Risk assessment and aeromedical disposition of migraine will be discussed in this presentation, incorporating applicable certification standards. **RESOURCES:** Ropper AH, Samuels MA, Klein JP. Headache and other craniofacial pains. In: Adams and Victor's principles of neurology, 10<sup>th</sup> ed. New York (NY): McGraw-Hill Education; 2014:168-197. Cutrer FM, Bajwa ZH. Pathophysiology, clinical manifestations, and diagnosis of migraine in adults. UpToDate. 2017 Nov 13. [Accessed 1 Aug. 2018]. Available from [https://www.uptodate.com/contents/pathophysiology-clinical-manifestations-and-diagnosis-of-migraine-in-adults?search=pathophysiology-clinical-manifestations-and-diagnosis-of-migraine-in%20adults&source=search\\_result&selectedTitle=1~150&us\\_age\\_type=default&display\\_rank=1](https://www.uptodate.com/contents/pathophysiology-clinical-manifestations-and-diagnosis-of-migraine-in-adults?search=pathophysiology-clinical-manifestations-and-diagnosis-of-migraine-in%20adults&source=search_result&selectedTitle=1~150&us_age_type=default&display_rank=1)

#### **Learning Objectives:**

1. List major aeromedical risk concerns of migraine.
2. Discuss the aeromedical certification process for migraine.
3. List factors favoring a return to fly recommendation for aviators with migraine.

#### [187] AEROMEDICAL IMPLICATIONS OF MOVEMENT DISORDERS

Alison Leston

*University of Texas Southwestern Medical Center, Dallas, TX, USA*

*(Education - Tutorial Proposal)*

**INTRODUCTION:** Movement disorders such as Parkinson's disease and essential tremor have the potential to impact performance

in affected pilots. The frequency of these conditions is increasing as both the general population and pilot population are aging. Therefore, it is essential to appropriately evaluate for and treat these conditions in a manner that promotes flight safety. **TOPIC:** Movement disorders are neurological conditions characterized by either excessive movement or a paucity of movements, unrelated to weakness or spasticity. Parkinson's disease is a movement disorder defined by the cardinal motor symptoms of tremor, bradykinesia, rigidity, and postural instability. While these alone may be disabling, additional risks of non-motor symptoms including autonomic dysfunction and cognitive impairment must also be considered as they can also affect pilot performance. Essential tremor is a movement disorder which causes involuntary, rhythmic shaking. The hands and voice are commonly affected, which can adversely impact use of cockpit instruments and communication. In the non-pilot population, pharmacotherapy is standard of care for many of the movement disorders. These drugs typically target the central nervous system, introducing additional risks. Therefore, the use of certain medications to treat movement disorders in pilots can be disqualifying. **APPLICATION:** Movement disorders cause motor and non-motor impairment which have the potential to interfere with flight operations. Aviation medical examiners and flight surgeons must be able to recognize common movement disorders so that appropriate screening can occur to maintain flight safety.

#### **Learning Objectives:**

1. The participant will recognize signs and symptoms of common movement disorders, including Parkinson's Disease and essential tremor.
2. The participant will understand implications for flight safety related to pilots with movement disorders.

#### [188] TRAUMATIC BRAIN INJURY

Peter Letarte

*Premier Health, Dayton, OH, USA*

*(Education - Case Study: Clinical / Human Performance)*

The presentation will review the known evidence concerning the sequela of Traumatic Brain Injury for Air Crews. The basis for qualification and disqualification used by various Aeromedical screening authorities will be explored. Return to flight considerations for Concussion, Post-Concussion Syndrome, Major Neurocognitive Disorder due to Traumatic Brain Injury will be discussed. The impact of relative seizure risk post trauma on return to flight and disqualification decisions will be considered. The rational for return to flight or disqualification for operative and nonoperative bleeds, contusions and hematomas will be examined. The impact of cumulative injuries will briefly be examined.

#### **Learning Objectives:**

1. The participant will be able to understand the return to flight considerations for Concussion, Post Concussion Syndrome, Major Neurocognitive Disorder due to Traumatic Brain Injury.
2. The participant will be able to describe the impact of relative seizure risk post trauma on return to flight and disqualification decisions.
3. The participant will be able to describe the rational for return to flight or disqualification for operative and nonoperative bleeds, contusions and hematomas.

#### [189] RETURN TO FLIGHT FOR RISK ANALYSIS FOR THREE COMMON STROKE SYNDROMES

Christopher Skinner

*University of Ottawa, Ottawa, Ontario, Canada*

*(Education - Case Study: Clinical / Human Performance)*

This presentation will use a risk analysis model to discuss return to flight risk analysis following three common stroke syndromes. These disorders will include a moderate sized cortical infarct, a lacunar infarct and a gangliothalamic hemorrhage. The current evidence for risk of acute sudden incapacitation, cognitive deficits and psychomotor deficits for each of these syndromes will be discussed using the RCAF risk analysis model. The presentation will also discuss the challenges faced by regulators making decisions for risk of return to flight often using documentation that is incomplete or without source data such as neuroimaging or EEG.

**Learning Objectives:**

1. To describe an analysis strategy for use in the determination of risk of return to flight in three common stroke syndromes.
2. To discuss the risk of return to flight after a moderate sized cortical infarct, a lacunar infarct and a gangliothalamic hemorrhage.
3. To discuss the challenges facing regulators in making these determinations and the level of documentation required.

**[190] AEROMEDICAL CONSIDERATIONS IN MULTIPLE SCLEROSIS**

Frank Weber

*German Air Force Institute of Aerospace Medicine, Fuerstenfeldbruck, Germany**(Education - Program / Process Review Proposal)*

**BACKGROUND:** In the Neurology panel, frequent neurological disorders are discussed. Multiple sclerosis is a still incurable illness in which the body's own immune system destroys tissues in the central nervous system. T cells and B cells are thought to remove a protective coating called myelin that wraps around nerve fibres in the brain, spinal column and optic nerve. Exposed fibres are degraded, producing symptoms that vary depending on where the damage occurs. It affects an estimated 2.3 million people in the world, most common in the northern latitudes, reflecting the likely association with reduced exposure to sunlight and Vit D deficiency. **OVERVIEW:** Focusing on the aeromedical concerns, the following aspects will be covered: prevalence, conversion of a clinically or radiologically isolated syndrome to clinically definite MS, benefit of an early start of a disease modifying treatment, prognosis and natural history, the NEDA-concept, risks of and time to disability, prodromal symptoms. **DISCUSSION:** Based on the aspects above, guidelines for aeromedical decision-making will be given.

**Learning Objectives:**

1. The participant will be able to understand the basic concepts of pathophysiology, diagnosis and treatment in Multiple Sclerosis.
2. The audience will learn about the conversion of a clinically or radiologically isolated syndrome to clinically definite MS, benefit of an early start of a disease modifying treatment, prognosis and natural history, the NEDA-concept, risks of and time to disability, prodromal symptoms, paroxysmal events.
3. The participant will learn to apply this knowledge on aeromedical decision-making.

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4:00 PM

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**[S-39] SLIDE: MULTINATIONAL PERSPECTIVES ON AIR TRAVEL****Chair: Gordon Landsman****Co-Chair: Ed Feeks**

4:00 PM

**[191] AMDA VISION OF GLOBAL AVIATION MEDICINE ISSUES: OUTPUT AND CONCLUSION OF MOSCOW CONGRESS**

Olga Verba

*Aviation Medicine Doctors Association of Russia, Novosibirsk, Russian Federation**(Education - Program / Process Review Proposal)*

**BACKGROUND:** Founded in December 2016, Aviation Medicine Doctors Association (AMDA) of Russia takes an active participation in liaising with members of aviation community in developing aviation medicine and exchanging research results and experience throughout the Russian Federation, CIS countries and globally. The Association is a provider of educational programs in aerospace medicine for continuing medical education. This presentation will give AMDA vision of the ways of mutual collaboration, contribution to the evidence base and to the growing body of recommendations, based on the outputs of Moscow

International Congress "Current Issues of Aviation Medicine". **OVERVIEW:** The reports presented by 45 world leading experts in aviation medicine, including the members of ESAM and AsMA, CIS countries, as well as Russian leading flight medical experts allowed the 245 participants from 13 countries to form an objective vision of the state and perspectives of the industry, the similarities and differences in approaches to medical provision and certification in the Russian Federation and international practices as well as opportunities for mutual contribution. The approaches in Russia are characterized by strict regulations based on military aviation standards. Such an approach is considered to be unreasonable within international regulations. Medication treatment needs to be revised considering the latest pharmaceutical updates. The European participants gave high estimates of Russian experience in health monitoring and medical provision, rehabilitation, prophylaxis and support of flight longevity in pilots. AMDA Congress participants established specialized committees in cardiology, neurology, ophthalmology, otorhinolaryngology, surgery, psychology and in-flight medical provision. **DISCUSSION:** It is the next step for the field of aviation medicine to change and harmonize the policies and approaches to medical dynamic supervision, functional diagnostics, medication treatment and aviation psychology to be aligned the latest achievements, technologies and expertise of Russian and international practices.

**Learning Objective:**

1. The audience will learn about the existing system of medical provision in the Russian Federation and AMDA vision of the ways of mutual collaboration and contribution to the flight safety measures.

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**[192] AUSTRALIAN TRAINING IN AEROSPACE MEDICINE: "SANS FRONTIÈRES"**Alan Drane<sup>1</sup>, Ian Hosegood<sup>2</sup>, David Powell<sup>3</sup>*<sup>1</sup>Air New Zealand, Civil Aviation Safety Authority, Australia, Auckland, New Zealand; <sup>2</sup>Medical Services, Qantas Airways Limited, Sydney, Australia; <sup>3</sup>Virgin Australia Airlines, Auckland, New Zealand**(Education - Program / Process Review Proposal)*

This paper reports on a novel approach to providing work-based training in aerospace medicine, by successfully crossing traditional aviation "frontiers" between the regulator and operators. **BACKGROUND:** Historically, many civilian regulators and airlines have drawn upon former military aeromedical specialists to provide expertise in support of their functions. With the reduction of military workforces in many countries, there is a need for a new training pathway. In addition, the obligations of civilian aviation are significantly different to those of military operations. The lack of relevant training to support the move into the civilian environment may result in poorly tailored processes and decision-making. **OVERVIEW:** Two airlines and the Australian regulator, Civil Aviation Safety Authority, launched a joint training programme in 2018. Through a joint selection process, suitable trainees in aerospace medicine are offered a work rotation through each organisation. The programme was initially designed to last two years, but at the request of the trainees has been extended to three, with each placement lasting one year. It also fulfills the experience requirements for the fellowship training programme of the Australasian College of Aerospace Medicine. **DISCUSSION:** This is the first time we are aware of, that a regulator and major international airlines have collaborated to provide practical experience, which bridges the regulator / regulated divide. Important issues addressed included the integration of theoretical and practical learning, management of conflicts of interest, attractive employment conditions, corporate and patient confidentiality and intellectual property. The support of senior management of each organisation was critical in facilitating this development. Already there has been an increased level of interest in this speciality, and broadening of the pool of doctors who are wishing to commence specialist training. **CONCLUSION:** Collaboration between the regulator and operators in the provision of aerospace medicine training offers a breadth of knowledge and experience, invaluable to efficient and effective practice from day one in the specialist role. This presentation considers the risks and benefits of such a programme and how some of the very real challenges were solved.

**Learning Objectives:**

1. The audience will learn about a practical demonstration of the benefits of collaborative working between a major regulator and international airlines.
2. The audience will learn about the significant differences between military and civilian aeromedical practice.

**4:30 PM****[193] QUESTIONNAIRE SURVEY FOR JAPANESE AIR CARRIERS FLYING SHORT-HAUL ROUTES WITH REGARD TO IN-FLIGHT MEDICAL EMERGENCY**

Kazunori Takazoe, Hideho Gomi

Japan Aeromedical Research Center, Tokyo, Japan

*(Original Research)*

**INTRODUCTION:** In Japan, aircraft with 60 or more passenger seats must carry an emergency medical kit onboard and its contents are based on the recommendation by ICAO. Although there are comprehensive reports on in-flight medical emergency both on long- and short-haul routes, medical emergency requiring the use of the kit on board focusing on aircrafts flying short-haul routes are rarely reported. **PURPOSE:** To investigate medical emergency events onboard aircraft for short haul-routes, focusing on the use of medications in the kit. **METHODS:** A questionnaire study was performed on medical emergency events in which doctors participated and made assessment including medication use during the 10 years between 2006 and 2015 from 15 applicable Japanese airlines flying short haul routes. **RESULTS:** Thirteen airlines responded with data and the results between 2010 and 2015 were used for analysis. In addition to the cases where doctors participated, cases using medication that the passengers carried with them and cases where AED and/or CPR was used were included. Totally 100 cases were analysed. The incidence rate among total flight number was 0.005%. Loss of consciousness (17.5%) and impairment of consciousness (17.5%), both of which being the top cause, gastrointestinal symptoms (13.6%), convulsion (11.7%) and discomfort (7.8%) were the top five causes of the medical emergency. Treatment included oxygen administration for 45 cases (45.0%) being most frequent. The use of medication accounted for 14 cases (14.0%), including 6 drip infusion cases, but no cases used oral medications required to be carried onboard. Although there were two cases with drip infusion before takeoff (i.e. ground turn back), there were no cases of medication use during flight onboard the aircraft whose flight time was less than 1 hour. Six among the 13 airlines (46.2%) used medications. There were 10 cases (10.0%) where passengers used the medication they had with them, which accounted for 41.7% of the total medication use. There were 10 AED uses and 3 CPRs performed. There were 2 offloads, 2 ground turn backs and 1 flight diversion. **DISCUSSION:** Even during short distance routes, medical emergency can occur which requires medications and AED and/or CPR. However, due to low incidence of medication use, it should be discussed on whether distinction should be made with regard to the medication contents in the kit between short-haul and long-haul routes.

**Learning Objective:**

1. The participant will be able to understand the present status of medical emergency events and medication use onboard Japanese aircraft flying short-haul routes.

**4:45 PM****[194] TRANSCRIPTIONAL RESPONSE OF BRONCHIAL EPITHELIUM, BRONCHO-ALVEOLAR CELLS, AND BLOOD TO ALTITUDE DIFFERS BETWEEN SMOKERS AND NONSMOKERS**Scott Nicholson<sup>1</sup>, Susan Munster<sup>1</sup>, Hilary Uyhelji<sup>1</sup>, David Hutchings<sup>2</sup>, Vicjy White<sup>1</sup>, Leland Booth<sup>3</sup>, Jordan Metcalf<sup>3</sup>, Dennis Burian<sup>4</sup><sup>1</sup>FAA Civil Aerospace Medical Institute, Oklahoma City, OK, USA;<sup>2</sup>Venescio, LLC, Oklahoma City, OK, USA; <sup>3</sup>University of OklahomaHealth Sciences Center, Oklahoma City, OK, USA; <sup>4</sup>Retired, FAA-CAMI, Oklahoma City, OK, USA*(Original Research)*

**INTRODUCTION:** Commercial aircraft cabins are pressurized to ~ 8,000 feet, equating to 15% O<sub>2</sub>. Smokers and other individuals with reduced respiratory responsiveness may display inhibited biological

altitude responses during flight reflecting the known difference in physiological response. We examined gene expression in smokers (S) and nonsmokers (NS) in a hypobaric chamber under simulated "flight" (F) and "ground" (G) conditions. Blood was taken from subjects before, during, and after each treatment and lung cells were taken after treatment. Comparison of S and NS determined transcriptional differences in the blood and lung cells between conditions, revealing genetic responses to flight conditions. **METHODS:** Subjects were recruited and the study conducted according to an FAA approved IRB protocol. Subjects completed 2 treatment phases, one "ground" (720 mmHg/1,400 ft), and one "flight" (565 mmHg/8,000 ft). Physiological data and venous blood were taken before, during, and after treatments, bronchial epithelial brushings (HBEC) and broncho-alveolar lavages (BAL) were taken after treatment. RNA was isolated from each tissue sample and processed to allow examination of gene expression in that tissue by microarray (Affymetrix HTA 2.0). Microarray-derived gene expression data was processed and normalized using the R packages array QualityMetrics and Oligo. Comparisons were made between S and NS at F and G using the R packages limma and timecourse and Ingenuity Pathway Analysis.

**RESULTS:** HBEC and BAL samples exhibited significant transcriptional change between S and NS post-flight. Smoker HBEC displayed 548 differentially expressed (DE) genes, and BAL displayed 136 DE genes, during flight versus NS. Hypoxia-related genes expression increased in BAL cells and declined in smoker HBEC during flight. Pathway analysis revealed that smoker HBEC showed a decline in the hypoxic response in contrast with NS, resulting in activation of mitigating responses. Smoker BAL displayed activation of inflammatory and cellular movement responses. Smoker blood displayed fewer differences with NS blood during flight (42 DE genes). Only 4 DE blood genes were protein-coding, the remainder were regulatory RNAs. **DISCUSSION:** In summary, smokers exhibit an inhibition of the hypoxic response compared with NS during a 5h exposure to flight conditions in certain cell types. The data presented are consistent with alternate responses in smokers to mitigate the inhibited hypoxic response.

**Learning Objectives:**

1. Physiological response to flight varies between smokers and non-smokers, with smokers exhibiting non-significantly increased heart rate, blood oxygen saturation, and exhaled CO<sub>2</sub>, with a decrease in exhaled O<sub>2</sub>.
2. Transcriptional response to flight differs between smokers and non-smokers in bronchial epithelium and broncho-alveolar lavage cells, but less so in blood.
3. Hypoxia-related genes are upregulated in smoker alveolar cells during flight but downregulated in smoker bronchial epithelium during flight in comparison with nonsmokers.

**5:00 PM****[195] RE-CONTAMINATION RATE AFTER COMMERCIAL AIRCRAFT DISINFECTION**

Arthur Kreitenberg

University of California, Irvine School of Medicine, Los Angeles, CA, USA

*(Original Research)*

**INTRODUCTION:** Commercial air travel volumes correlate with influenza severity. Flight attendant illness rates are double that of school teachers. Passengers wear surgical masks and wipe disinfectants on their seating area. This investigation seeks to address how frequently aircraft should be disinfected. The Specific Hypothesis was to determine the Staph A recontamination rates in a single aircraft during successive flights in a single day. **METHODS:** A U.S. commercial carrier cooperated with this study and approved all personnel and materials brought on board their A320 aircraft. The airline did not disclose performance of this investigation to flight crews to avoid special procedures or bias. Surfaces tested were both aisle seats of rows 11-15 at the aisle side of seatback top, the forward part of aisle armrest, and the aft/aisle quadrant of tray table top. This yielded 30 test sectors. Prior to passenger boarding, all test areas cultured then disinfected using 70% isopropyl alcohol. Cultures were then obtained to confirm disinfection. In a single day, 4 flights of 55-180 minutes duration were flown with an investigator on-board. After each passenger deplaning, all 30 sectors were cultured in a unique spot within the sector. Contact culture plates

with Baird Parker medium provided quantitative environmental testing specific for *Staph aureus*. **RESULTS:** Tray tables on short flights without food consumption remained relatively uncontaminated. The other 3 surfaces showed levels returning to baseline after 2 short duration flights, totaling about 4 hours of flight time. **DISCUSSION:** This study suggests that aircraft interior disinfection should ideally be performed before each flight. "Short turns" of 45 minutes or less render this approach unfeasible. However, infectious agents, including MRSA, Ebola, and influenza survive on hard surfaces for up to one week. In the current state of no disinfection, each passenger may be exposed to germs from 30 or more prior occupants of that seat. Disinfection once per 24-hour cycle reduces the number of prior occupants between disinfection to an average of less than 3. Therefore, daily aircraft disinfection can be very effective and is feasible during a longer duration routine overnight cleaning.

**Learning Objective:**

1. The participant will be able to describe how quickly high touch commercial aircraft surfaces become recontaminated with infectious agents after disinfection.

**5:15 PM**

**[196] EVIDENCE-BASED RISK ASSESSMENT: CURRENT FAA APPROACH**

James DeVoll

FAA, Washington, DC, USA

*(Education - Tutorial Proposal)*

**INTRODUCTION:** This presentation will review the FAA's evolving evidence-based risk assessment methodology, and its application to the field of oncology in aeromedical decision-making. **TOPIC:** Past practice for aerospace medical regulatory authorities was to codify decision-making as standards and policies. The pace of medical advances, evolution of evidence-based standards of care, legal concerns, and airmen's demands for "individualized assessment" have changed the landscape for regulators. In response, the FAA is evolving to a structured evidence-based risk assessment (EBRA) methodology. EBRA is a transitional link between clinical risk assessment and regulatory go/no-go decisions. Final decisions must be "to a reasonable degree of medical certainty," supportable by clinical documentation, medical literature, generally accepted medical guidelines and standards of care, and expert consultation when necessary. Risk considerations must address the likelihood of sudden or subtle incapacitation or impairment vs. severity of consequences. Risk stratification must define the general acceptable baseline risk, compare the individual airman's risk profile to that baseline, and then assess whether any risk mitigation strategies are available, practical, effective, measurable, trackable, and aeromedically acceptable. **APPLICATION:** The breadth and pace of change in oncology is a significant challenge for aeromedical decision-making. Complex practice guidelines, genomics, new treatment modalities and individualized therapies have made policy-based decision-making unworkable and obsolete. By defining EBRA methodology, the FAA uses a flexible approach adaptable to individual airmen with oncologic conditions. Developing EBRA protocols and procedures must also address tolerance of risk related to diffusion of innovation in medical practice, plus strength of evidence and association. FAA physicians and consultants must be knowledgeable in EBRA development and application. Appropriately applied to oncology and all medical specialties, EBRA is putting aeromedical decision-making on par with current leading edge evidence-based medical practice.

**RESOURCES:** Amin MB, Edge SB, Greene FL, et al, eds. AJCC Cancer Staging Manual. 8th ed. New York: Springer; 2017; National Comprehensive Cancer Network, www.nccn.org.

**Learning Objectives:**

1. The audience will learn about why and how the FAA is evolving to a structured evidence-based risk assessment (EBRA) methodology.
2. The audience will learn about evidence-based risk assessment (EBRA) methodology, the key underpinning concepts, and how it relates to risk stratification, baseline risk, risk mitigation, and aeromedical decision-making.
3. The audience will learn about how the FAA is applying about evidence-based risk assessment (EBRA) methodology to airmen with oncologic conditions.

**Tuesday, 05/07/2019**

**Brasilia 7**

**4:00 PM**

**[S-40] PANEL: MEDICAL CARE FOR ANALOGUE SPACE MISSIONS**

**Chair: Bonnie Posselt**

**Co-Chair: Sheyna Gifford**

**PANEL OVERVIEW:** Human exploration of space is the aspiration of many space agencies whose missions push the boundaries of human physiological and psychological tolerance and employ technologies and techniques first trialed in terrestrial analogs. Analogue missions provide not only economical precursor environments in which to test operations, procedures and technologies, but, due to their relative proximity, are inherently safer, less resource-intensive, and more easily controlled. However, they are by no means risk-free. These earthbound space simulations pose unique challenges, including differentiating between in-simulation medical care and real-life emergency intervention. Such disparities create the potential for gaps in medical planning and response, sub-optimal patient care, and increased medical personnel liability. This panel will raise awareness of these challenges, seek the feedback of our community on how to manage these situations, and provide practical advice for medical practitioners involved in planning analogue space missions. We will hear from the perspectives of medical care providers across a breadth of different analogue environments; from the heat of the desert; the cold of the Antarctic; the depths of the sea; and the year-long mission in the volcanic region of HI, with the goal of imparting to the audience a greater understanding of the elements of risk management inherent to this kind of human experimentation and space simulation. Finally, the panel will discuss the standardization of a risk mitigation approach to these simulated-space, real-patient situations.

**[197] HOW ANALOG FOCUSED ACTIVITY IS CONTRIBUTING TOWARD NASA'S SCIENTIFIC RESEARCH AND MEDICAL GOALS**

Marc Shepanek

NASA, Washington, DC, USA

*(Education - Program / Process Review Proposal)*

**BACKGROUND:** As space agencies prepare for long duration missions to the moon and Mars the survival, health and safety of crew is of paramount importance. This presentation will begin with a review of the general human health challenges identified by NASA before describing how those challenges drive critical questions, and in turn, requirements that are assessed with respect to specific potential missions. **OVERVIEW:** NASA has developed a process focusing on a scientific "roadmap" which is continuously updated, to mitigate risk and guide the agency in making investments in human research. That roadmap incorporates the use of a broad range of analog environments from test chambers through to the International Space Station (ISS). There are currently a range of physiological and psychological challenges identified by NASA under the current scientific roadmap, which are considered a high priority; mitigating the effects of microgravity, radiation exposure, isolation and confinement. Various analog environments have been identified as being the best, way to address some of these critical challenges. **DISCUSSION:** This talk will highlight the relative strengths of using different analog platforms as well as discussing the prospect for synergy between scientific and clinical opportunities in these environments. There can be significant and conflicting challenges between scientific research and delivering optimum primary medical care; this will be discussed in detail and illustrated in subsequent presentations. Practical issues to be addressed include Institutional Review Boards for working scientific research protocols, ensuring adequate patient privacy and rights to confidentiality, as well as the potentially conflicting roles of the physician as a data gatherer and provider of clinical care. A comprehensive medical plan should be developed and documented with all appropriate parties to address all potential simulation and real life medical incidents. The best, and most appropriate standard of care should be defined and agreed to by and for all parties with respect to any analog environment. NASA's approach to

mitigating risk in their analogue platforms is driven by U.S. medical standards and shared transparently with all appropriate participants.

**Learning Objective:**

1. The audience will be able to understand the process used to consider analog research at NASA.

**[198] LONG-DURATION ANALOG MEDICAL MANAGEMENT: LESSONS FROM THE LONGEST NASA-FUNDED SPACE SIMULATION TO DATE**

Sheyna Gifford

Washington University St. Louis, Saint Louis, MO, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** Since the beginning of human space exploration, Earth-based research analogs have been utilized by the aerospace community as operational environments in which to discover and mitigate mission risks. In preparation for crewed Mars missions, between 2012 and 2018 six NASA-sponsored analogs of increasing duration took place on Mauna Loa volcano at 2500m (8,200 ft) above sea level. The longest of these six high-altitude studies of the psychological factors of isolation and confinement included a physician on the crew. That simulated mission lasted 366 contiguous days, during which time multiple notable medical incidents occurred. **OVERVIEW:** This panel talk will highlight the pathology encountered during the longest U.S. space simulation to date, with an emphasis on expected versus unanticipated events; resource availability and resource limitations; and how all these affected patient management and outcome. **DISCUSSION:** Provision of medical care in such an austere analogue environment is challenging. The medical events and options for management at this long-duration analog can be compared to those in other analogue environments presented in this panel. Resulting lessons for current and future aerospace medicine practitioners will be reviewed and considerations for safely operating in analog and real missions of similar duration and environment will be discussed.

**Learning Objective:**

1. To familiarize the medical community with the challenges inherent to medication management while on long-duration analogs including patient examination, doctor-patient relationships, event reporting, and administrative oversight.

**[199] BIOMEDICAL & HEALTHCARE CONSIDERATIONS DURING NEEMO UNDERSEA SPACEFLIGHT ANALOG MISSIONS**

Marc O Griofa

UCD/UL, Dublin, Ireland

(Education - Program / Process Review Proposal)

**BACKGROUND:** The Aquarius Undersea Laboratory is a saturated diving habitat at a depth of 19.2 m (63 ft) located 5 miles off the coast of Key Largo, where NASA conducts the NASA Extreme Environment Mission Operations (NEEMO) analog mission. Here, the spaceflight environment can be closely replicated from an operational, training and psychological standpoint and has unique considerations for the healthcare of the crew and biomedical research for application during spaceflight. **OVERVIEW:** Astronaut/Aquanaut crews train for several weeks on both the operational components of saturation diving and executing individual experiments from a variety of disciplines. Specific prior training includes operation of the Kirby Morgan SS diving helmet procedures and ensuring a full understanding of the system. Crewmembers must be familiar with all contingencies and practiced in emergency scenarios, particularly during saturation diving. Once aquanauts are in saturation on the seafloor within the Aquarius Undersea Habitat, they must undergo a ~15-hour decompression to return to the surface regardless of any emergency that may occur. Aquarius Reef Base has a sophisticated well tested medical response protocol in place including shipboard and land-based hyperbaric chambers. NEEMO missions also provide an opportunity to collect biomedical data for comparison with spaceflight data, fine tune methods and protocols for use onboard ISS and test the efficacy of just in time (JIT) training protocols for advanced medical procedures. **DISCUSSION:** In addition to the risks in a saturated diving environment, the medical risks of decompression sickness and encounters with marine life cannot be underestimated while the very real psychosocial effects of living in a confined undersea laboratory while

executing an aggressive scientific timeline are some of the reasons that NEEMO presents a comprehensive analog environment for spaceflight mission preparation. These risks, combined with an aggressive operational tempo, provision and limitations of resources and the planning for unexpected and unanticipated contingencies create the ideal environment for a true mission-based analog where medical contingencies are of paramount concern. This presentation will discuss how these risks are addressed and mitigated as part of the medical planning process.

**Learning Objective:**

1. The audience will learn about the risks of saturated diving while conducting mission-oriented activities in preparation for spaceflight.

**[200] MEDICAL CONSIDERATIONS ON THE TREATMENT OF SLEEP DIFFICULTIES IN THE UNIQUE CONDITIONS OF CONCORDIA STATION IN ANTARCTICA**

Adrianos Golemis

MEDES-IMPS / European Space Agency (ESA), Cologne, Germany

(Education - Program / Process Review Proposal)

**INTRODUCTION:** Concordia is a French/Italian Antarctic station where a small international crew overwinters in isolation and confinement every year. Several stressors affect human health and performance at this special location; that is why Concordia is an analogue environment where the European Space Agency (ESA) conducts medical and psychological research. In addition to isolation, the abnormal day-night cycle, high altitude and low humidity can have severe implications on the crew's sleep, leading to an unusual form of insomnia. **OVERVIEW:** Not unlike astronauts, winterover crews spend several months in complete isolation and confinement. Many health and safety risks arise from these conditions, some are life-threatening while others appear milder but can influence performance, well-being and psychology: sleep difficulties are such a case. Sleep is affected at Concordia due to psychological stress, circadian desynchronization, caffeine/sleep medication abuse, and sleep apnea due to low atmospheric pressure. To mitigate all these issues together, no established and tested procedure is available at present. By examining existing bibliography and adapting its suggestions to the special environment of Concordia, this presentation aims at recommending a practical algorithm to deal with this form of insomnia. Several strategies to address these issues are explored with a view to combining all aspects that can lead to a more effective medical treatment. **DISCUSSION:** As is the case in other analogue environments, there are several challenges of providing high-quality medical care at Concordia: Means of treatment have to be prepared and shipped in advance, consultation suffers from communication limitations, while the unique combination of stressors unavoidably takes physicians off the beaten track of standard methodology and into unknown territory. The small number of patients exposed to overwintering in Antarctica together with the lack of adapted medical care procedures for each specific location adds to the problem. This presentation aspires to add a stepping stone towards improving the treatment of sleep difficulties in Antarctica.

**Learning Objectives:**

1. Understand the many different parameters leading to sleep difficulties at Concordia Station and the fact that they form a unique combination.
2. Revisit current insomnia treatment methods and assess how these could be adapted and combined to treat winterover sleep difficulties in Antarctic Stations.

**[201] MEDICAL CONSIDERATIONS DURING THE AUSTRIAN SPACE FORUM MARS ANALOGUE MISSIONS**

Rochelle Velho<sup>1</sup>, Christian Luthen<sup>2</sup>, Andreas Zoller<sup>3</sup>,

Lucas Rehnberg<sup>4</sup>, Nils Kaufmann<sup>5</sup>, Adrianos Golemis<sup>6</sup>,

Gernot Groemer<sup>6</sup>, Stefan Dobrovolsky<sup>6</sup>, Bonnie Posselt<sup>6</sup>

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Birmingham, United Kingdom; <sup>2</sup>Department of Cardiothoracic

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Rotterdam, Netherlands; <sup>3</sup>University of Ulm, Ulm, Germany;

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<sup>5</sup>Southmead Hospital, Bristol, United Kingdom; <sup>6</sup>Austrian Space Forum,

Innsbruck, Austria

*(Education - Program / Process Review Proposal)*

**INTRODUCTION:** The Global Space Exploration Roadmap delineates a pathway for human exploration of our solar system. This roadmap emphasizes the need to conduct high-fidelity ground-based space analogues to identify, evaluate and mitigate against biopsychosocial risks to crew health. There have been several terrestrial Mars analogue studies evaluate the health of analogue astronauts (AAs) in extreme environments. These include the AMADEE missions coordinated by the Austrian Space Forum (OeWF). During these analogues, AAs performed experiments during Extra Vehicular Activities (EVAs) in evolving iterations of AOUDA spacesuits that simulate the telemetry, dexterity and communications of pressurized spacesuits. The cumulative medical lessons learnt from OeWF analogues helped shape the preparation for the AMADEE18 mission; a 4-week Mars analogue based in the Dhofar desert region of Oman in February 2018. **OVERVIEW:** Pre-mission the medical team engaged in all elements of mission preparation, that ranged from AA selection to lab-based EVAs, to stratify potential health risks to crew members. During the mission, the field crew (n=15) performed 19 research studies in accordance to a flight plan, remotely supported by a Mission Support Centre (MSC) (n=150). The field medical officer (MEDO) was responsible for the medical care of the field crew, AAs and major incident management. The MEDO liaised with the MSC medical team to manage medical issues contemporaneously, within the constraints of a 20-minute time delay during simulation. **DISCUSSION:** Mars analogues that support suited EVAs in the remote pre-hospital environment adopt a similar approach to terrestrial occupational considerations, risk assessment and management. The thematic analysis of medical lessons learnt during the mission identified recurring medical issues when compared with previous missions and novel challenges posed by the desert analogue. This led to the development of the medical analogue risk assessment model, which enables medical teams for space analogues to stratify environmental, habitat and EVA specific hazards.

**Learning Objectives:**

1. The participant will gain an insight into lessons learnt during a series of Mars analogue missions in extreme environments (high altitude and desert) conducted by the Austrian Space Forum or OeWF.
2. The participant will learn about risk stratification for Mars analogue missions by utilizing the medical analogue risk assessment model that enables medical teams for space analogues to stratify environmental, habitat and EVA specific hazards.

Tuesday, 05/07/2019

4:00 PM

Miranda 5/7

**[S-41] SLIDE: HUMAN PERFORMANCE AND PILOT ASSESSMENT****Chair: Douglas Boyd****Co-Chair: Chuck DeJohn**

4:00 PM

**[202] NECK FORCES IN COMBAT JET PILOTS- AN ALGORITHM THAT PREDICTS SEGMENTAL NECK FORCES FROM HEAD WORN SENSOR DATA AND GZ IN FLIGHT**

Phil Newman, Wayne Spratford

University of Canberra Institute for Sport and Exercise, Canberra, Australia

*(Original Research)*

**INTRODUCTION:** In order to understand neck pain and neck forces in fast jet pilots, our previous study collected three-dimensional motion data using the VICON camera system from RAAF fast jet pilots performing common "head checks" whilst seated on an F/A-18A ejection seat. Pilots were modelled wearing 2 helmet types (HGU-55/P and JHMCS). Dynamic graphical models were derived using Opensim software. The OpenSim model calculated forces at each cervical segment for 1-9Gz conditions. This study sought to train and test the Opensim model to predict the forces acting at the neck and evaluate the efficiency and accuracy of the

subsequent algorithm using only head co-ordinates and Gz flight data from helmet mounted sensors. **METHODS:** Part 1- Three ensemble learning algorithms- linear regression, k- nearest neighbors (kNN) and adaptive boosting were deployed and trained 5 times on random stratified samples of 75% of the Opensim model dataset to establish an algorithm that could predict segment moments at C7 using only head co-ordinates and Gz. The resultant algorithms were tested on the remaining 25% of the OpenSim dataset and the best model identified based on predictive accuracy. Part 2- Head position co-ordinates and Gz values were obtained from helmet-mounted sensors during 42 sorties involving 7 pilots over 7 days. Unfiltered raw data from flight was analyzed by the most accurate machine learner and the resultant predicted cervical spine moments collated. **RESULTS:** The Adaptive boosting learner performed best (R2=0.938, RMSE=3.533), kNN (R2=0.927, RMSE 3.828), linear regression was least accurate (R2=0.419, RMSE= 10.819). The Adaptive boosting algorithm was selected for predicting the real flight data. 42 samples from sorties totaling 223 minutes of flight were analyzed successfully by the machine learner. Predicted moments at C7, duration, frequency and direction were determined for all flights in less than 5 minutes. **DISCUSSION:** The results demonstrate that neck forces can be measured in dynamic flight environments. From this data both muscle and joint loads can be determined, within a maneuver, within a sortie, within a training week or longer. This technology will enable instructors and health staff to quantify neck workload of pilots in order to better understand flight related neck pain.

**Learning Objective:**

1. The audience will learn about a new computer model that can predict neck forces during flight in fast jet pilots.

4:15 PM

**[203] EEG ACTIVITY, HRV AND COGNITIVE FUNCTION IN ACUTE HYPOBARIC HYPOXIA EXPOSURE IN PILOTS**Mathias Aebi<sup>1</sup>, Jérôme Barral<sup>2</sup>, Nicolas Bourdillon<sup>2</sup>, Andres Kunz<sup>1</sup>, Grégoire P. Millet<sup>2</sup>, Denis Bron<sup>1</sup><sup>1</sup>Aeromedical Center, Swiss Air Force, Dübendorf, Switzerland;<sup>2</sup>University of Lausanne, Lausanne, Switzerland*(Original Research)*

**INTRODUCTION:** In hypobaric hypoxic (HH) environment, pilots must remain focused to accomplish mission and prohibit incident. However, the effects of altitude severity on Electroencephalography (EEG), heart rate variability (HRV) and cognitive function remain unclear. **METHODS:** EEG was recorded randomly at 3000 and 5500 m in HH and compared with Normobaric Normoxia (NN) values in eleven healthy pilots (26 ± 4 years old). Four min of EEG were recorded at rest (eyes closed) with a portable EEG device (Trackit, Lifelines, USA) and a 21-electrodes EEG cap (Waveguard connect, eemagine, Germany). Bandpass filter (1-40 Hz; Notch:50Hz), corrections for artifacts (ICA) and average-referenced were applied. Power map analyses were performed on windows of 10 s and averaged in the theta (4-7 Hz), alpha (8-12 Hz) and beta (14-25 Hz) frequency bands. HRV (frequency domain including very-low frequency band, VLF, 0.004-0.04 Hz) was measured continuously. Participants also performed a cognitive test (KLT, Germany). **RESULTS:** Power maps revealed progressive increases of beta power from baseline to 3000 m (26% of the electrodes; p<0.05) and 5500 m HH (79%; p<0.05). At 5500 m, higher increase of EEG beta power was related (r>0.73, p<0.05) to a lower decrease of VLF and conversely (52% of the electrodes). Moreover, increase in beta power for four electrodes was correlated (r=-0.81, p<0.05) with decrease of calculation speed during KLT while percentage of error was increased (13±6%) compared to 3000 m (8±6%, p<0.05) and NN (6±4%, p<0.001). **DISCUSSION:** Acute 5500-m HH exposure led to a more intense beta synchronization, an increase in VLF and an altered cognitive function. Increased beta amplitudes (power) have been related to slowed movement (Gilbertson *et al.*, 2005), drowsiness (Spiegelhalter *et al.*, 2012) or cognitive processing (Engel and Fries, 2010) while VLF increase was reported in obstructive sleep apneas (Shiomi *et al.*, 1996) or during hypobaric normoxic exposure (Tripathi, 2010). Overall, our results suggest a kind of idling or "freezing" state of the global brain activity that may impair concentration. Acute HH exposure has probably a broad effect on brain functioning by altering multiple levels of top-down control. It is therefore paramount to further investigate

for pilots' safety how central nervous system, motor and cognitive functions are modulated in hypoxic environments.

**Learning Objective:**

1. The participant will be able to understand how EEG beta power is affected with increase of altitude level in hypobaric hypoxia and its relationship to heart rate variability and concentration performance in pilots.

**4:30 PM**

**[204] CARDIAC PERFORMANCE OF CADETS DURING THE CENTRIFUGE TRAINING WITH RAPID ONSET RATE**

Chung-Yu Lai<sup>1</sup>, Min-Yu Tu<sup>1,2</sup>, Hsin Chu<sup>3</sup>, Chun-Cheng Liu<sup>2</sup>

<sup>1</sup>Aviation Physiology Research Laboratory, Kaohsiung City, Taiwan;

<sup>2</sup>Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan; <sup>3</sup>Institute of Aerospace and Undersea Medicine, National Defense Medical Center, Taipei City, Taiwan

(Original Research)

**INTRODUCTION:** By measuring cardiac performance noninvasively, our previous study showed that subjects performing anti-G straining maneuver (AGSM) during gradual-onset-rate (GOR, 0.1G/sec) training profile couldn't persistently maintain adequate cardiac performance about five seconds before G-force induced loss of consciousness (GLOC). **Aims:** To evaluate the physiological changes of subjects during rapid-onset-rate (ROR, 3G/sec) centrifuge training and to compare the cardiovascular performance between non-GLOC and GLOC groups. **METHODS:** We reviewed the acceleration training dataset; and eligible participants were undergraduate student pilots of Air Force Academy, Republic of China, who undertook intermediate-level high G training. A non-invasive hemodynamic monitor (PhysioFlow®Enduro™Manatec Biomedical, Paris, France) was applied to record cardiac parameters (stroke volume, SV; cardiac output, CO; and heart rate, HR) during baseline, acceleration to 7.5G profile for 15 seconds (ROR, 3G/sec), and 5 seconds before cessation of acceleration. Data was analyzed with SPSS 22.0 software. **RESULTS AND DISCUSSION:** In total, data from 21 subjects (17 non-GLOC and 4 GLOC) were analyzed in this study. The mean relaxed and straining G tolerance of participants were 5.2G and 8.2G, respectively. AGSM effectiveness was 3.0G at GOR profile. Compared with data obtained before operating AGSM at 7.5G profile, HR and CO significantly increased during AGSM, before 5 seconds of G force termination, with ratios of 1.21 and 1.31, respectively. In addition, ratio of HR in non-GLOC group was significantly higher than that in GLOC group (1.32 vs. 1.23;  $p$  value=0.009). Further evaluation of the association between individual cardiac parameters and G tolerance in broader population could provide insight for fighter pilot acceleration training.

**Learning Objectives:**

1. To understand the changes of cardiac data in the centrifuge training.
2. To compare the difference of physiological parameters between non-GLOC and GLOC subjects.

**4:45 PM**

**[205] OPERATIONAL BASED VISION ASSESSMENT: COLOR DEFICIENCY AND PERFORMANCE ON SIMULATED REMOTELY PILOATED AIRCRAFT COLOR-CODED DISPLAY TASKS**

James Gaska<sup>1</sup>, Marc Winterbottom<sup>2</sup>, Steve Hadley<sup>2</sup>, Jefferson Fu<sup>3</sup>, Gregory Eisenhauer<sup>3</sup>

<sup>1</sup>U.S. Air Force, Dayton, OH, USA; <sup>2</sup>USAF School of Aerospace Medicine/FHOH, Wright-Patterson AFB, OH, USA; <sup>3</sup>KBRWyle, Beaver Creek, OH, USA

(Original Research)

**INTRODUCTION:** Although computer-based tests such as the Air Force cone contrast test (CCT) allow precise estimates of an individual's color discrimination capabilities, mapping these metrics onto operational performance is complex. In this research we used simulation technology to measure observer performance in tasks that use colored targets whose discrimination is critical to mission success in the remotely piloted aircraft (RPA) environment. These results are compared to CCT results to estimate the functional relationship between these metrics to develop platform-dependent color vision standards. **METHODS:** Fifteen (seven color vision normal and eight red-green deficient) participated in the study. The

simulator was designed to replicate the size, shape, and color of visual stimuli on the safety, tactical, operation, reliability, maintenance (STORM) display and the heads-up display (HUD) of the MQ-9 (block 30) workstations. The HUD task required the observer to locate a red or green car and the STORM task required observers to locate a red, green, or yellow color-coded warning. For the first experiment, stimulus contrast was fixed and response speed and accuracy were measured. In the second experiment, performed only on the HUD, the contrast of the targets was manipulated to estimate contrast sensitivity. Correlation metrics between CCT scores and operational performance metrics were computed.

**RESULTS:** CCT scores were positively correlated with throughput (percent correct/reaction time) for the HUD ( $r = 0.75$ ) and STORM ( $r = 0.77$ ) tasks and negatively correlated with the standard deviation of the log reaction time distribution for the HUD ( $r = -0.67$ ) and STORM display tasks ( $r = -0.68$ ). CCT scores were positively correlated with HUD contrast sensitivity ( $r = 0.95$ ) and negatively correlated with the standard error of the sensitivity estimate ( $r = -0.64$ ). All correlations had  $p$ -values  $< 0.01$  using a two-tailed  $t$ -test.

**DISCUSSION:** The results clearly demonstrate performance in color-critical RPA tasks becomes less sensitive, slower, and less reliable as CCT test scores decrease. The data are particularly relevant since the U.S. Air Force recently lowered color vision standards (CCT score of 55 instead of 75). The results of this work, and similar studies, can be used to manage the potential benefit of increasing the pool of medically qualified operators with the potential risk of decreased performance in the RPA environment.

**Learning Objective:**

1. Understand the relationship between color vision test and performance in a remotely piloted aircraft (RPA) environment.

**5:00 PM**

**[206] ASSESSING GA PILOTS' ABILITY TO INTERPRET TRADITIONAL WEATHER SYMBOLS AND CODING UTILIZED IN NEW INTERACTIVE WEATHER PRODUCT DISPLAYS**

Jayde King, Yolanda Ortiz, Jacqueline McSorely, John Kleber, Elizabeth Blickensderfer, Thomas Guinn, Robert Thomas Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Original Research)

**INTRODUCTION:** For several years, weather-related accidents and high fatality rates have plagued General Aviation (GA) operations. Previous research has identified poor preflight planning as a possible contributing factor to the GA weather-related accident rate. Upon further investigation, inadequate aviation weather interpretation and experience has been linked to poor preflight planning practices and inflight decision making. With the development of new weather products, such as the new HEMS and MRMS tool, it is imperative to consider usability and interpretability during product design. The evolution of weather product design should be coupled with interpretability improvements. However, if new weather products continue to use the same symbols and codes as traditional products, new weather products may be just as challenging to use as their predecessors. Therefore, the purpose of this paper is to test pilots' ability to interpret Radar, Satellite, SIGMET, G- AIRMETS, METAR, and TAF symbols and coding, to infer how pilots will interact with the new HEMS and MRMS weather tools. **METHODS:** Seven hundred and twenty-nine pilots (ranging from Private, Instrument, Commercial with Instrument, CFI/CFII, to ATP) were recruited and separated into four groups, each group completed a weather interpretation assessment for specific weather products. Group 1 ( $n=165$ ) completed a weather product interpretation assessment for METAR and TAF products, Group 2 ( $n=150$ ) for G-AIRMET products, Group 3 ( $n=195$ ) for Radar products, and Group 5 ( $n=219$ ) for SIGMET and Satellite products. The weather product interpretation assessment measured pilot's ability to interpret aviation weather product information. Therefore, this study will assess and pilots' ability to interpret Radar, Satellite, SIGMET, G- AIRMETS, METAR, and TAF products. **RESULTS:** Four 5 x 5 Mixed ANOVAs were performed to assess the effect of test topic and certificate/ratings on weather product interpretation scores. **DISCUSSION:** RESULTS suggest that pilot certificate/rating and test topic have effects on pilots' ability to interpret weather products. However, despite variations in score between pilot certificate/rating and test topic, overall weather product interpretation scores were quite low. Future research should be invested in investigating how to improve the interpretability of new aviation weather products without recycling traditional aviation weather coding and symbols.

**Learning Objectives:**

1. The audience will gain insight on General Aviation pilots' ability to interpret aviation weather products.
2. The audience will understand the implications of recycling traditional aviation weather product symbols and coding in new interactive weather product displays.

**5:15 PM**

**[207] EXPANDING THE FRONTIER OF HUMAN FACTORS DESIGN: USABILITY TESTING COGNITIVE AIDS AND IMPLICATIONS FOR AEROSPACE MEDICINE**

Anna Ruskin<sup>1</sup>, Barbara K. Burian<sup>2</sup>

<sup>1</sup>University of Chicago, Chicago, IL, USA; <sup>2</sup>NASA Ames Research Center, Moffett Field, CA, USA

(Education - Program / Process Review Proposal)

**BACKGROUND:** Critical event cognitive aids are an important tool in medicine and aerospace medicine. Although human factors design can assist with optimizing the functionality of these tools, an evaluation must be performed to ensure that the aid performs as intended. Usability testing provides a method of testing this functionality before the cognitive aid is introduced into real-life situations and may be particularly useful for new modalities such as mobile apps. **DESCRIPTION:** The first step in usability testing is *alpha testing*, which is an initial examination of the aid to find and fix problems. Next, beta testing is performed with subjects who represent those who will actually be using the aid (e.g. clinicians responding to in-flight emergencies). Ideally, beta testing will occur in a realistic environment (e.g. a flight training center) and under a variety of realistic conditions (e.g. low lighting, narrow aisle), but useful information can be gathered even if testing is performed in an empty conference room, with the clinician and the researcher sitting at a desk. Next, training should include time for the clinician to look at the aid, followed by a presentation explaining the features of the aid. Next, the subjects should work through a series of realistic, scripted scenarios, that are derived from real-life cases. These should incorporate a range of situations and can be timed for comparison. Examples include simple scenarios, such as hypoglycemia, and complex scenarios such as two sick passengers at once or a combative patient. The last scenario should require the clinician to pick a recently encountered situation and think through using the aid in that situation. A follow-up survey can ask about which aspects of the aid were useful, which could use improvement, and which could be adapted for that specific environment (e.g. the location of the oxygen tank and medical kit on a given airplane). **DISCUSSION:** Although usability testing originated in the software development domain, it can be successfully applied to medicine and aerospace medicine. Specifically, the design and features of new cognitive aids can benefit from usability testing, which can be performed quickly and with minimal cost.

**Learning Objectives:**

1. Why usability testing should be considered before introducing a new cognitive aid (such as an aid for in-flight medical emergencies) for aerospace medicine.
2. How to create a step-by-step plan for implementing usability testing for your cognitive aid.

**WEDNESDAY, MAY 8, 2019**

**Wednesday, 05/08/2019**  
**Brasilia 1**

**8:30 AM**

**[S-42] PANEL: U.S. NAVY AEROMEDICAL DISPOSITION – CHALLENGING CASES FROM NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI)**

*Sponsored by Society of US Naval Flight Surgeons*

**Chair: Kai Yan Cheng**

**Co-Chair: Michael Adriano**

**PANEL OVERVIEW:** This panel represents selected challenging cases from the Naval Aerospace Medical Institute (NAMI). NAMI is the center of

excellence for U.S. Navy (USN) and Marine Corps (USMC) aerospace medicine and is staffed by flight surgeons, aerospace clinical specialists, and support personnel. All USN and USMC aerospace medicine dispositions are made at NAMI. Annually, NAMI receives approximately 50,000 flight physicals from fleet flight surgeons throughout the world and conducts more than 5,500 clinical encounters in Pensacola, FL. This multi-disciplinary panel will highlight six challenging cases dispositioned by NAMI in the past year. Case 1 highlights the importance of corneal topography and pentacam scans, Case 2 highlights the complexity of aeromedical evaluation for a male to female transgender pilot, Case 3 concerns an aviator with a history of anaphylaxis to fire ants, Case 4 reviews the significance of vertigo and the decision process for a return to flight recommendation, Case 5 describes a pilot with type 1 diabetes mellitus in remission, and Case 6 reviews a case of a pilot with obsessive-compulsive disorder.

**[208] NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI) CHALLENGING CASES: LOOK OUT FOR THOSE PECULIAR TOPOGRAPHIES**

Kyle Dohm

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(Education - Case Study: Clinical / Human Performance)

**BACKGROUND:** Corneal irregularities such as keratoconus, post-operative ectasia, and scarring from trauma can yield corneal mapping images that are difficult to properly disposition with regards to meeting aviation standards. It is important to be cognizant of the nuances when analyzing corneal maps (i.e. topography, pentacam) in order to successfully disposition a myriad of cases that may present during an initial pilot flight physical. **CASE PRESENTATION:** Two female pilot applicants will be discussed. A 22-year old had previously undergone photorefractive keratectomy (PRK) in both eyes seven months prior. She had a moderate amount of pre-operative astigmatism without signs of corneal ectasia. The post-operative corneal topographies displayed inferior steepening in both eyes but the patient reported no visual symptoms, had excellent uncorrected visual acuity, and no pathological signs on slit lamp examination. A 25-year old had previously undergone phototherapeutic keratectomy (PTK) and PRK in 2015 in her right eye only for a central corneal scar and low refractive error. The right eye scar was due to a contact lens induced corneal ulcer in 2014. Her left eye was emmetropic without any scarring. Post-operatively she had excellent uncorrected visual acuity, but a residual (less dense) scar remained in her right eye. The patient had no visual complaints and no visual decline during glare testing. Both cases presented a challenge for final disposition for aviation duties. In the end, both were given clearance to start Naval flight training from an ophthalmic standpoint, but the 25-year old ultimately was not cleared due to other medical issues. **CLINICAL RELEVANCE:** These cases highlight the importance of thoroughly analyzing corneal map images for aviation duties. It is not enough to simply view the different corneal imaging maps and determine that red is disqualifying and green is qualifying. Nor is it acceptable to assume that if visual acuity is within standards there are no problematic visual entities present. Nuances will be discussed in order to give the clinician a better understanding of corneal topography and pentacam scans. A simplified topography criterion will be given so the non-eyecare provider can better determine when appropriate to consult a specialist for further investigation on indeterminate cases. Improper dispositions can have profound ramifications for safety of flight as well as career implications for those involved.

**Learning Objectives:**

1. The audience will be able to explain the significance of different corneal topographical indices.
2. The audience will be able to recall the simplified criterion to use for aviation screening when analyzing corneal topography for possible keratoconus or ectasia.
3. The audience will be able to recall that corneal mapping machines, such as the pentacam, do not account for refractive surgery or scarring in the normative database.

**[209] TRANSGENDER AND MILITARY AVIATION: TO WAIVE OR NOT TO WAIVE: A CASE REPORT**

William Nguyen, Benjamin Childers

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