

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

Learning Objectives

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

THURSDAY MAY 26, 2022

Thursday, 05/26/2022
Tuscany C,D,E,

8:30 AM

56TH HARRY G. ARMSTRONG LECTURE

Melchor Antuñano, M.D., M.S.

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

Thursday, 05/26/2022
Tuscany C,D,E

10:00 AM

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

Sponsored by the Space Medicine Association

Chair: James Vanderploeg
Co-Chair: Richard Jennings

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

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

James Vanderploeg

Self, Granby, CO, United States

(Education - Program/Process Review)

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

Learning Objectives

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

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

Tarah Castleberry

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

(Education - Program/Process Review)

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

and trained astronauts in longer duration space flight environments to a much broader population in the shorter suborbital environment. Management of medical risk involves the development and implementation of: 1) new requirements for spaceship design, life support systems, and safety systems; 2) new standards for suborbital pilots and spaceflight participants; 3) ongoing capture, analysis, and interpretation of biomedical and environmental data; and 4) plans for preflight, inflight, and postflight support for a broad population over a short training and flight period. Future developments and continued changes will likely include collaboration with industry leaders for data management, experiences or lessons learned with various medical conditions in flight, and standards refinement.

Learning Objectives

1. The participant will gain an understanding of the factors involved in the job of Chief Medical Officer for a private suborbital spaceflight company.
2. The participant will learn some of the challenges encountered and solutions implemented in medical risk management for private space flight participants.
3. The participant will gain an understanding of future developments and collaboration envisioned for support of suborbital spaceflight medical operations.

[323] FLIGHT SURGEON SUPPORT FOR SPACE ADVENTURES SPACEFLIGHT PARTICIPANT MISSIONS

Richard Jennings¹, Jennifer Law¹, Akane McCarthy²

¹UTMB Medical Branch, Galveston, TX, United States; ²Space Adventures, Vienna, VA, United States

(Education - Tutorial/Review)

INTRODUCTION: Space Adventures (SA) is a leader in providing access to space for commercial spaceflight participants (SFPs) and has worked primarily with the Russian space program to provide Soyuz transportation to the ISS. **TOPIC:** Seven individuals have completed eight missions with a ninth mission scheduled in December 2021. Since 2003, the company has relied on flight surgeon (FS) medical support throughout all mission phases. This paper highlights medical support activities required for mission success. **APPLICATION:** Preflight: SFPs must pass pre-training medical certification in Russia and later with the ISS International Partners (IPs). The FS assesses the medical history and arranges appropriate prescreening exams to assure the flight is possible and mitigates medical issues that could jeopardize medical certification or mission safety/success. Risk mitigation strategies may include additional diagnostic testing, monitored analog environment exposure, pharmaceutical control of medical conditions, or surgery. The FS facilitates data transfer and supports the medical certification process in Russia. Once the SFP is approved for training, the FS prepares a medical kit for inflight use and medical packs for launch and landing support. The FS briefs the crewmember about the medical aspects of spaceflight and facilitates crewmember medical research. Following the final preflight medical approval for short-duration spaceflight, the FS stays with the crewmember during the quarantine in Baikonur and supports the crew and SA personnel. Inflight: After launch, the FS supports from mission control in Korolev, Russia. Private medical conferences are held periodically to assess crewmember status and offer advice, medications, or strategies to deal with medical or research issues. The frequency of inflight medical communication depends on medical status and can be adjusted based on need. Prior to deorbit, the FS helps coordinate countermeasures to reduce risk of orthostasis, injury, and neurovestibular symptoms. For landing, the FS returns to Kazakhstan and works with the Russian medical team to extricate the crewmember from the Soyuz, respond in case of landing-related injury/illness, and assist with readaptation to 1G. Following a medical exam, the FS and crewmember return to Star City where the FS assists the Russian medical team with health assessment and rehabilitation. Additional examinations may be needed for completion of the scientific research program.

Learning Objectives

1. Participants will learn how flight surgeon medical support is utilized to facilitate medical certification for spaceflight participants on short duration spaceflight on the Soyuz and ISS.
2. The audience will be able to recognize the steps needed to medically support launch, landing, and inflight medical care for spaceflight participants on Soyuz missions to the ISS.

[324] AXIOM SPACE MEDICAL OPERATIONS FOR COMMERCIAL SPACE EXPLORATION

Smith Johnston III

Axiom Space, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Axiom Space is building and will operate the world's first private space station, the pillar of a thriving commercial network in Low Earth's Orbit (LEO) slated for completion 2028, after the retirement of the International Space Station (ISS). Axiom private astronaut missions is the first major milestone on this journey, with the launch of the Ax-1 mission scheduled for February 2022. This will be accomplished medically in cooperation with NASA and the ISS partners, KBR, SpaceX, local academic institutions, philanthropic organizations brought along by Axiom private astronauts, and private industry. **DESCRIPTION:** This presentation will focus on Axiom Space's unique challenges in three parallel pathways of rapid simultaneous development, all completed while the company selects, trains, and certifies private astronauts for short and long duration missions planned to launch to the ISS beginning in Feb 2022: genesis of a medical team for the development of the occupational, aerospace, and behavioral health programs required for a commercial start up; building of a first of its kind Houston-based Ellington Spaceport manufacturing facility, inclusive of pre- and postflight astronaut living quarters with a complement of quarantine, training, exercise/rehabilitation, and research capabilities; and design and building of a private LEO Space Station, with a full complement of medical surveillance and research capabilities.

DISCUSSION: Medical certification of the Axiom private astronauts flying to the ISS will include prime and backup astronauts for the role of commander, pilot, mission specialists, and backups for both short and long duration missions. Challenges associated with Axiom's preflight screening processes, inflight medical management, postflight landing support will be discussed. Legal, human resources, and contracting challenges associated with working with industry stakeholders will also be discussed. Lessons learned as the company engages in this work will help to foster goals of opening access to LEO for commercial exploration to a wider population of industries and individuals to take advantage of the limitless potential of the microgravity environment for scientific discovery.

Learning Objectives

1. The audience will learn about processes Axiom is implementing to screen, select, certify, train, and fly commercial astronauts in partnership with NASA and its international partners.
2. The audience will learn about Axiom's three parallel pathways of development enabling commercial space station operations and the associated medical operations implications.

[325] MEDICAL DIRECTION AT A COMMERCIAL SPACE COMPANY

Anil Menon

SpaceX, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: As more humans fly to space, medical direction is becoming increasingly important particularly at the companies that are flying these humans. Scientific method, good metrics, and data driven decisions will drive future development of vehicles and support the human system. A data driven approach to medical safety and health is applied by SpaceX as a pathway to safe and healthy flight. **DESCRIPTION:** This presentation will focus on SpaceX's approach to obtaining the data and

conducting the analysis that will support medical safety and health for government sponsored flights, privately contracted flights, and its own development for future deep space exploration. **DISCUSSION:** Medical certification of the SpaceX private astronauts provides challenges for the CMO and medical team. Data requirements, medical acceptance criteria, emergency response planning and management of medical risks are just a few of those challenges. The scientific method used to meet these challenges will be described during this panel.

Learning Objectives

1. The audience will learn about processes SpaceX is implementing to screen, select, certify, train, and fly commercial astronauts.
2. The participants will learn about the SpaceX scientific approach to data collection and analysis to direct its implementation of safe and healthy space missions.

Thursday, 05/26/2022
Tuscany A

10:00 AM

[S-63]: PANEL: FAILURE TO FOLLOW PROCEDURES: EXPLORING THE ROLE OF THE ORGANIZATIONAL, SITUATIONAL, TASK-RELATED, AND INDIVIDUAL FACTORS

Sponsored by Aerospace Human Factors Association and the Human Performance Committee

Chair: Thomas Nesthus

Co-Chair: David Schroeder

PANEL OVERVIEW: Failure to follow procedures (FFPs) can be defined as occurring when those performing a task do not follow the prescribed procedure(s) for accomplishing that task. In aviation, it is present when a maintainer misses or skips a step in a procedure, a pilot might not execute a mandatory missed approach during a thunderstorm with wind shear alerts, and/or when a controller might issue a clearance to the wrong aircraft at the end of a midnight shift. However, FFPs is not unique to the aviation environment. It is present in everyday events and, to some degree, in all work environments. This panel includes presentations concerning FFPs in five work environments. Each presenter will provide insights regarding one or more approaches to assessing FFPs: through accident/incident analysis, mandatory or voluntary reporting systems, behavioral observations, and/or questionnaires. The causes can range from a deliberate violation to more complex interactions of individual, organizational and situational factors. Each panelist will describe findings from the scientific literature or experience concerning multiple contributing factors to FFPs and efforts to mitigate the more common factors. These examples will reveal some of the consistent challenges that surround FFP occurrences. Kylie Key will provide insight into conditions involving FFPs in aircraft maintenance. Carlos Salicrup will describe the events that contribute to FFPs in pilot operations. Laura Wood will reveal how FFPs arise in air traffic control operations. Keith Ruskin will describe typical events associated with FFPs in medical settings and the operating room. Cathy DiBiase will also discuss factors that contribute to possible FFPs and reduced performance in nursing care.

[326] PROCEDURAL COMPLIANCE IN AVIATION MAINTENANCE

Kylie Key

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

(Education - Tutorial/Review)

INTRODUCTION: Despite the continued training and focus on procedure following, much work remains to be done to mitigate Failure to Follow Procedures (FFP), as this is a pervasive human factors issue in aviation maintenance, contributing to over 70% of all maintenance-related safety events. The historic approach of managing FFP events was

person-centered “blaming and training;” but, the scientific literature has found that such person-centered mitigations do not effectively reduce FFP. A systematic approach is needed where contributors at all levels of the organization are considered and mitigated. **TOPIC:** This research reviews the scientific literature regarding the contributing factors to and potential mitigations for FFP in aviation maintenance. Consistent with the HFACS-ME framework, this research describes FFP as a multi-level issue consisting of an interaction between the organizational conditions (culture, resource allocation), supervisory conditions (task prioritization, performance management), working conditions (environmental, availability of resources), and maintainer conditions (mental and physical state; crew coordination). Expanding upon the HFACS-ME framework, this research proposes evidence-based recommendations and potential mitigations for the contributing factors. **APPLICATION:** While these mitigations may each seem self-evident, the research contribution is a compilation of evidence-based countermeasures that can be used to build a systematic response to FFP. However, the complex nature of FFPs, along with the advances of new technology, tools, and procedures, will require continued human factors oversight. This presentation will describe the complexities of the FFP issue within aviation maintenance and the recommended mitigations suggested from the research. **RESOURCES:** 1.) Dekker, S. (2014). *The Field Guide to Human Error*. <http://leonardo-in-flight.nl/PDF/FieldGuide%20to%20Human%20Error.PDF>; 2.) Reason, J., & Hobbs, A. (2003). *Managing Maintenance Error: A Practical Guide*. Ashgate; 3.) Schmidt, J. K., Lawson, D., & Figlock, R. (2003). *Human factors analysis and classification system-maintenance extension (HFACS-ME) review of select NTSB maintenance mishaps: An update*. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.595.4827&rep=rep1&type=pdf>

Learning Objectives

1. This presentation will describe the complexities of failure to follow procedures within aviation maintenance.
2. The audience will learn the common contributing factors and potential mitigations for failure to follow procedures.

[327] AIRLINE PILOTS AFTER COVID

Carlos Salicrup

AEROMEXICO/IFALPA, Mexico City, Mexico

(Education - Case Study)

INTRODUCTION: Adherence to procedures and rules during pandemic is getting relevant during the call back to “normal” operations, these pilots are facing a new era consisting on an exposed to covid environment, up to the top of flying roster and half of a pay check, safety depending on good call back training and adherence to procedures while trying to maintain a good mental and physical health. **BACKGROUND:** After time off the cockpit pilots, special training and recently internal new raised envelope safety parameters are helping to prevent the worst in some airlines, while others are offering the minimum that actual rules implicate. Many factors may prevent a pilot to follow procedures, including lack of proper training, airline bankruptcy stage, flying full rosters, trying to re-adapt to shift lag and jet lag, fatigue, a loss of close family members, the fear of taking home the virus and an uncertain future. **CASE PRESENTATION:** How an out of practice pilot, after some 18 months of not touching the controls may be safe again? Some airlines are offering a full initial training, while others just the minimum. Some are amplifying their safety envelopes. Reports of unstable approaches that are finished in a forced landing instead of a “go-around” (GA) are a concern that is rising, more than 90% of unstable approaches are ending in landings. A go-around maneuver is not as usual in airlines and there are many factors that may prevent a pilot to perform, a maneuver that per se involves some risk if not performed correctly (less risk than landing from an unstable approach). If the GA is not being regularly trained the pilot may not feel confident. Most of unstable approaches happens after long duties and in airports that involve some unusual environments, added to lack of training, this leads to risks. It may be challenging to change the mind of a bankrupted company and a pilot that is coming back from a furlough to rise the limitations and to provide extra training, be strict in

the adherence to the procedures and raised safety limitations while on the other side to maintain a physical and psychological balance.

DISCUSSION: It is important to consider the adherence to rules and procedures during the pandemic, as well as protecting crews at their working environment, to provide them with the appropriate training and surveillance of their operations using approved methods that far away from being punitive are an active and proactive measure to guarantee safety.

Learning Objectives

1. The attendee will familiarize with airline operational safety risks and mitigation.
2. The attendee will familiarize with call back challenges when a pilot comes back to activity after a long leave.

[328] FAILURE TO FOLLOW PROCEDURES IN AIR TRAFFIC CONTROL

Laura J. Wood, Jason Demagalski

Federal Aviation Administration (FAA), Washington, DC, USA

(Education - Tutorial/Review)

INTRODUCTION: Failure to follow procedures (FFP) in Air Traffic Control (ATC) operations can arise from many different factors. The 'dirty dozen' are twelve factors that are associated with increased likelihood of accidents/incidents and with FFP. In fact, analyses of accident/incident reports and voluntary reporting systems indicate that FFP are frequently the result of a combination of these factors along with other organizational, situational, and individual elements. It is critical that these factors and their interactions are understood in order to develop appropriate methods to mitigate their impacts on FFP and facilitate safety within the ATC environment. **TOPIC:** The focus here is on the interrelationship between these commonly cited dozen factors along with other causal and contributory factors and FFP, demonstrated via examples from accidents/incidents. A three-pronged approach to understanding FFP will be discussed, including FFP as it relates to air traffic controllers, supervisors, and the quality assurance process of the FAA. Within this approach, types of FFP will be noted, including the differentiation between routine violations/workarounds to reduce safety risk, exceptional violations, and errors. Identification of these factors will be discussed, including data collection and analysis methods (e.g., Voluntary Safety Reporting systems, Barrier Analysis review process), common ATC situations that involve FFP cases (e.g., Opposite Direction Operations), and other examples of interactions between the organizational, situational, and individual factors that converge. For example, high pressure due to high workload (i.e., situational), combined with a lack of resources (i.e., too few controllers; organizational) and fatigue (i.e., individual) could be especially detrimental. Additionally, efforts to mitigate these factors will be highlighted, including tracking of recommendations, discussions of scenarios through Partnership for Safety presentations, education on behavioral indicators of performance, and encouragement of safety culture initiatives such as Professionalism within the workplace. **APPLICATION:** FFP in ATC Operations can arise from an interaction of many factors in the ATC Operation, with these elements overlapping and influencing each other. Knowledge of these complex interrelationships can deepen our understanding of how these scenarios emerge and ultimately inform mitigation strategies for increased safety practices within the NAS.

Learning Objectives

1. The participant will gain a deeper understanding of the interrelationship between the commonly cited dozen factors that have been associated with increased likelihood of accidents/incidents, along with other causal and contributory factors and FFP.
2. The participant will learn about the FAA processes for identifying and analyzing FFP. Additionally, the participant will gain a deeper appreciation of how these factors are mitigated and monitored.
3. The participant will acquire a greater understanding of how FFP occur in the Air Traffic Control field, as well as the unique factors involved within this context.

[329] FAILURE TO FOLLOW PROCEDURES IN MEDICINE

Keith Ruskin

University of Chicago, Chicago, Illinois, USA

(Education - Tutorial/Review)

INTRODUCTION: Failure to follow procedures (FFPs) in medicine occurs when a clinician does not follow the commonly accepted procedure(s) for accomplishing a specific task. FFPs may be an error or a violation or may be caused by more complex interactions between individual, organizational, and situational factors. Although FFP is usually the result of an error or a violation, Safety 2 suggests that some process variability may enhance resilience. Adapting human performance principles may reduce adverse events associated with FFPs. **TOPIC:** FFP can occur because of errors or violations. *Errors* are unintentional and occur because no human is perfect, systems are flawed, and every patient has a different combination of pathophysiology and comorbidities. A *violation* is a deliberate action that may create unnecessary risk, predispose to error, and exacerbate the consequences of an error. Organizational culture has a significant impact on FFP and safety. In a *Just Culture*, individuals report and learn from errors and help to prevent them from recurring. Violations may result in a disciplinary action even if no harm occurs. *Responsibility Culture* incorporates Just Culture and expects physicians to actively mitigate errors (e.g., by insisting that a surgeon performs the time-out procedure). **APPLICATION:** The classic approach to safety in healthcare is *Safety 1*, in which adverse events are studied and used for growth and learning. *Safety 2* is designed to increase resilience by understanding how adaptability and variability can improve outcomes under adverse conditions. Under *Safety 2*, *Work as Imagined* is defined as guidance developed by senior management based on theoretical constructs but may not reflect the actual conditions that affect work at the "sharp end," which directly affects patients. *Work as done* is how physicians at the sharp end accomplish tasks and incorporates process variability to ensure safety in a dynamic environment. This presentation will explore why physicians fail to follow procedures and how *Safety 2* can increase resilience. **RESOURCES:** Mannion R, Braithwaite J. False Dawns and New Horizons in Patient Safety Research and Practice. *Int J Health Policy Manag.* 2017 Dec 1;6(12):685-689. doi: 10.15171/ijhpm.2017.115.

Learning Objectives

1. After attending this session, clinicians will be able to improve the culture of safety in their practice.
2. Healthcare professionals will be able to increase resiliency and mitigate adverse events using the concepts of Safety 1 and Safety 2.

[330] FAILURE TO FOLLOW PROCEDURES: A NURSING PERSPECTIVE AND VIABLE SOLUTIONS

Cathy DiBiase

Kennedy Space Center, Kennedy Space Center, FL, USA

(Education - Tutorial/Review)

Failure to follow procedures (FFP) in any medical setting (acute care facilities, operating rooms, a clinic or doctor office) can lead to errors resulting in poor patient outcomes, loss of life and blame to the health care provider, and subsequent loss of license, loss of employment, malpractice, and even suicide. Understanding failure to follow procedure elements, risks, and prevention helps facilitate patient care that does not result in harm, while fostering an environment that leads to error reduction and prevention. Medical errors are complex and are multifactorial. Issues with nursing staffing ratios in acute care settings, inexperienced staff, new protocols that were not adequately vetted, and many more issues are some of the areas affecting the types and frequencies of errors. There are several approaches that can be employed to assess the anatomy of an error. Scientific methods are not always employed, which hinders appropriate data collection and analysis. There are a number of accepted quality improvement processes, which may be useful if implemented. However, nomenclature is not standardized across the profession and may be ill-defined. Medical errors typically occur through omission or commission. They are not

usually malicious or willful. Forgetting to lock a wheelchair before a patient ambulates or giving the patient the wrong medication, though harmful, stem more from an action not taken or taken incorrectly. Identifying and appropriate reporting of sentinel events are critical to developing and implementing improvement efforts aimed at preventing similar events. There are many challenges associated with failure to follow procedures faced by every provider. This presentation will provide some viable solutions.

Learning Objectives

1. List at least three effects the Health Care Provider experiences when an error is made
2. Describe the difference between omission and commission and the definitions effect on failure to follow procedure
3. Define a sentinel event

Thursday, 05/26/2022

10:00 AM

Tuscany B

[S-64]: SLIDE: AIRCRAFT AND CAVES

Chair: Gordon Landsman

[331] HYPOXIA SIGNATURE: A USEFUL TOOL FOR HYPOXIA RECOGNITION AMONG AIRCREW

Shivani Kasture, Nataraja MS, Sudhanshu Mohapatra, Biswajit Sinha

Institute of Aerospace Medicine, Bengaluru, India

(Original Research)

INTRODUCTION: Hypoxia, often referred to as 'silent killer', a common aeromedical stressor in aviation, may have catastrophic events unless recognized well in time while flying. On exposure to hypoxia, an individual manifests a specific spectrum of symptoms referred to as 'hypoxia signature'. The present study was conducted to assess the manifestation of 'hypoxia signature' on repeated exposure to simulated hypobaric hypoxia for its potential usage as a tool for hypoxia recognition. **METHODS:** 22 healthy adult volunteers were subjected to a simulated altitude of 22,000 feet for a duration of five minutes in the hypobaric altitude chamber. The symptoms experienced by the participants at the said altitude were recorded using a questionnaire. The heart rate (HR) and oxygen saturation (SpO₂) were recorded during the exposure. The hypoxia exposure was repeated two more times with a minimum interval of 03 weeks between each. The hypoxia symptoms and their severity reported during the exposures were compared with those of recalled symptoms (reported after 03 weeks of exposure) using McNemar test and Wilcoxon Signed Rank test respectively. **RESULTS:** Paired t-test revealed a statistically significant increase in HR and fall in SpO₂ with rise in altitude from ground level to 22000 feet. The three most common symptoms consistently observed were light-headedness, thinking slow, and warm feeling. The common hypoxic symptoms and their severity scores reported at 22,000 feet compared with recalled counterpart during subsequent exposures did not reveal any significant differences ($p > 0.05$). **CONCLUSION:** There was a high degree of similarity in the frequency and severity score of symptoms between acute exposure to hypobaric hypoxia and recall indicating evidence of repeatability of symptoms across the three sessions of hypoxia exposure within the individuals. This brings out the usefulness of 'hypoxia signature' as a tool for hypoxia recognition and its application in hypoxia indoctrination and training for aircrew.

Learning Objectives

1. The audience will learn about the potential benefit of hypoxia training to recognize hypoxia symptoms
2. The audience will learn about the significance of repeated hypobaric chamber training in preventing hypoxia-related incidents

[332] A CHANGE POINT ANALYSIS OF THE HISTORICAL RATES OF MAJOR NAVAL AVIATION MISHAPS

Jefferson Grubb

Naval Safety Center, Norfolk, VA, USA

(Original Research)

INTRODUCTION: To determine what factors drive safety in Naval Aviation, this study examined the annual rates of major Naval Aviation mishaps. These data are typically presented as a line graph of the time series of annual mishap rates. Such graphs are usually annotated with markers indicating the timing of theoretically important safety events. However, the specific annotations, and even the timing of commonly cited events, vary widely between presentations. Additionally, the graph itself appears to descend asymptotically and without obvious evidence of the discrete impact of the annotated events. Moreover, because these graphs normally only show data back to 1950, it is unclear whether this asymptotic pattern is a general feature of Naval Aviation safety or something specific to modern Naval Aviation. **METHODS:** A series of regression analyses was conducted on a time series of annual Naval Aviation major mishap rates that spanned 1922 to 2019. After selecting the best fit model, the mishap data were detrended and submitted to a change point analysis using the pruned exact linear time (PELT) algorithm for mean and variance changes. **RESULTS:** The regression analyses revealed that an exponential function best fit the raw data, explaining 97% of the variance in annual mishap rates across the entire time series. The change point analysis on the detrended data detected nine points at which the underlying statistical properties of the time series changed. **DISCUSSION:** The overall exponential trend extends across the history of Naval Aviation and is therefore a general feature of the major mishap rate data. The author argues that this trend is an eliminative learning curve, suggests that organizational learning is the dominant factor in historic mishap rates. The timing of the change points indicates that resourced safety and standardization efforts can speed up this organizational learning. However, disruptive technologies and mismatches between resourcing levels and operational requirements can slow or even reverse learning trends.

Learning Objectives

1. Understand what factors drive changes in the annual rate of major Naval Aviation mishaps.
2. Understand the utility of change point algorithms for analyzing mishap rate data.

[333] HYPOBARIC HYPOXIA MIMICS CARDIAC ISCHEMIA IN THE HISTOLOGICAL EXAMINATION OF AN AIRCRAFT ACCIDENT VICTIM

Michael Schwerer

Air Force Centre of Aerospace Medicine, Fuerstenfeldbruck/Cologne, Germany

(Education - Case Study)

INTRODUCTION: Comprehensive and expedient aircraft accident investigation requires the confirmation or exclusion of medical conditions being involved in the deadly cascade. **CASE PRESENTATION:** A 26 year old German fighter pilot was recovered dead after an aircraft accident. False estimation of the distance between two Eurofighters ("Typhoon") had resulted in a midair collision in approximately 21.000 feet above MSL. Both aircraft crashed in unoccupied areas. One pilot survived slightly injured after bail out. The other flyer's body was found fixed to his ejection seat. The propellant of the seat was partially spent. The parachute was incompletely unfolded. Forensic autopsy documented severe destruction of the corpse with rupture of the abdominal wall and the diaphragm. The heart was found completely torn out of the thoracic cavity and showed penetrating cuts through the ventricle walls. Therefore, only incomplete macroscopic examination of the coronary arteries was possible. Histology showed loosening of the internal perimysium consistent with blunt trauma. Further, extensive positivity of cardiac muscle cells was observed using the basic-fuchsin-picric-acid-staining technique ("Lie"-staining). Hence, an

early sign of ischemia had to be considered. The absence of immunohistochemical co-positivity for complement C_{5b-9}, another marker for hypoxic myocardial fibers along with lacking signs of coagulation necrosis in standard histology and absent arteriosclerosis, wall hemorrhage or thrombosis in the accessible coronary arteries raised doubt about regional hypoxia resulting in an early stage of myocardial infarction. General hypoxia in the pilot was excluded by the histological assessment of other tissues, especially neural cells in the central nervous system. However, soot was demonstrated microscopically in superficial tissue areas including the heart's surface. **DISCUSSION:** Positive Lie-staining in the present case resulted from hypoxic changes in cardiomyocytes not as a result from malperfusion but from hypobaric hypoxia when the torn-out heart was exposed to low ambient pressure. In addition, oxygen consumption from burning propellant of the ejection seat putatively contributed to this histological mimic of myocardial ischemia. Hence, no hints on pre-existing disease or short-term sudden incapacitation in the pilot were present. Neither an error in the pilot's aeromedical certificate nor a malfunction of the aircraft's oxygen system had to be concluded.

Learning Objectives

1. The audience will learn about possible markers for myocardial ischemia in aircraft accident victims and their interpretation in forensic pathology.
2. The participants will be able to distinguish between real cardiac hypoxia in aircraft accident victims as a possible accident cause and mimics of myocardial ischemia resulting from the mishap's circumstances.

[334] EVALUATION OF LITTER STRAP TENSION ON THE BIODYNAMICS OF SUPINE PATIENTS

Amy Lloyd¹, Rachel Kinsler², Kerri Caruso¹, Eric Frick³, Khalid Barazanji³, Salam Rahmatalla³, Laura Kroening¹, Jeff Molles¹

¹Goldbelt Frontier, LLC, Fort Rucker, Alabama, USA; ²U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, USA; ³ActiBioMotion, Coralville, Iowa, USA

(Original Research)

INTRODUCTION: Recent surveys from health care providers in the field have reported severe discomfort and pain experienced by casualties during military transport, with the pain attributed to vehicle vibration and shock. The method and degree of strapping tension varies depending on patient injuries. The level of tension may play a role in the severity of the motion transmitted to the patient's body segments. **METHODS:** The hypothesis that strap tension has significant effects on transmitted vibration during transport was tested during three phases of testing. In Phase 1, standard tension practices were observed by having medics strap a manikin to a litter. This phase determined average litter strapping tension. Phase 2 consisted of test setup validation using an instrumented vibration manikin. The simulated patient manikin was tested on a ride simulation platform in several configurations while vibration data was collected. In Phase 3, data was collected using 25 human subject participants with different body weights. The weight of each participant was between 102 and 275 pounds. The human subject participants were secured to a litter on the ride simulator and subjected to multiple vibration profiles. The ride profiles for Phases 2 and 3 include vibration of different magnitudes and directions as well as repeated shocks. **RESULTS:** The primary comparison metric was transmissibility, specifically the maximum transmissibility (MT), area under the transmissibility curve (AoT), and resonant frequency. Overall, the preliminary results from data analyses suggest that segments not directly secured by straps (such as the head) generally exhibit more desirable responses (in terms of lower MT and AoT) when secured at standard tension. However, the segments directly secured by straps (such as the pelvis) are more impacted by the type of vibration than the strap tension. **DISCUSSION:** The level of strap tension did significantly affect the biodynamics of the supine patient. The effects of strap location and strap tension varied by segment because of the difference in strap proximity to and placement on each segment. Results from this project will provide

significant information and strategies that can be used toward increasing patient safety, reducing discomfort, and developing vibration mitigation systems.

Learning Objectives

1. Describe the effects of strapping tension on patient transport, and how it can be used to increase patient safety.
2. Describe how the simulated patient manikin and human subject participant vibration data correlate.

[335] HOW THE COLUMBIA DISASTER HELPED THE CHILDREN IN THE THAILAND CAVE RESCUE

Douglas Hamilton¹, James Polk²

¹University of Calgary, Calgary, Alberta, Canada; ²NASA, Washington, DC, USA

(Original Research)

INTRODUCTION: The Space Shuttle Columbia disaster was a fatal incident in the United States space program that occurred on February 1, 2003, when the vehicle disintegrated as it re-entered the atmosphere. After Columbia, when a Shuttle reached orbit, the astronauts collected images of the orbiter thermal protection tiles. If the tiles had suffered excessive damage, the crew would abort to the ISS and live there until they could be rescued by another Shuttle mission comprised of 11 crew members on a vehicle designed to support 7. **METHODS:** To estimate the O₂ and the CO₂ produced by each crew member a metabolic model was created based on the Revised Harris-Benedict Equation and the atmosphere was supercomputer modelled with computation fluid dynamics. This model uses biometrics (age, weight, height and gender) to calculate basal metabolic rate (BMR). A multiple of the BMR was used to estimate total metabolic rate, O₂ consumed, and CO₂ produced. **RESULTS:** This model drove the modifications made to the STS-400 Shuttle Endeavour which was the designated rescue vehicle for the successful STS-125 Hubble Telescope repair mission. This model was further refined to help create the refeeding diet and the life support for the rescue capsule during the 2010 Chilean Copiapó mining accident (where 33 miners were trapped for 3 months underground in 40°C heat and 95% humidity and initially 21 days without food or water. **DISCUSSION:** In June and July 2018, a soccer team was trapped in the Tham Luang Nang Non cave in northern Thailand. Twelve children (aged 11 – 16), and their 25-y/o coach were trapped in the cave on 23 June. Using our metabolic model for the players and coach with a cave oxygen level of 15% measured on July 6th, we calculated the cave volume to be approximately 1.75 million liters (or one Olympic sized 10 lane pool). On July 7th NASA Space Medicine informed the rescue authorities that the team's calculated survival to be between 4-12 days (depending on factors such as shivering, hyperventilating, malnutrition, and activity, etc) when the atmosphere might become lethal. Between July 8th-10th, the children and coach were evacuated by an international rescue team.

Learning Objectives

1. The audience will understand how to estimate the O₂ and the CO₂ produced by a subject using the Revised Harris-Benedict Equation.
2. The audience will understand how to model the atmosphere of the Space Shuttle using a supercomputer to perform computational fluid dynamics.
3. The audience will understand how to estimate the O₂ and the CO₂ produced by the children and the volume of the Tham Luang Nang Non cave accident in northern Thailand.

Thursday, 05/26/2022
Tuscany F

10:00 AM

[S-65]: SLIDE: RESPIRATORY FACTORS IN HUMAN PERFORMANCE

Chair: Michael Greene

Co-Chair: Nicholas Natoli

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

Denis Bron, Mathias Aebi

Aeromedical Center, Duebendorf, Switzerland

(Original Research)

INTRODUCTION: In hypoxic environment, cerebral blood flow regulation is vital to maintain adequate oxygen supply to the brain. The present study aimed to evaluate change in cerebral blood flow velocity (MCAv) and its influence on cerebral oxygen delivery (cDO₂) at rest vs. moderate-intensity exercise, in acute normobaric vs. hypobaric normoxic/hypoxic conditions. **METHODS:** Eighteen healthy pilot trainees (26±3 years old, 177±10cm, and 70±11kg) performed a 6-min moderate-intensity exercise (1W/kg, at 80rpm) on a cycle ergometer (eBike II basic, GE medical systems, Germany) in four randomized conditions (normobaric normoxia, NN: hypobaric hypoxia, HH and normobaric hypoxia, NH at 5000m; and hypobaric normoxia, HN). Inspired oxygen pressure (PIO₂) was matched between normoxic (NN vs. HN, 141.2±0.8 vs. 141.5±1.5 mm Hg) and hypoxic (NH vs. HH, 75.7±0.4 vs. 74.3±1.0 mm Hg). Pulse oxygen saturation (SpO₂), heart rate (HR) and MCAv (Transcranial Doppler, ST3, Spencer Technology, Seattle, WA) were measured at rest and during exercise as well as rating of perceived exertion (RPE). Repeated measures ANOVAs were performed to assess statistical significance. **RESULTS:** At rest MCAv was higher in HH (48±7 cm/s) than NN (43±6 cm/s, p=0.022) and HN (42±5 cm/s, p=0.003). HR was higher and SpO₂ lower in NH and HH than in NN and HN (i.e., hypoxic effect, p=0.001). During exercise, MCAv was higher in HH (57±6 cm/s, p=0.01) than in NN and HN (49±6 and 48±6 cm/s, respectively). Moreover, HH induced greater HR (131±17 bpm, p=0.002) and lower SpO₂ (69.2±5.7%, p<0.001) than NN (119±15 bpm and 81.4±4.8%). RPE was higher (p<0.001) in NH (11.3±2.2) and HH (11.8±2.3) compared to NN (8.1±1.3) and HN (9.1±1.3). There was no significant difference in cDO₂ between conditions either at rest or during exercise. No significant difference was reported between NN and HN. **DISCUSSION:** Hypoxemia in NH and HH induced an increase in MCAv to maintain cDO₂ (Brugniaux *et al.*, 2007). The present results (i.e., lower SpO₂ and greater HR) confirm the more severe condition in HH than in NH (DiPasquale *et al.*, 2015; Savourey *et al.*, 2003). However, the effect of hypobaria seems negligible in normoxic conditions since there was no difference in MCAv, HR and SpO₂ between NN and HN. These findings are of clinical importance for pilots training in flight simulator (i.e. NH) to prepare for flights hypoxic events at real altitude in HH.

Learning Objectives

1. How is cerebral oxygen delivery (cDO₂) modulated in hypoxic and hypobaric conditions during low-intensity cycling exercise.
2. Physiological responses to low-intensity cycling exercise in normobaric hypoxia, hypobaric hypoxia and hypobaric normoxia.
3. Understand the importance of instructions under hypoxic conditions.

[337] A PILOT'S WORK OF BREATHING ASSESSMENT IN HIGH ALTITUDE, MASKED ENVIRONMENTS

Rheagan Horne, Nicholas Napoli, Victoria Ribeiro Rodrigues, Jeremy Prieto, Wendy Olsen, Paul Davenport

¹University of Florida, Gainesville, FL, USA

(Original Research)

INTRODUCTION: Military fighter pilots are presented unique physiological and human performance challenges. One such example is their work of breathing (WoB), or energy expenditure by respiratory muscles to maintain appropriate gas exchanges (alveolar ventilation) in flight. Over the last 75 years of aerospace respiratory physiology, we have modeled respiratory signals as ideal sinusoidal waves. However, fighter pilots' breathing dynamics should not be approximated as sinusoidal waveforms, especially during aerobatic maneuvers. We present how

non-sinusoidal breathing models render a deeper understanding of WoB in aviation and significantly deviate from the classical model. **METHODS:** Our WoB model's foundation is generated from the classical Otis, Fenn and Rahn (1950) research, which is extended to delineate the variables of frequency, rate, and period. While non-sinusoidal waveforms make this distinction, these variables are all synonymous within sinusoidal waveforms. Our non-sinusoidal model computes total work as the sum of elastic, viscous, and turbulent forces, where frequency, breathing rate, period, dead space, and alveolar ventilation are discussed and accounted for.

RESULTS: WoB pressure and volume measures made at the mouth neglect turbulent and viscous forces which are compounded exponentially during aerobatic maneuvers. Our model indicates up to a 400% increase in WoB between the classical model and our non-sinusoidal model. This large deviation in error is contributed to the frequency (not to be confused with rate) of the inspired phase of breath due to the viscous and turbulent forces, impacting the WoB exponentially. Additionally, our model provides critical information on how WoB can drastically change within a pilot's breathing pattern. Our model indicates how specific patterns can be potentially adapted when new environmental conditions are imposed (mask failures) to reduce WoB. **DISCUSSION:** The simulated results indicate that the classical model is a significant underestimation of WoB. Coupling high dead space and frequency exponentially raises WoB and, thus, it would behoove pilots to limit G-manuevers when their mask regulator is malfunctioning. This model can lead to an educational recommendation paradigm for breathing dynamics in pilot training programs to optimize their WoB and compensate when equipment fails. With appropriate modeling, we can begin to uncover an aviator's true WoB.

Learning Objectives

1. The audience will gain understanding on how modeling breathing as a non-sinusoidal waveform, instead of the classical model, can exponentially impact work of breathing estimations.
2. The audience will be able to delineate between the work of breathing variables frequency, rate, and period.
3. The audience will learn about potential compensation methods for pilots when met with extreme work of breathing conditions or external environmental malfunctions.

[338] VENTILATION RATE AND NORMOBARIC HYPOXIA TRAINING IN F/A-18C HORNET TACTICAL FLIGHT SIMULATOR

Nikke Varis¹, Antti Leinonen², Kai Parkkola¹, Tuomo Leino³

¹University of Tampere, Tampere, Finland; ²University of Kuopio, Kuopio, Finland; ³Aeromedical Center, Helsinki, Finland

(Original Research)

INTRODUCTION: Hyperventilation has been identified as one of the most frequent causes behind physiological episodes. In military aviation hypoxia training is conducted in hypobaric chamber or by reducing the fraction of inspired oxygen in normobaric environment. The aim for this study is to document normobaric hypoxia's (NH) effect on pilots' ventilation during NH training in fighter simulator. **METHODS:** 81 fighter pilots from the Finnish Air Force (FINAF) participated NH training. Subjects performed normobaric hypoxia training flight in WTSAT simulator with full flight gear, regulator and mask on. First training set-up was conducted by using 8% oxygen in nitrogen gas mixture. 47 subjects participated also in second set-up, in which 6% oxygen in nitrogen gas mixture was used to demonstrate shorter time of useful consciousness (TUC). In the middle of identification sortie, hypoxic gas was turned on without subject's knowledge. Subject's task was to recognize hypoxic symptoms and perform emergency procedures. Forehead SpO₂, wireless ECG and subjective symptoms were documented. Ventilation rate (VE) was measured before, during and after the hypoxic exposure. A Pearson correlation coefficient was used to assess the relationships between SpO₂, ventilation and exposure time. **RESULTS:** VE was increased during NH from 13.0 l/min to 17.2 l/min (range 9-25) with 8% oxygen (n=82, p<0.01) and from 11.4 l/min to 17.7 l/min (range 12-39) with 6% oxygen

($n=47$, $p<0.01$). Subjects recognized hypoxic symptoms with SpO₂ 79.0% and 76.1% respectively. During symptom recognition, oxygen saturation level was found to correlate ($r=.55$) between two different flights. Also VE during hypoxia correlated strongly ($r=.47$) between the flights. Exposure time correlated with SpO₂ level as expected (8% $r=-.67$, 6% $r=-.64$).

DISCUSSION: Hypoxia leads to hyperventilation as a compensatory response to provide sufficient oxygen levels. Ventilatory response to 6% oxygen had range from 12 l/min to 39 l/min mirroring psychological workload's effect on ventilation. Some recognized symptoms are rather due to hyperventilation induced hypocapnia than hypoxia. SpO₂ level is not used as aborting criteria in hypoxia training in FINAF. More emphasis is put on exposure time and pilot's decreased performance level which is evaluated by flight surgeon.

Learning Objectives

1. The audience will learn about reflectory hyperventilation caused by hypoxia.
2. Participant will be able to understand that some symptoms in hypoxia training are rather due to hypocapnia than hypoxia.

[339] RESISTANCE BAND EXERCISE REGIMEN EFFECTS ON CERVICAL SPINE RANGE OF MOTION, STRENGTH, AND MUSCULAR CONTROL

Brian Novotny, Adrienne Madison, Shannon McGovern, Valeta Chancey

U.S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama, USA

(Original Research)

BACKGROUND: Recent reviews of the Defense Medical Surveillance System database show intervertebral disc and cervical spine disorders among the top ten ambulatory diagnoses for all military services. Reports also show that neck pain is even more prevalent (43-48%) in U.S. military rotary-wing pilots; approximately 20% of personnel experience regular or continuous neck pain. Increasing cervical spine strength has been shown to decrease neck pain in clinical settings and improve muscle performance in aviators. Previous studies on cervical spine-directed exercise regimens (CSDERs) do not include rotational loading or incorporate the full musculature range of motion (CROM). U.S. Army Flight School (Fort Rucker, AL) students and instructors participated in a six-week progressive resistance band CSDER to determine the effects on cervical spine strength, CROM, and control in military aviators. **METHODS:** Participants were recruited and consented under a Naval Air Warfare Center Aircraft Division IRB-approved protocol. Participants performed five resistance band exercises for two sets of 10-15 repetitions once a day, five days a week, for six weeks. Pre- (Week 0), mid- (Week 3), and post-training (Week 6) assessments were completed for CROM (eight measurements), isometric strength, and targeted incremental force output (muscular control). **RESULTS:** Data from participants ($N=12$) were collected and analyzed. A statistically significant ($p<0.05$) difference was found for all eight CROM measurements between pre- and post-training, with all except extension and right lateral flexion being statistically different from pre- to mid-training. A statistically significant difference was found for isometric strength in extension between pre- and post-training measurements. A statistically significant difference was found for both incremental targeted-force output measurements pre- and post-training, with flexion also being statistically different from pre- to mid-training. **CONCLUSION:** Study outcomes demonstrate that a CSDER is an effective training method for increasing CROM, isometric strength, and muscular control. While the subject population consisted of healthy military aviators exclusively, the exercise regimen has implications for the general military and public, both therapeutically and prophylactically. Future work will leverage these findings to develop and incorporate operationally-specific training and treatment interventions to optimize Soldier performance.

Learning Objectives

1. Examine the outcomes of a progressive cervical spine-directed resistance band exercise regimen.

2. Understand how the exercise regimen individually affected cervical spine muscular strength, control and range of motion.

[340] THE EFFECT OF THE COVID-19 PANDEMIC ON THE WELL-BEING OF PROFESSIONAL PILOTS

Emily Stratton, Robert Haddon, Hassan Murad, Tanya Petterson, Mitchell Nelson, Clayton Cowl

The Mayo Clinic, Rochester, Minnesota, USA

(Original Research)

INTRODUCTION: The COVID-19 pandemic has adversely affected many populations, including professional pilots. Therefore, we sought to evaluate the pilot population's well-being using a survey that included the World Health Organization (WHO)-5 Well-Being Index. **METHODS:** We constructed a ten-question survey and performed convenience sampling. The study was ruled exempt by our Institutional Review Board. Pilots self-categorized as: Airline Transport Pilot (ATP), Commercial Pilot, or both. 639 individuals returned the survey. The majority of respondents were ATPs and a majority identified as male. The average well-being score was 68.0 out of 100 possible, with 22% of respondents meeting the threshold definition of impaired well-being. Chi-squared and Fisher's exact tests were used as well as logistic regression to calculate odds of impaired well-being both in univariate and multivariate models.

RESULTS: The odds of having impaired well-being were not dependent on gender. The odds of having impaired well-being were higher in the younger age groups as compared to those 60+ in age. There was a significant association between age and type of pilot with commercial pilots tending to be younger than those who were either airline transport pilots or both, consistent with known industry patterns. In multivariable regression, adjusting for female gender, the odds of impaired well-being were 92% higher for those flying as Commercial Pilots as compared to ATPs. Only a little over half of the surveyed pilots agreed or strongly agreed that pilot risk of occupational exposure to COVID-19 was appropriately controlled. **DISCUSSION:** This survey suggests an important connection between both pilot age and pilot type with impaired well-being scores during the COVID-19 pandemic. Future studies targeting the well-being of younger pilots will be of interest. Additionally, measures to improve occupational risk of COVID-19 exposure, may be helpful in view of the substantial fraction of pilots expressing concern about that risk.

Learning Objectives

1. The audience will learn about how the COVID-19 pandemic is affecting the well-being of professional pilots.
2. The audience will learn about the connection between both pilot age and pilot type and well-being scores during the COVID-19 pandemic.
3. The audience will learn about possible countermeasures targeting the well-being of younger pilots.

[341] EFFECT OF FLIGHT-RELEVANT INSPIRATORY RESISTANCE AND RESTRICTED CHEST WALL MOTION ON CO₂ HOMEOSTASIS

Barbara Shykoff, Dan Warkander, DeAnne French, Eric Robinson

Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Life support systems inevitably increase work of breathing because of added external inspiratory resistance. Flight crew wear gear and harnesses ("flight equipment") that restrict chest wall expansion. As part of a larger IRB-approved study, NAMRU-D investigated CO₂ control and work of breathing with flight-relevant chest wall restriction and inspiratory resistance in conjunction with physical activity to study the effects of the two breathing loads. **METHODS:** Fifteen participants breathed room air. Three inspiratory resistances ("R_level") were presented, each on its own day: R1, minimal; R2, at the pressure - flow limits of MIL STD 3050; and R3, more resistive than allowed. Each day, participants also donned a vest fitted to limit large

breaths without impeding quiet breathing. Inspiratory flow and mask CO₂ fraction were measured continuously during rest and cycling exercise. End-tidal CO₂ fraction (F_{ET}CO₂) was extracted and inspiratory minute ventilation (V_I) was computed breath-by-breath. Variables were averaged over one minute shortly before the end of rest or exercise. **RESULTS:** Exercise generated V_I similar to that of flight; V_I with R1 and no vest (mean ± SE: 32 ± 1 L/min) was between that for routine flight and aerial combat maneuvers, 26 and 42 L/min, respectively (Gordge, 1993). Corresponding F_{ET}CO₂ was 6.08 ± 0.08%. During rest neither R_{level} nor vest altered F_{ET}CO₂ or V_I. During exercise, repeated measures analysis of variance and post-hoc testing indicated a significant effect of the vest on F_{ET}CO₂, but only for R1, when F_{ET}CO₂ decreased to 5.8 ± 0.1%. The related increase in V_I to 35 ± 1 L/min was not statistically significant with this small sample and the necessary non-parametric testing. **CONCLUSIONS:** With exercise, flows and chest wall movements higher than at rest increase the effects of both resistance and restriction from flight equipment. The greater effort of breathing was expected to damp chemoreceptor response, permissively increasing F_{ET}CO₂. Counterintuitively, with minimal inspiratory resistance, chest wall restriction stimulated minute ventilation in excess of that needed for CO₂ balance, as evidenced by the lower F_{ET}CO₂. This effect of restriction was reduced when inspiratory resistance increased. For flight crew, interactions among respiratory loads may have unexpected effects.

Learning Objectives

1. Attendees should understand that the average effect of a breathing load may change when other impediments to breathing co-exist with the load.
2. Attendees should be aware that the level of physical activity, hence of minute ventilation, can also alter the effect of an impediment to breathing.

Thursday, 05/26/2022
Tuscany 3

10:00 AM

[S-66]: PANEL: ADVANCES IN AEROSPACE MEDICINE IN IBEROAMERICA

Sponsored by the Iberoamerican Association of Aerospace Medicine

Chair: Lina Sanchez

PANEL OVERVIEW: In 2022, the panel sponsored by the Iberoamerican Association of Aerospace Medicine (IAAM) celebrates 24 years of sharing scientific advances in Iberoamerica. Conducted in the Spanish language, it will be chaired by the IAAM's past president, Dr. Lina Sanchez, of Colombia. The panel will commence with an original research about analysis of the Colombian civil aviation accident rate (2009 to 2018) using the HFACS framework, conducted by Dr. Mateo Gonzalez, an aerospace medicine specialist of Colombia. Next, Dr. Jean Carlos Duenes, a cardiologist of Venezuela, will present a descriptive study on post COVID-19 electrocardiographic alterations in commercial pilots and flight attendants of Latin American countries from 2020 to 2021. The panel will continue with Dr. Marian Farfan, a resident of aerospace medicine (RAM) at the National University of Colombia, who will discuss an advisory circular: mental health of aviation personnel during the COVID-19 pandemic. Dr. Jean Carlos Duenes, of Venezuela, will complement the session by presenting his research study about acute myocarditis and moderate/severe systolic dysfunction post COVID-19 in commercial pilots, flight attendants and pilot students in Colombia, from 2020 to 2021. Finally, Dr. Diego García, an aerospace medicine specialist of Colombia and adjunct professor at the Embry-Riddle Aeronautical University, will conclude the panel by discussing the importance of developing evidence-based aeromedical policy during the COVID-19 pandemic. As always, the panel offers an opportunity to learn from our dear colleagues in Iberoamerica and encourages an internationally united environment towards enhancing world aviation safety.

[342] ANALYSIS OF THE COLOMBIAN CIVIL AVIATION ACCIDENT RATE (2009 TO 2018) USING THE 'HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM' – HFACS FRAMEWORK

Mateo Gonzalez-Agudelo¹, Omar Agudelo-Suarez², Diego Garcia-Morales³, Johana Giraldo-Alzate⁴

¹National University of Colombia, Bogota, Colombia; ²National University of Colombia, Bogota, Colombia; ³National University of Colombia, Bogota, Colombia; ⁴Aviation Medicine Office, Colombian Civil Aviation Authority, Bogota, Colombia

(Original Research)

INTRODUCTION: Aviation accidentality has varied its causes.

Currently, it is considered that the human factor is responsible for approximately 70 to 80%. Although mechanical or environmental causes have decreased considerably during the 20th century, accidents caused by human error have not followed the same rate of reduction. Since Human Factors are the main determinants involved in aviation accidents, applying models for their analysis is necessary. The 'Human Factors Analysis and Classification System' (HFACS) is a widely validated tool with ample application in military and civil aviation safety investigations, that other safety-critical industries have also adopted. In Colombia, accidents proportions have steadily decreased at the beginning of this century. A comprehensive recognition of the human error after applying the HFACS framework to the Colombian civil aviation accident rate will allow renewing and strengthening the epidemiological panorama of the country's aeronautical safety, thus providing the context and prevention baseline for being considered by the regulatory entities. **METHODS:** The reports of civil aviation accidents between January 2009 and December 2018 were examined. An observational, descriptive, cross-sectional study was carried out. The percentages and frequencies of the HFACS types of errors were determined. **RESULTS:** A sample of 136 eligible cases was obtained. When applying HFACS to probable cause, skill-based errors (SBE) accounted for 33.3%, followed by violations (V), decision (DE), and perceptual errors (PE). SBE were registered in more than 50% of accidents involving pilots with low experience and low continuity. In fatal accidents, there was a higher proportion of violations than in non-fatal. More PE was seen in rotary-wing accidents. In both probable cause and contributing factors, organizational processes were the most frequently observed error from the upper levels of HFACS. **DISCUSSION:** A higher proportion of violations were observed in the country's aviation accidents. The distribution of unsafe acts for the last five years (SBE > DE > V > PE) is consistent with other studies. HFACS application to the Colombian civil aviation accident rate can be helpful for coding, characterization, and analysis of different types of specific errors. Generally, it provides congruent and comparable results with reference studies.

Learning Objectives

1. To determine the occurrence and prevalence of the Human Factor in the different levels of error from the Colombian civil aviation accident rate during the period studied.
2. To renew and strengthen the epidemiological panorama of the country's aeronautical safety, thus providing the context and prevention baseline for the regulatory entities.

[343] DESCRIPTIVE STUDY ON POST-COVID ELECTROCARDIOGRAPHIC ALTERATIONS IN COMMERCIAL PILOTS AND FLIGHT ATTENDANTS OF LATIN AMERICA COUNTRIES (2020 TO 2021)

Jean Carlos Duenes¹

¹Cardiocountry, Country Medical Center, Bogota, Colombia

(Original Research)

INTRODUCTION: Coronaviruses are viruses wrapped in an RNA genome, whose name derives from its appearance that resembles a real crown with a surface with bumps or spikes. Cardiac affectations were

diagnosed post COVID-19, when the patients presented new electrocardiographic or echocardiographic alterations and an important result is that all the patients presented elevated troponin. **METHODS:** This is a descriptive study carried out by means of a questionnaire to users who presented COVID-19. The questions were related to the presence of COVID-19 and its possible cardiovascular complications in the period from July 2020 to October 2021. The total sample consisted of 201 patients, of which 177 were men and 24 were women. Each patient had a resting electrocardiogram taken in the cardiology consultation and it was repeated one month and three months later. To participate in this research was required to be active Class I commercial pilots or an active flight attendant from different countries of Latin American. **RESULTS:** An association between COVID-19 and sinus tachycardia was found even up to 2 months later in more than 67% of the population. First degree atrioventricular block was the most common finding in the acute stage of COVID-19 in 15%. Second-degree AV blocks were found in only 1 participant, which is equivalent to 0.45%. Ventricular and supraventricular arrhythmias were present in 11%. Atrial fibrillation and atrial arrhythmias in fewer cases. **DISCUSSION:** It was considered that most of the patients studied should continue a pattern of follow-up by the cardiology consultation with performance of control electrocardiograms, holter studies and even an ischemia induction test is not ruled out depending on the case for the next three and six months due the persistence of both first and second degree atrioventricular blocks. In relation to the alterations in the QT and PR intervals, these gradually improved as the disease subsided. The presence of atrial fibrillation in the only patient was paroxysmal; however, prophylactic new oral anticoagulants management was started before the risk factors and the Chas2vas index as a suggestion. Finally, a routine baseline electrocardiogram should be performed on all patients with COVID-19.

Learning Objectives

1. To understand the importance of identifying conduction and heart rhythm disorders in acute COVID-19.
2. To understand the importance of measuring the PR and QT interval in acute COVID-19.
3. To know the recovery time of these electrical findings in this population with COVID-19.

[344] ADVISORY CIRCULAR: MENTAL HEALTH OF AVIATION PERSONNEL DURING THE COVID-19 PANDEMIC.

Marian Farfan¹, Laura Pineda¹, Johana Giraldo-Alzate^{3,2} Diego Garcia¹

¹National University of Colombia, Bogota, Colombia; ¹National University of Colombia, Bogota, Colombia; ²Aviation Medicine Office. Colombian Civil Aviation Authority, Bogota, Colombia; ³National University of Colombia, Bogota, Colombia

(Education - Program/Process Review)

BACKGROUND: In January 2020, the World Health Organization (WHO) declared the outbreak of COVID-19 caused by the SARS-CoV-2 virus as a public health emergency of international concern. The pandemic produced profound impacts on public health and the economy, the aviation industry being one of the first and most affected. In October of 2021, ICAO estimated a decline in global passengers up to 50% compared to 2019, and an overall reduction of 40% of seats offered by airlines. Most states imposed strict travel restrictions affecting airlines' sustainability. The subsequent grounding of most aircrews, job uncertainty, new operational protocols leading to increased cognitive demand, and even the disease itself all present clear risks to mental health, human performance, and to operational safety. These risks must be addressed. **OVERVIEW:** The emerging challenges in mental health require States and aviation stakeholders to develop interventions focused on strengthening human performance by means of tools for the identification of hazards in aviation safety. We propose a systemic, non-prescriptive guide for the implementation of actions focused on safety to mitigate the risk of human performance impairment due to the impact of the SARS-CoV-2 (COVID-19) pandemic on the mental health of aeronautical personnel during the reactivation of air

operations. Based on a holistic approach to well-being (salutogenesis), this program starts from an individual commitment to healthy lifestyles and mental health awareness then transcends to social support networks, enhanced risk management methods, and readily diagnostic and recovery methods. The program includes mental health self-assessment resources, peer support networks, psychological first aid strategies, occupational health approaches, and safety management plans of action. **DISCUSSION:** This advisory circular addresses the mental health challenges of aeronautical personnel, with specific recommendations for the different actors of the aeronautical industry including the individuals themselves, their support networks, aviation medical examiners, and regulatory authorities. By means of easily interpretable tools and workflows that are validated and adjusted to the population, that allows the identification of red flags in mental health that may affect aviation safety, afterward the strategies to prevent them, and the following steps such as coping strategies, and risk mitigation.

Learning Objectives

1. Identify the sources of psychological stress in aviation personnel in the context of the COVID-19 pandemic.
2. Aeronautical industry personnel will demonstrate familiarity with the tools for coping strategies to mitigate the risks affecting mental health that may affect aviation safety.

[345] ACUTE MYOCARDITIS AND SYSTOLIC DYSFUNCTION POST COVID-19, IN COMMERCIAL PILOTS, FLIGHT ATTENDANTS, AND PILOT STUDENTS IN COLOMBIA, (2020 TO 2021)

Jean Carlos Duenes

Cardiocountry, Country Medical Center, Bogota, Colombia

(Original Research)

INTRODUCTION: Coronaviruses are a large family of viruses that cause illnesses. The main cardiovascular manifestations induced by coronavirus are sinus tachycardia and myocarditis mild to severe complicated with hypotension and cardiogenic shock. **METHODS:** This is a retrospective study, with a population of 400 patients post COVID-19 who attended outpatient consultations in the Cardiology service in two different health centers where Cardiology and Aeronautical Cardiology services are provided. The medical evaluation was carried out with the help of 2D-dimensional echocardiography and cardioresonance (CMRI) in those patients who had moderate to severe systolic dysfunction. This population was divided into two groups: 206 of aeronautical personnel (AP) comprised of pilots, flight attendants and air traffic controllers, and 194 of non-aeronautical personnel (NAP). **RESULTS:** This study identified in AP: global hypokinesia with mild altered ejection fraction in 9 patients (4.36%), moderate systolic dysfunction and myocarditis in 11 patients (5.33%), severe systolic dysfunction and myocarditis in 1 patient (0.48%), and inferior hypokinesia with conserved systolic function in 3 patients (2.17%). Also, this study found in NAP: mild systolic dysfunction with mild hypokinesia in 15 patients (7.73%), moderate systolic dysfunction with myocarditis in 15 patients (7.73%), severe systolic dysfunction with myocarditis in 4 patients (2.06%). NAP represented 25.25% of all cases with myocarditis and heart failure in relation to 13.59% of AP; 55% of them improved their ejection fraction approximately 7 months after starting medical treatment and their functional class was I/IV. Also, 7.75% of patients presented wall thickening with hypokinesia of the left ventricle, especially the apical segments with moderate to severe systolic dysfunction. **CONCLUSIONS:** This research indicates that there is heart involvement in patients post COVID-19, as other studies in other countries have revealed, and the inflammatory process resolves spontaneously in most patients after 1-4 months. However, sometimes the immune response fails to eliminate the infectious agent and the inflammatory process does not resolve, resulting in myocardial damage. It is important to continue doing this type of research in the

aeronautical population since at the moment there is no other study that reveals these afflictions in this type of population.

Learning Objectives

1. To understand the importance of evaluating the ejection fraction in the aeronautical and non-aeronautical patients post COVID-19 using echocardiography.
2. To understand the value of CMRI for seeing alterations in cardiac structure and compare it with echocardiographic results.

[346] DEVELOPING EVIDENCE-BASED AEROMEDICAL POLICY DURING THE COVID-19 PANDEMIC

Diego Garcia¹, Paulo Alves²

¹National University of Colombia, Bogota, Colombia; ²Medaire Inc., Phoenix, Arizona, USA

(Education - Program/Process Review)

BACKGROUND: The COVID-19 pandemic affected the aviation industry. Although reports of SARS-CoV-2 superspreading events onboard commercial flights have been scattered, the risk of transborder translocation of the virus must be mitigated. Aviation authorities and stakeholders faced the challenge of producing effective policy and guidelines in a fast-paced manner. **OVERVIEW:** To mitigate the risk of COVID-19 spreading, and to protect the health and safety of aircrews and passengers, The Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA) hosted by the International Civil Aviation Organization (ICAO), developed the concept of a Public Health Corridor (PHC) as a mechanism to maintain international connectivity. CAPSCA supported ICAO by producing evidence-based guidelines to be adopted by member states. There was a peremptory need to answer aviation-relevant questions extracting medical information coming from multiple channels. CAPSCA formed a sub-committee, the COVID-19 Aviation Scientific Assessment Group (CASAG) with the objective of quickly assessing relevant scientific literature in a systematically validated fashion to produce informed, evidence-based recommendations. CASAG curated all relevant scientific literature related to different topics applicable to air transport and travel medicine such as characteristics of SARS-CoV-2 transmission, vaccines effectiveness, or duration of immunity. Then the group adopted the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) methodology, which provided a systematic and analytical approach endorsed by numerous global health authorities to produce evidence summaries and graded recommendations. The GRADE structured process analyzes different metrics such as size effect, primary/secondary outcomes, methods, discussion, and conclusions in order to establish the quality and strength of certainty of the selected evidence body, which provides support for developing public health policies. **DISCUSSION:** Among the many challenges of the COVID-19 pandemic to the aviation industry is the need for evidence-based policy development in a very complex scenario, the constant update of scientific knowledge, and scarce aviation-specific scientific evidence. The CASAG methodology for achieving evidence-based expert consensus demonstrated to be successful not only during the pandemic but also for future aeromedical policy development.

Learning Objectives

1. To review evidence-based processes for producing public health guidelines.
2. To understand scientific evidence assessment using the GRADE methodology.

Thursday, 05/26/2022
Tuscany 4

10:00 AM

[S-67]: PANEL: ADVANCES IN AEROSPACE OPTOMETRY AND OPHTHALMOLOGY

Chair: Jonathan Ellis
Co-Chair: Michael Parsons

PANEL OVERVIEW: The fields of optometry and ophthalmology have seen vast improvements in diagnostic and therapeutic technologies over the past decade. This has led to an increased ability to diagnose aircrew and aircrew applicants with earlier and milder presentations of disease, offer new treatments to stabilize diseases that previously were disqualifying, and expand the range of refractive errors that can be treated. This panel will discuss these changes in technology and how they have affected the vision standards for flying and special operational duties in the United States Air Force. Lecturers will educate the audience with a refresher on the clinical condition, provide updates in current technology that spawned changes in medical standards and what we can offer our aircrew, and provide relevant data from the respective management group to show the interim findings of our medical surveillance of our aircrew. The data will come from the REACT Study, the Keratoconus Management Group, the Crosslinking Management Group, the Optic Nerve Head Drusen Management Group, the ICL Management Group, and from the USAF Aircrew Refractive Surgery Program. Each of these programs were enhanced by advances in different technologies to include corneal imaging, corneal biomechanical measurement, the development and FDA approval of corneal collagen crosslinking, advances in OCT imaging, and the FDA approval of toric ICLs as well as Small Incision Lenticule Extraction (SMILE).

[347] RE-EVALUATION OF ABNORMAL CORNEAL TOPOGRAPHY UPDATE

Austen Tanner

711 HPW/USAFSAM, Wright Patterson AFB, OH, USA

(Education - Tutorial/Review)

TOPIC: Re-Evaluation of Abnormal Corneal Topography (REACT). Keratoconus is a condition that frequently goes undiagnosed until the quality of vision is affected. Corneal cross-linking is a treatment that preserves visual acuity if performed early in the disease process. REACT seeks to utilize corneal imaging to longitudinally track individuals and derive factors that are predictive of conversion to ectasia allowing for earlier identification and treatment. Early findings from the REACT study along with a discussion of keratoconus, its diagnosis, how to separate it from normals and suspects will be discussed to improve provider's diagnostic abilities and optimize visual outcomes. **APPLICATION:** Identification of ectasia in Aircrew Applicants for Military populations. **RESOURCES:** 1.) Asri D, Touboul D, Fournié P, et al. Corneal Collagen Crosslinking in Progressive Keratoconus: Multicenter. 2.) Gomes JA, Tan D, Rapuano CJ, et al. Global consensus on keratoconus and ectatic diseases. *Cornea*. 2015;34(4):359-369. doi:10.1097/ICO.0000000000000408. 3.) Motlagh MN, Moshirfar M, Murri MS, et al. Pentacam® Corneal Topography for Screening of Refractive Surgery Candidates: A Review of the Literature, Part I. *Med Hypothesis Discov Innov Ophthalmol*. 2019;8(3):177-203.

Learning Objectives

1. The participant will gain an understanding of the current status of the USAF REACT Study.
2. The audience will learn the inclusion and exclusion criteria for the diagnosis of abnormal corneal topography and enrollment into the REACT study.
3. The audience will learn the current rate of progression found at the study's midpoint to keratoconus and the associated initial diagnostic findings on Pentacam and corneal topography imaging.

[348] CORNEAL COLLAGEN CROSSLINKING IN AIRCREW: A THERAPUTIC APPROACH

Michael Parsons

USAFSAM, Wright-Patterson AFB, USA

(Education - Tutorial/Review)

TOPIC: Keratoconics frequently have poor quality of vision. Optical correction mitigates those effects somewhat, but many cases eventually require hard contact lenses to optimize correction. These contact lens fittings, however, are complicated and not always successful. Corneal cross-linking

(CCXL) is a treatment that preserves visual acuity if performed early in the disease process). A more recent treatment procedure was developed and FDA approved which utilizes Riboflavin (Vitamin B2) and ultraviolet light to polymerize stromal collagen and induce corneal stiffening, with the goal to halt progression of KCN. This method is known as collagen cross-linking (CXL) and has widespread use in Europe since 2003 and gained FDA approval in 2016. ACS CCXL management group has shown very promising results with reduction in corneal steepness, improved corrected visual acuity, and halting of progression of KCN. **APPLICATION:** Treatment of Ectasia to halt further disease progression and loss of best corrected visual for Military populations. **RESOURCES:** 1. Asri D, Touboul D, Fournié P, et al. Corneal Collagen Crosslinking in Progressive Keratoconus: Multicenter Results From the French National Reference Center for Keratoconus. *J Cataract Refract Surg*, 2011; 37: 2137-43. 2. Caporossi A, Mazzotta C, Baiocchi S, and Caporossi TI. Long-term Results of Riboflavin Ultraviolet A Corneal Collagen Cross-linking for Keratoconus in Italy: The Siena Eye Cross Study. *Am J Ophthalmol*, 2010; 149(4): 585-93. 3. Hersh PS, Greenstein SA, and Fry KL. Corneal Collagen Crosslinking for Keratoconus and Corneal Ectasia: One-year results. *J Cataract Refract Surg*, 2011; 37(1): 149-60. 4. Agrawal VB. Corneal collagen cross-linking with riboflavin and ultraviolet – a light for keratoconus: results in Indian eyes. *Indian J Ophthalmol*. 2009; 57(2): 111–14. 5. Janov MR, Jovanovic Vm Nikolic L, et al. Corneal Collagen Cross-linking. *Middle East Afr J Ophthalmol*, 2010; 17(1): 21-27. 6. Koller T, Mrochen, and Seiler T. Complication and failure rates after corneal crosslinking. *J Cataract Refract Surg*, 2009; 35: 1358-62. 7. Raikup-Wolf F, Hoyer A, Spoerl E, and Pillunat LE. Collagen cross-linking with riboflavin and ultraviolet-A light in keratoconus: Long-term results. *J Cataract Refract Surg*, 2008; 34(5): 796-801.

Learning Objectives

1. The participant will be able to understand the nature of the problem associated with reduction in visual performance as a result of keratoconus.
2. The participant will be able to describe how keratoconus negative impacts the cornea and the reasoning behind stabilizing the cornea using cross-linking.

[349] OPTIC DISC DRUSEN: ADVANCEMENTS IN DIAGNOSTIC IMAGING

Olivia Reed

USAFSAM, Wright-Patterson AFB, OH, USA

(Education - Tutorial/Review)

The diagnosis of optic disc drusen is of concern in the aeromedical community due to its association with progressive reduction in the visual field. At present, there is no effective treatment for drusen of the optic disc. In this panel, we will discuss methods for the accurate diagnosis of this condition and present data on the clinical outcomes of a population of aviators with drusen of the optic disc.

Learning Objectives

1. The audience will learn how to apply new diagnostic imaging techniques to the diagnosis of optic disc drusen.
2. The audience will learn about the risks associated with optic disc drusen in aviators through case reports.

[350] CORNEAL REFRACTIVE SURGERY FOR AVIATORS UPDATE

Darrell Rousse

711 HPW/USAFSAM, Wright Patterson AFB, OH, USA

(Education - Tutorial/Review)

TOPIC: Approved procedures and parameters for corneal refractive eye surgery have significantly changed over the last twenty years. This update will discuss the current demands for surgery among aviators and applicants to aviation duty including rates of disqualification. The percentage of PRK versus LASIK procedures and visual outcomes are also topics that will be discussed. **APPLICATION:** Corneal Refractive Surgery in Military Aircrew populations. **RESOURCES:** 1. Larys

RP. LASIK at high altitude – a study of the worst-case mission scenario. Presented at the International Military refractive Surgery Symposium, February 5-7, 2007 in San Antonio, Texas. 2. Tutt RC, Baldwin JB, Ivan DJ, et al. Simulated altitude and G-force tolerance after photorefractive keratectomy (PRK). Brooks City Base, TX: USAF School of Aerospace Medicine; 2005 June. Report No: SAM-FE-BR-TR-2005-0002. 3. Aaron M, Wright S, Gooch J, et al. Stability of Laser-Assisted In Situ Keratomileusis (LASIK) at Altitude. *Aviat Space Environ Med*, 2012; 83: 958-61. 4. Ruiz-Moreno JM, Perez-Santonja, JJ, and Alio JL. Retinal Detachment in Myopic Eyes After Laser In Situ Keratomileusis. *Am J Ophthalmol*, 1999; 128(5):588-594. 5. Sandoval HP, Donnenfeld ED, Kohnen T, et al. Modern Laser In Situ Keratomileusis Outcomes. *J Cataract Refract Surg* 2016; 42:1224-1234. 6. Gharaibeh Villanueva A, Mas D, et al. Corneal Stability Following Hyperopic LASIK with Advanced Laser Ablation Profiles Analyzed by a Light Propagation Study. *J Ophthalmol*, vol. 2018, Article ID 3060939, 10 pages, 201

Learning Objectives

1. The audience will be able to identify the difference between PRK and LASIK surgery.
2. The audience will learn all the current refractive surgical procedures authorized for USAF aircrew.
3. The participant will learn the visual outcomes of USAF aircrew after corneal refractive surgery.

[351] THE ICL MANAGEMENT GROUP: AN INTERIM CASE SERIES UPDATE ON VISUAL OUTCOMES

Jonathan Ellis

¹United States Air Force School of Aerospace Medicine, Wright Patterson Air Force Base, OH, USA

(Education - Tutorial/Review)

TOPIC: Implantable Collamer Lenses (ICLs) are a newer implant used to correct refractive error in patients who are not better candidates for laser refractive surgery. Recently, the USAF has started allowing ICL implantation in trained aircrew to date, includes one pilot applicant. Visual outcomes for those members enrolled in the ICL Management Group will be discussed as well as the diagnostic equipment used in preoperative planning, implant selection, and to aid in determination of postoperative aeromedical risk. **APPLICATION:** Patient Selection for ICL Implantation and Postoperative Aeromedical Risk for Military and Civilian Aircrew. **RESOURCES:** 1. Dougherty PH, Priver T. Refractive outcomes and safety of the implantable collamer lens in young low-to-moderate myopes. *Clinical Ophthalmology*. 2017;11 273-277. 2. Sanders DR, Brown DC, Martin RG, Shepherd J, Deitz MR, DeLuca M. Implantable contact lens for moderate to high myopia: phase I FDA clinical study with 6 month follow-up. *J Cataract Refract Surg*. 1998;24:607–611. 3. Alfonso JF, Lisa C, Fernández-Vega L, Almanzar D, Pérez-Vives C, Montés-Micó R. Prevalence of cataract after collagen copolymer phakic intraocular lens implantation for myopia, hyperopia, and astigmatism. *J Cataract Refract Surg*. 2015;41(4):800–805. 4. Lisa C, Alfonso JF, Alfonso-Bartolozzi B, Fernández-Vega L, Pérez-Vives C, Montés-Micó R. Collagen copolymer posterior chamber phakic intraocular lens supported by the ciliary sulcus to treat myopia: one-year follow-up. *J Cataract Refract Surg*. 2015;41(1):98–104. 5. Packer M. Meta-analysis and review: effectiveness, safety, and central port design of the intraocular collamer lens. *Clinical Ophthalmology* 2016;10 1059-1077. 6. Sanders DR, Schneider D, Martin R, et al. Toric implantable collamer lens for moderate to high myopic astigmatism. *Ophthalmology*. 2007; 114(1): 54-61. 7. Lee JS, Kim YH, Park SK, et al. Long-term clinical results of posterior chamber phakic intraocular lens implantation to correct myopia. *Clin Experiment Ophthalmol*. Epub December 12, 2015. 8. Gonvers M, Bornet C, Othenin-Girard P. Implantable collamer lens for moderate to high myopia: relationship of vaulting to cataract formation. *J Cataract Refract Surg*. 2003;(29)5:918-924.

Learning Objectives

1. The audience will learn about preoperative metrics used to determine an ideal ICL implantation candidate.

2. The audience will learn about the outcomes of USAF aircrew who have received ICL implants.
3. The participant will learn the minimal postoperative vault that will minimize cataract formation risk.

Thursday, 05/26/2022
Tuscany 12

10:00 AM

[S-68]: PANEL: LOOKING BACK AND FORWARD FOR BETTER HUMAN PERFORMANCE AND HSI FOR AEROSPACE SYSTEMS DESIGN, TEST, AND SUSTAINED OPS

Sponsored by Life Sciences and Biomedical Engineering Branch of AsMA

Chair: Dwight Holland, MD, PhD

Co-Chair: Lynn Stanwyck

PANEL OVERVIEW: *This session takes a look back at a few issues that have come up in systems design where human beings are deeply involved in the planning, design, testing, and sustained operations of various systems or tools that are used in aerospace systems design.*

[352] OVERCOMING INSTITUTIONAL RESISTANCE TO LIFE-SAVING TECHNOLOGIES

Angus Rupert¹, John Brill², Braden Mcgrath³

¹Embry-Riddle Aeronautical University, Daytona Beach, FL, USA; ²Air Force Research Laboratory, Dayton, OH, USA; ³University of Canberra, Canberra, Australia

(Education - Program/Process Review)

In the history of aviation there have been many examples of institutional resistance to human factors technology solutions to prevent the loss of pilots and platforms, including such simple technologies as seat belts, oxygen systems, parachutes and spatial orientation instruments. The largest contributor to both military and civilian aviation accidents and loss of lives has been spatial disorientation (SD). From the 1970s through 2010 the USAF alone has lost at least five aircraft and pilots per year due to SD accidents classified as controlled flight into terrain (CFIT) mishaps. With the introduction of the fly-by-wire F-16 fighter aircraft there was a significant increase in SD mishaps. It was quickly realized that fly-by-wire technology would permit the development of an automated ground collision avoidance system (Auto GCAS) using software designed to take over control of the aircraft, roll the wings level and execute a 5 G pull-up to save both aircraft and pilot from impact with the ground. Although the Auto-GCAS program was initiated in 1984 the system did not become operational until 2014. No aircraft with Auto-GCAS installed (initially half of the F-16 fleet) has experience a CFIT mishap while the aircraft without Auto-GCAS installed have continued to lose pilots and aircraft at the normal rate. What delayed the installation of this life-saving technology for 30 years? The USAF senior leadership strongly resisted the development and implantation of Auto-GCAS for a variety of reasons similar to the excuses used in the past to prevent the use of parachutes, ejection seats, and oxygen systems. The ultimate acceptance of Auto-GCAS is a success story that is largely the result of USAF aerospace medical professionals. It will be discussed in detail the reasons for this delay as well as the failure of DoD leadership to accept other simple technologies that would prevent SD mishaps. If military acquisition systems adopted human factors design solutions proactively during the design phase most civilian and military SD mishaps would be avoided. To prevent future failures, we will propose acquisition related solutions that promote adoption of human systems integration design features into next generation platforms.

Learning Objectives

1. The participant will understand the value of the Auto Ground Collision Avoidance System (Auto GCAS) in the prevention of controlled flight into terrain (CFIT).
2. The participant will learn why the current acquisition systems fail to promote and accept safety related technologies onto platforms.

[353] DETECTING AND PREDICTING DEGRADED AIRCREW PERFORMANCE IN THE ROTARY-WING AIRCRAFT COCKPIT: ACHIEVABLE OR NOT?

John Crowley

US Army Aeromedical Research Laboratory, Fort Rucker, AL, USA

(Education - Program/Process Review)

BACKGROUND: Since the beginnings of aviation medicine, flight surgeons have worked tirelessly to ensure that aircrew are optimized and ready to perform their flying duties. Traditional roles for the flight surgeon include assessing initial and continuing medical fitness for aviation, ongoing training of aircrew, advising leaders regarding aircrew health and safety issues, etc. – all of which are aimed at preventing performance degradation during aviation missions. However, even the most fit and prepared aviator can be affected by inflight stressors, whether predictable or not, with resulting adverse effects on aircrew performance. If it were possible to detect, or optimally, predict these degraded states having adverse performance effects, and take some corrective action(s), there would be profound effects on aviation safety and successful mission completion. This presentation will discuss a range of strategies that could accomplish this goal in the rotary-wing flight environment, lessons-learned from previous attempts, and recommendations for the future. **OVERVIEW:** There are numerous aircrew 'states' that can develop during the aviation mission with consequent negative effects on aspects of task performance. Examples include hypoxia, sustained acceleration, varieties of fatigue, task saturation, fear, pain, injury, etc. The challenges to the operational aeromedical and human factors research community are to a) determine the risk of specific stressors in the relevant aviation environment (e.g., rotary-wing vs fixed-wing fighter aircraft), b) assess potential ways to detect and predict the important stressor effects, c) validate detection and mitigation strategies, and d) advise aviation leadership on the pros and cons of these potentially expensive capabilities. Examples of relevant data include preflight aircrew state, aircraft parameters, and psychological/physiological indices. **DISCUSSION:** Detection of performance-degrading states that may develop during flight will require real-time monitoring and assessment. Despite many challenges to the development of this capability, the benefits of a system that detects and prevents potential sources of aircrew performance degradation prior to any effects on aviation safety or mission success would be enormous.

Learning Objectives

1. Understand the potential benefits of the prediction and detection of inflight aircrew performance degradation.
2. Learn the principal challenges to the successful development of an operator state monitoring capability for future rotary-wing aircraft.

[354] EMERGENCE OF COMMERCIAL AND FUTURE MILITARY SPACE OPS REQUIRING CONSIDERATION OF ANTHROPOMETRY WITH SOYUZ REFIT AS A HARBINGER

Mark Pestana¹, Scott Parazynski²

¹US Air Force Test Pilot School, Edwards AFB, CA, USA; ²Fluidity Technologies, Inc, Houston, TX, USA

(Education - Program/Process Review)

BACKGROUND: The emerging commercial space industry is attracting much attention, from space tourists to new experimenters flying with Axiom and others. One can assume a broader range of body types will fly than traditionally selected for astronauts in the early space age. Drawing parallels with the commercial airline industry, challenged

with a “growing” population faced with narrow and closely spaced seats and safety requirements for an emergency evacuation within 90 seconds, the commercial space industry can likewise be challenged, as both volume and mass can also be limitations to launch and orbital performance. The design of commercial spacecraft might well include standardization of requirements for human anthropometry/ergonomics akin to commercial airlines. **OVERVIEW:** The history of human space-flight includes a Mercury spacecraft height limit of 5’11”. Design considerations also include sitting height and arm/hand reach. The International Space Station (ISS) involves the inclusion of partner nations as both contributors and participants in the launch, assembly, and operations of ISS. ISS requirements specify a range of human dimensions from the 5th percentile Japanese female to the 95th percentile American male. Along with the inclusion of Russia as an ISS partner, their Soyuz crew transport spacecraft was also designated as the ISS “lifeboat” for emergency evacuation. This decision excluded a significant percentage of astronauts from serving on ISS due to anthropometric/ergonomic limitations of Soyuz. A re-design effort ensued, resulting in modifications that could accommodate more, but not all, astronauts serving on ISS. **DISCUSSION:** Experience in designing and specifying accommodations for broader anthropometrics in commercial airliners is a precursor to similar challenges in the commercial space sector. The benefits of designing for a broader pool of humans will serve a larger number of opportunities for public participation, whether planning for tourists, commercial crew, or military astronauts for the anticipated exploitation of space by commercial space industry, or for expansion of human military space operations. Rather than performing expensive re-engineering and modifications of existing systems, as in the case of the Soyuz “lifeboat” for ISS, the accommodations for humans must include anthropometric/ergonomic considerations for a broader range than has been previously specified.

Learning Objectives

1. The audience will learn about anticipated requirements for a broader range of human anthropometric/ergonomic specifications in commercial, government, and military space operations.
2. The audience will learn about a real-world example where a spacecraft was modified to accommodate a broader range of human anthropometric/ergonomic specifications.

[355] NOVEL EXTRAMUSCULAR AUGMENTED SPACESUIT GLOVE DESIGN FOR MITIGATION OF INJURY AND FATIGUE

Danielle Carroll¹, Spencer Dansereau¹, Allison Anderson¹, Jacob Segil¹, Stephen Robinson²

¹University of Colorado Boulder, Boulder, CO, USA; ²University of California Davis, Davis, CA, USA

(Education - Program/Process Review)

BACKGROUND: Extending the limits of interplanetary travel is a challenging undertaking for upcoming exploration-class space missions. Creating a sustainable lunar or Martian surface habitat introduces unique engineering challenges in supporting astronaut health over longer durations. Extravehicular surface operations will play a vital role for missions of such scale, and crewmembers’ ability to perform tasks efficiently and effectively during extravehicular activity (EVA) will be impacted by any compromise in manual dexterity. Thus, it is imperative that spacesuits and associated hardware be optimized to accommodate a broad spectrum of tasks that might be involved for planetary surface operations. Historically, EVA has been fraught with human factors-based challenges related to spacesuit design, to the extent that many NASA astronauts continue to experience early hand fatigue, musculoskeletal injuries, and nail delamination from use of existing pressurized gloves. Fatigue and injury have the potential to compromise EVA performance on the lunar surface for extended mission profiles. **OVERVIEW:** We developed a novel design solution to address current EVA glove shortcomings, incorporating a soft hand exoskeleton with firm fingertip caps and flexible silicone phalangeal

frames that are actuated via guided carbon-fiber tendons to augment palmar and phalangeal flexion and reduce the risk of injury. The device proposed, the Extramuscular Augmented Spacesuit Glove (EMAG), is driven by electromechanical actuators and incorporates principles of biomimicry, closely following the human hand flexor pulley system. **DISCUSSION:** Our preliminary studies, the results of which were very favorable, were limited to a small sample size. The next phase of testing will increase sample size as well as improve the technology prototype. The design will use myoelectric sensors to measure electromyographic activity in several key muscles of the hand and forearm. This experimental approach quantifies the mechanical assist provided by the soft hand exoskeleton and offers a mechanism to validate the effectiveness of our technology in mitigating hand fatigue and reducing the risk of musculoskeletal injury and nail delamination, in support of scientific exploration of lunar and Martian surfaces.

Learning Objectives

1. Understand the ways in which current spacesuit glove design elements contribute to injury and fatigue among astronauts on EVA.
2. Explore how a biomimicry-inspired design can serve to reduce muscle fatigue through features such as grip augmentation and lock-out.

[356] WHAT IS OLD IS NEW– LESSONS FROM THE X-15 PROGRAM, SPACESHIP TWO MISHAP, AND MIR-PROGRESS 234 MISHAP FOR HSI, CONTROL/DISPLAYS, WORKLOAD IN SPACE OPS

Dwight Holland

Human Systems Integration, Roanoke, VA, USA

(Education - Program/Process Review)

BACKGROUND: The world of new Aerospace Systems is exploding from supersonic BOOM test vehicles to evolving Commercial Space Operations and future Lunar and Mars missions. If history is any indication, often aerospace systems designer and systems engineering managers do not fully appreciate the need to incorporate human system integration (HSI), workload, etc into systems evolution, and especially during the development and testing phases of system design. **OVERVIEW:** Some of the key areas of HSI in early phases of systems design include effective, adaptable controls and displays, adequate, pertinent, and accurate workload levels assessments during the various phases of flight or systems operations, and consideration of the human factor as an element that can overcome great adversity, and make unusual errors under some circumstances. Fatigue, complacency, and group dynamics/culture need to be thoughtfully considered as well. Automation levels and various modes of operation can present problems in high workload situations where error likelihoods are actually increased due to poor HSI design considerations. **DISCUSSION:** HSI in Flight test is too often neglected as was the case in the X-15 Mike Adams mishap, and the SpaceShip Two mishap and will be compared and contrasted for lessons learned. The famous “Six Million Dollar Man” crash of the M2-F2 lifting body at Edwards AFB is a great example of difficult flying handling qualities along the longitudinal axis, leading to high workloads, where the additional distraction of a helicopter near the flight path lead to a famous, well-known crash. Modern blended wing-body designs such as Sierra Nevada’s ‘Dream Chaser’ help to create more stable ‘lifting body’ gliding flying handling qualities, reducing pilot workload in manual landing modes. This author will report on his experience flying these simulated Dream Chaser control laws versus others with higher workload due to challenging flying handling qualities. The MIR-Progress 234 Mishap which nearly forced abandoning the MIR Space Station in the late 1990’s was caused by ground control over-ruling a concerned cosmonaut after a very close call of the MIR-Progress 233 Remotely Pilot Progress Vehicle. another attempt should NOT be made. The very fatigued cosmonaut tried execute the ordered Progress 234 fly around and docking, and between poor controls and displays, but failed. Key educational HSI lessons for 21 century ops will be highlighted from these cases.

Learning Objectives

1. What lessons can we learn for future aerospace systems design in the Human Systems Integration realm from past key mistakes. Why are these repeated over decades?
2. What do the X-15, Lifting Body, and Space Ship Two have in common. How are they different, and why is the Mir-Progress 234 mishap the first major Remotely Piloted Vehicle mishap in space that nearly forced the MIR space station to be abandoned?

Thursday, 05/26/2022
Tuscany 5/6

10:00 AM

[S-83]: POSTER: SPACE MEDICINE: OVER THE HORIZON BUT UNDER THE RADAR

(This is out of numerical session order. Apologies for any inconvenience this may cause.)

Chair: Jeff Myers

Co-Chair: Samantha King

[427] LOWER BODY NEGATIVE PRESSURE MAY NOT BE A SUITABLE COUNTERMEASURE FOR SANS

Mimi Lan¹, Rongfei Lu², Scott Phillips³, Veronique Archambault-Leger³, Abigail Fellows¹, Ryan Halter¹, Jay Buckley¹

¹Dartmouth College, Hanover, NH, USA; ²Stanford University, Palo Alto, CA, USA; ³Creare LLC, Hanover, NH, USA

(Original Research)

Spaceflight associated neuro-ocular syndrome (SANS) is a collection of ophthalmic symptoms observed in many astronauts after long duration spaceflight. Mader et al. first reported the collection of SANS symptoms in 2011, which included optic disk edema, globe flattening, choroidal folds, and hyperopic shifts—some of which present asymmetrically in astronauts. The etiology of SANS is unknown. A leading SANS countermeasure candidate is reducing the cephalad fluid shift with lower body negative pressure (LBNP). To investigate fluid redistributions in microgravity and simulate LBNP, our group built a craniovascular numerical model, called the Numerical Model for Spaceflight (NuMoS). A key feature of NuMoS is the inclusion of tissue compressive forces—pressures exerted on the body vasculature from the weight of the tissue above the vessel. These are modeled as external vascular pressures proportional to the thickness of body tissue above the vessel. Gravity, lower body chamber pressure, and body position can be adjusted in the model to investigate changes to fluid distribution. One hypothesis is that globe flattening is caused by elevated ICP exerting pressure on the posterior of the eye and flattening it. Measurements in short duration weightlessness do not show ICP levels elevated above supine levels, but changes in the transmural pressure—the pressure difference between ICP and intraocular pressure (IOP)—across the posterior eye could still be the mechanism by which globe flattening occurs in microgravity. Simulating posterior eye transmural pressure with LBNP, we found ICP was reduced less than IOP. Similarly, recent spaceflight measurements of IOP have shown reductions in IOP with the use of LBNP. Terrestrial measurements of ICP changes in response to LBNP while supine and while in 15° head-down tilt show that LBNP reduces pressure more when ICP is pathologically elevated and less when ICP is in a normal physiological range. Therefore, if ICP is not pathologically elevated in spaceflight, or perhaps if ICP in microgravity is less than a supine or seated baseline, LBNP will have limited ability to reduce ICP. The resulting transmural pressure from applying LBNP encourages further globe flattening and therefore, may not be a good countermeasure for SANS.

Learning Objectives

1. Highlight how lower body negative pressure (LBNP) affects intraocular pressure and intracranial pressure differently.
2. Describe that the difference between intraocular pressure and intracranial pressure creates a net force on the posterior eye that can cause lengthening or shortening of the globe.

[428] STRUCTURAL CHANGES IN BRAIN MRI DUE TO HEAD DOWN TILT BED REST – A HUMAN SPACEFLIGHT ANALOGUE (SYSTEMATIC REVIEW AND FUTURE RESEARCH GUIDELINES)

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(Original Research)

INTRODUCTION: Magnetic Resonance Imaging (MRI) studies performed in astronauts have shown changes in brain anatomy after prolonged exposure to microgravity. Several studies are taking place to better understand their clinical implication. Head Down Tilt Bed Rest at a 6-degree angle (HDT) is a high-fidelity research model when trying to replicate the upward shift of the forebrain and isolate the actions of microgravity on the human brain's structure. We aim to systematically summarize the available data on the changes in brain structure observed in MRI induced by exposure to HDT. Likewise, we also aim with this review to create a foundation for future studies involving Brain MRI and HDT to be built upon, in order to better understand and explain the changes the human brain goes through when exposed to microgravity. **METHODS:** We performed a comprehensive literature search on EMBASE, MEDLINE, Web of Science, CENTRAL, and Google Scholar following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guidelines. We included experimental studies on healthy human individuals exposed to HDT longer than 24 hours and assessed using structural Brain MRIs at the beginning of the intervention and during HDT exposure. We extracted the data describing mean volumetric changes of grey and white matter, as well as detailed structural analysis of the whole brain. **RESULTS:** One hundred and twenty-four papers were identified. Three papers were eligible for systematic review. Gray matter volume increases in the posterior parietal regions, decreases in frontotemporal regions, and ventricular volume increases were found, lacking strong statistical significance and needing further research. No significant white matter changes were found. **DISCUSSION:** Volume changes identified seem comparable to those observed after prolonged exposure to microgravity. Further research with adequate protocols and higher sample size are needed to better evaluate these changes and their clinical implications.

Learning Objectives

1. The current research on microgravity analogue research HDT used to understand the changes induced by microgravity on the human brain.
2. How to conduct research on the human brain using HDT and the best practices needed in order to achieve quality and reproducible research.

[429] MEDICAL STUDENT INTEREST IN AEROSPACE MEDICINE

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(Original Research)

INTRODUCTION: Aerospace Medicine is a growing field that provides physicians with the expertise to promote the health and safety of those traveling in space. Commercial spaceflight is now a reality, meaning that individuals with a variety of medical conditions will be flying in space. NASA has Mars plans and SpaceX plans to send humans to Mars within the next decade, so today's medical students may be future physicians on these crews. Considering these developments, we evaluated interest in Aerospace Medicine among medical students in the United States (US). **METHODS:** This study was reviewed by the Dartmouth College Committee for the Protection of Human Subjects. A 19-question anonymous multiple-choice questionnaire was emailed to current medical students throughout the US. Information about demographics, career and research interests in Aerospace Medicine, opportunities available at students' respective institutions, and possible avenues for supporting students' interests was collected and analyzed. **RESULTS:** 1,121 students (446 males, 672 females) with a mean age of 25.8 +/- 3.5 years from 61 institutions completed the questionnaire. 85.0% expressed an interest in learning more

about Aerospace Medicine if given the opportunity with 17.4% specifying an interest in research and 77.7% in career opportunities. 4.4% indicated that they had access to research opportunities at their institutions while 73.0% of those who did not, suggested they would pursue research if they had access. Only 8.3% of respondents reported that their institution offered an Aerospace Medicine Interest Group or elective. Students from institutions who offered an interest group, elective, or access to research opportunities expressed significantly more interest in Aerospace Medicine than those who did not ($p < 0.0001$). 82.8% of respondents rated the importance of physician involvement in space exploration as moderately to extremely important. **DISCUSSION:** Most respondents expressed an interest in learning about Aerospace Medicine during their training. A strong interest in research as well as career opportunities exists despite the majority of students reporting minimal access to opportunities to get involved in the field at most of the surveyed institutions. With growing interest and an expected increase in demand for physicians with a background in Aerospace Medicine, medical schools may be able to support students by increasing access to opportunities.

Learning Objectives

1. The participant will understand the current level of interest in Aerospace Medicine among current medical students in the United States.
2. The audience will learn about the prevalence of opportunities available for medical students to engage in Aerospace Medicine at institutions in the United States.
3. The participant will understand about how medical schools can help support medical students interested in Aerospace Medicine.

[430] AUGMENTED AND MIXED REALITY TO SUPPORT CLINICAL DECISION MAKING

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(Original Research)

INTRODUCTION: Communication delays for exploration class missions pose a significant challenge to the delivery of medical care. Current management paradigms rely on medical experts on Earth guiding crewmembers through diagnosis and treatment protocols. Future crew medical officers will require autonomous tools to provide them with the knowledge, skills, and judgment needed to manage various medical conditions. The goal of our study was to examine the available medical literature and assess the current, published capabilities of augmented reality (AR) and mixed reality (MR) modalities specifically related to clinical decision-making support during long-duration spaceflight. **METHODS:** A comprehensive literature search was conducted using MEDLINE (Ovid), Web of Science, and Scopus to identify relevant articles published between January 2010 and August 2021. This search yielded a total of 934 articles for title and abstract review. Abstracts were screened for inclusion and exclusion criteria by two independent reviewers. At this stage, a third independent reviewer provided further verification of the remaining manuscripts. Subsequently, included full text manuscripts were reviewed and analyzed. **RESULTS:** Of the reviewed manuscripts, many focused on the transfer of medical knowledge through enhanced access to information overlaid digitally onto the real world or specific skill guidance. Skill guidance was the predominant use of AR or MR, as would be expected, in the surgical subspecialties evaluating these technologies. It appears that a few studies measured enhanced clinical judgment as an outcome. **DISCUSSION:** Extended realities are a promising solution for medical support infrastructure in exploration class space missions. AR and MR technologies have been successfully developed and are currently being utilized to enhance medical training, provide guidance during medical procedures, and support surgeons intraoperatively. Despite these significant advances, very little research has been done examining the potential application of these technologies as autonomous clinical

decision-making tools terrestrially or in the setting of exploration class spaceflight. The lack of data in this area presents an important field of research with clear benefits to both spaceflight and remote or resource-limited terrestrial environments.

Learning Objectives

1. The audience will learn about the current capabilities and applications of augmented and mixed reality technologies in medicine.
2. The audience will learn about the potential use of augmented and mixed reality technologies as autonomous clinical decision-making tools.
3. The audience will learn about the challenges of clinical decision-making during exploration class missions.

[431] THE EFFECTS OF HIPPOCAMPAL RADIATION AND METHODS TO MITIGATE DAMAGE

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(Education - Tutorial/Review)

INTRODUCTION: With long-duration space missions beyond low Earth orbit on the horizon, it is essential to understand the effects of radiation on the human body, especially the brain. The hippocampus is an important regulator of cognitive function, mood, and memory; although it is one of the most easily damaged structures in the brain, it also has the unique ability to undergo repair and regeneration due to neurogenesis that occurs throughout life. **TOPIC:** This work evaluates the literature concerning the effects of radiation on the hippocampus. We review both simulated space radiation studies in animal hippocampal tissue and brain radiation studies employed as cancer treatment in humans. Furthermore, we discuss both short- and long-term effects of hippocampal radiation, including implications astronauts may face both in flight and upon return to Earth. Lastly, we summarize the methods to mitigate risk and reduce damage associated with radiation to the hippocampus. **APPLICATION:** Hippocampal radiation results in a multitude of effects, including impaired learning, memory, spatial memory, and anxiety/depression. These effects have the potential to cause permanent damage to the astronaut. Knowing the risks that space radiation poses to brain tissue, especially the hippocampus, it is essential to develop and understand ways to reduce or ameliorate those risks to ensure the health and safety of astronauts.

Learning Objectives

1. The participant will understand the mechanisms and consequences of radiation to the hippocampus.
2. The participant will be able to recognize and promote therapeutic strategies that are radioprotective and/or mitigate damage caused by radiation to the hippocampus.

[432] DEVELOPMENT OF AN ONLINE SPACE MEDICINE COURSE FOR MEDICAL STUDENTS TO INCREASE THEIR ACCESSIBILITY TO THIS FIELD

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(Education - Program/Process Review)

BACKGROUND: To date, only a handful of medical schools and institutions offer formal Space Medicine courses despite the rapid growth of the field. Due to this limited accessibility, many students remain unaware of the field, and interested students face difficulty gaining academic exposure - a critical issue for AsMA attendees to address now. Thus, we endeavored to create a readily adaptable two-week online aerospace medicine course to address this gap in medical education. **OVERVIEW:** The two-week online course consists of ten modules (full list below) covering topics adapted from: 1) Fundamentals of Space Medicine

by Clement 2) Space Physiology by Buckley and 3) Space Physiology and Medicine by Nicogossian. Each module contains readings, PowerPoint presentations with integrated clinical cases, quizzes, and supplementary assignments (consisting of journal articles, videos, podcasts, etc). The course also includes a pre-and post-course assessment and a list of further readings, opportunities, and resources. Module 1: Introduction and Historical Perspectives; Module 2: Operational and Life Support Systems in Space; Module 3: Preflight and Postflight Recovery; Module 4: Radiation in Space; Module 5: Neuro-Vestibular System in Space; Module 6: Vision in Space; Module 7: Cardiopulmonary System in Space; Module 8: Musculoskeletal System in Space; Module 9: Psychological Considerations in Space; Module 10: Nutrition in Space; This course structure successfully provides students an introductory exposure to space medicine and career possibilities within it. The course has been formalized at the University of Michigan Medical School, and it is also set to launch at the University of Cincinnati in Jan 2022. The qualitative and quantitative data categories that have been gathered include 1) Knowledge Gained (100% of students) 2) Course Satisfaction (100% of students) 3) Course Influence on Future Goals (>50% of students) and 4) Quality Improvement/Program Evaluation. **DISCUSSION:** This introductory, online aerospace medicine course will fill a gap in medical education and make the field more accessible to interested students - thus recruiting young talent to advance the field of space medicine. Next steps include 1) incorporating students' and subject-matter experts' feedback into the class and 2) piloting the course at other medical schools. Future directions include making the elective widely available online to support students across international and civilian/military spheres.

Learning Objectives

1. The audience will learn about a new, formalized, and vetted online Space Medicine course that is being offered at and expanding across select medical schools nation-wide.
2. The audience will have the chance to learn about how to launch this online Space Medicine course at their own institutions.
3. The audience will learn about this online Space Medicine course as a strategy to increase medical students' accessibility to, knowledge of, and interest in space medicine.

[433] MEDICAL MANAGEMENT OF ATRIAL FIBRILLATION ON EXPLORATION MISSIONS

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(Education - Program/Process Review)

BACKGROUND: Atrial fibrillation is the most common sustained arrhythmia in the US. Affected individuals have a wide variety of presentations from being asymptomatic to fatigue, palpitations, dyspnea, syncope and hypotension. Atrial fibrillation has not been observed in US spaceflight history, but with the longer mission timelines that will be seen in missions to the moon or Mars, the risk of seeing an occurrence increases. Treatment regimens need to be considered carefully given the increasing distances from Earth and limitations in mass and volume of the medical resources. Rate control is the first-line treatment for atrial fibrillation. Rhythm control alone has not been shown to be superior to rate control and is associated with a greater number of hospitalizations. However, rhythm control can be adjunctive therapy in patients that have difficulty in achieving adequate rate control, tachycardia-mediated cardiomyopathy, younger patient age, and first episode of atrial fibrillation, with the latter two being important considerations for the astronaut population. **RESULTS:** 17 of 339 astronauts have been diagnosed with atrial fibrillation. Five of these cases were treated while active in the astronaut core and went on to fly. No incidences of atrial fibrillation have been recorded during flight. Risk factors in spaceflight include redistribution of body fluids leading to increased cardiac size and stroke volume. In thirteen astronauts, cardiac MRI revealed left atrial enlargement for up to three weeks after flight. Other contributing factors are intensive daily exercise regimen to help mitigate bone and muscle loss, radiation, and psychological stress. To assist with the selection

of treatment regimen for exploration missions, a literature review was performed specific to oral medication management of acute atrial fibrillation. **DISCUSSION:** Without the ability to provide electrical cardioversion or IV medications during a mission, oral metoprolol tartrate followed by oral propafenone should be used for rate/rhythm control in order to restore normal cardiac rhythm in the astronaut population. This regimen is recommended because it has the highest chance of quickly restoring regular rhythm with the lowest risk of harm. Oral amiodarone is not recommended for first-line in astronauts during spaceflight, as it would take days to reach a therapeutic concentration in heart tissue.

Learning Objectives

1. Understand the factors that put astronauts at higher risk for atrial fibrillation.
2. Given the limitations in exploration class medical kits, what is the best medication to manage atrial fibrillation should it arise during flight.

[434] MACHINE LEARNING FOR THE AUTOMATION OF OPTIC NERVE SHEATH DIAMETER MEASUREMENT

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(Original Research)

INTRODUCTION: Optic nerve sheath diameter (ONSD) is a part of Spaceflight Associated Neuroocular Syndrome (SANS) surveillance testing and performed routinely preflight, postflight, and on the International Space Station. Ultrasound ONSD limitations include need for experts and high variability in imaging. In this study, we aim to overcome these limitations by developing a machine learning algorithm for automated ONSD measurement. We utilize convolutional neural networks (CNNs) which can handle variable anatomies and spatial transformations better than non-machine learning methods used previously to automate ONSD. **METHODS:** 34 ultrasound imaging sessions from 28 patients were used. All patients were in the Neurocritical care unit with various brain injuries. A Philips Sparq™ ultrasound system with a L12-4 probe (4–12 MHz) on the ocular preset was used. ONSD was marked on a custom Matlab GUI to: (1) generate masks from marked points; (2) randomly split labeled images into training and cross validation (CV) datasets; (3) training data set was used to generate masks from marked points; (4) "training set" was used to train a convolutional neural network (MONAI-UNet) using PyTorch (pytorch.org); (5) 4 CNN models were produced image masks from which to measure ONSD on the CV set. Those masks were averaged into one label mask; (6) these masks were processed in Matlab using the *radon* function, to yield an ONSD estimate in mm. **RESULTS:** We averages 4 CNN models to increase robustness. Each model was constructed using 500 iterations (or "epochs") with unique training and CV sets. The mean Dice score of the 4 models was 0.65 (0.65-0.8). 40 images were then used for testing combined models. The mean ONSD measured by expert is 5.34mm (SD=0.27) compared to CNN estimate 5.78mm (SD=0.33). Mean Difference (95% CI, P value) was 0.44mm (0.31-0.57, P < 0.0001). **DISCUSSION:** While a difference of 0.44 mm between the human and CNN measurement was statistically significant, it is within reported lateral resolution limit of ONSD measurement using linear transducers (0.41-0.63 mm). The small tendency of the method to underestimate the ONSD might be remedied by enriching the training data with more image. Additionally, improvements in lateral resolution of linear ultrasound probes in the future and standardized ONSD imaging criteria may represent a further opportunity to improve ONSD automation.

Learning Objectives

1. Understand the basic challenges of using challenges of using ultrasound to measure optic nerve sheath diameter
2. Understand the advantages of machine learning to automate optic nerve sheath diameter when compared to non-machine learning automated image analysis techniques
3. learn about novel machine learning techniques for the automation of ultrasound optic nerve sheath diameter measurement

[435] MEASUREMENT OF OTOLITH ASYMMETRY THROUGH OCULAR MISALIGNMENT IN COMMERCIAL ASTRONAUTS

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(Original Research)

INTRODUCTION: Neural signals from the otoliths trigger compensatory vertical and torsional changes in eye position, maintaining stable vision and binocular alignment. Multiple lines of evidence suggest there is normally an asymmetry between the otoliths, due to small differences in synaptic strength or anatomy. This can lead to vertical or torsional misalignment of the eyes. Central neural processes compensate for this asymmetry, but this compensation becomes inappropriate in gravity levels other than 1.0. Thus, ocular misalignment can be used to measure otolith asymmetry and central compensation. Furthermore, this asymmetry has been linked to space motion sickness (SMS). The purpose of this study, therefore, is to determine whether ocular misalignment can predict SMS susceptibility. **METHODS:** Subjects were the crew of Inspiration4 (n=4, 2 females) who underwent two pre- and two post-flight testing sessions. Otolith asymmetry was quantified through ocular misalignment. Subjects viewed two line-segments, one with each eye, which were misaligned vertically or torsionally, and adjusted the lines until they appeared aligned. Any remaining misalignment reflects ocular misalignment. This protocol was approved by the Johns Hopkins IRB. **RESULTS:** A larger degree of pre-flight vertical ocular misalignment may be correlated with development of SMS. Range in performance may also have significance, as the two crew members who developed SMS showed either the widest or narrowest range in performance on vertical alignment, both pre- and post-flight. Additionally, a clear and consistent change in vertical alignment pre- vs. post-flight is associated with lack of SMS, suggesting that better central compensation for asymmetry is associated with reduced SMS susceptibility. If central compensation for 0 g were to occur during flight, we would expect it to be manifested as a systematic change in alignment post-flight compared to pre-flight, assuming the in-flight compensation state is retained in post-flight testing. **DISCUSSION:** Our retrospective analysis suggests ocular alignment may be correlated with SMS, in accordance with previous work linking SMS susceptibility to ocular disconjugacy. These results will be combined with those from future commercial spaceflights, expected to occur by May 2022. We plan to expand our testing to include VAN/TAN with static head tilt, as a simple means to place the otoliths into a gravitational orientation other than the normal upright.

Learning Objectives

1. The audience will learn about the use of ocular misalignment as a measure for otolith asymmetry.
2. The audience will learn about the value of quantifying otolith asymmetry as a potential predictive measure for susceptibility to space motion sickness.

[436] ENHANCING EXPLORATION PLATFORMS AND ANALOG DEFINITION PROGRAM

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(Education - Program/Process Review)

BACKGROUND: The Inspiration4 all civilian, orbital spaceflight mission had biomedical data collected from commercial astronauts (CA) during pre/in/post phases of the mission. With anticipation of the emerging commercial spaceflight industry becoming a desired enterprise and experience for humanity, TRISH has established the Enhancing eXploration Platforms and Analog Definition (EXPAND) Program. **OVERVIEW:** EXPAND will collect biomedical data and bio-samples from CA; store the original and processed biomedical,

environmental, and mission data in a database; and distribute the data to requestors with legitimate scientific inquiries. **DISCUSSION:** EXPAND is a thorough program with the following capabilities and processes. (1) A funding opportunity for researchers to perform biomedical research on CA that address risks to human health, safety, and performance on commercial spaceflight missions. Researchers should develop protocols that are minimal to no burden on the CA while minimizing mass, volume, power, and maximizing ease-of-use. (2) The EXPAND biobank will preserve and store bio-samples provided by CA. Current standard analysis of the bio-samples will be conducted and stored in the EXPAND database to avoid repeatedly performed testing on the limited bio-samples available. (3) The EXPAND database is designed to ingest biomedical, environmental, and mission data types and formats described above. The data access and governance model allows researchers to access and visualize their authorized data quickly and easily. (4) EXPAND has one unified, generic IRB protocol for medical data; research data; environmental and mission data; and bio-samples collection. A single broad consent form allows future use of data and bio-samples in compliance with international privacy laws (HIPAA, GDPR, etc.). (5) A data privacy and release board will review and release data and bio-sample requests to researchers and organizations who provide legitimate scientific inquiries that advance spaceflight public safety and human health/performance. (6) EXPAND will establish a set of commercial spaceflight biomedical data (CSBD) measures as a core dataset that will be proposed to all CA for data collection during their spaceflight mission. The CSBD will standardize the data/bio-samples collected and the hardware, training, and procedures for data collection.

This work is supported by the Translational Research Institute for Space Health through NASA Cooperative Agreement NNX16AO69A.

Learning Objectives

1. Understand the capabilities and processes of the EXPAND Program to support biomedical and bio-sample collection during commercial spaceflight missions.
2. Understand the opportunities for researchers, stakeholders, and government agencies to access data and bio-samples with the EXPAND Program.

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

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(Original Research)

INTRODUCTION: As humanity plans for long-duration crewed missions to Mars and beyond, astronauts will need more autonomy and training to deal with medical emergencies. Significant communication delays and long evacuation distances mean a surgical workstation will be a necessity on a spacecraft and could save lives. **METHODS:** The aim of this study was to assess the feasibility and design of such a micro-gravity surgical workstation. This research was conducted using two main approaches: the first was a thorough literature review to summarise current knowledge and inform the enclosure design; this was followed by an iterative process to perfect a workstation design proposal. Notably, a similar surgical enclosure has never been investigated and very few containment solutions have been tested in parabolic flight. **RESULTS:** This study proposes the design of a Crew Operating Microgravity Theatre Enclosure (COMTE), which has been shaped by conclusions from parabolic animal surgery experiments and by questionnaire feedback from space medicine experts and astronauts. A full technical characterisation of the proposed design is included in this report, and a prototype was constructed. The defining principle of the COMTE 'glovebox' was to use the capillary edge-effect of fluids in microgravity to contain surgical fluids and blood during an operation. This aims to improve operator visualisation of the surgical field, whilst maintaining a sterile surgical site and preventing contamination of the

closed-loop spacecraft atmosphere. Additionally, the proposed design includes extensive research on weight, volume and power requirements, and has been reviewed by external experts. This research not only safeguards astronauts but could present a unique solution to terrestrial surgery in remote and extreme environments. **DISCUSSION:** In conclusion, this presentation proposes a novel solution to the problem of safe and efficient surgery in space, and further work on the design will lead to testing on the ground and in parabolic flights.

Learning Objectives

1. Understand the process of designing for surgical capabilities in space.
2. Understand the surgical capabilities required for long duration missions to Mars and onwards.
3. Be presented with a solution to the current lack of microgravity surgical workstation.

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

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(Education - Program/Process Review)

BACKGROUND: Aerospace and exploration medicine are fascinating topics. However, the complexity of the fields, interdisciplinary nature, and the relatively small number of experts leave few options for either formal or informal education. Additionally, modern students seek flexible, on demand educational products where involvement can be titrated to their level of interest. **OVERVIEW:** To address the broad range of preprofessional, post professional, and amateur interest in aerospace and exploration medicine education, we created Explorationmedicine.com. It is as an online community centered around short podcast episodes, online discussion forums, and downloadable educational products. The community takes advantage of the unprecedented accessibility and customizability of internet based education to supplement formal training, provide an informal information source, and introduce aerospace and exploration medicine for unfamiliar with the field.

DISCUSSION: The episodes and website explorationmedicine.com are routinely accessed by 100s of people each month from more than a dozen countries, on 6 continents. Since it started in 2017, it has served to stimulate discussion, increase awareness of the aerospace and exploration medicine, and has had more than 15 individuals contribute content, ranging from students to residents to professionals practicing aerospace and exploration medicine around the world.

Learning Objectives

1. Informal, on demand education is a growing aspect of the educational world.
2. The Exploration Medicine Podcast provides an innovative medium for transmitting information to a wide audience.

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

Amy Kreykes

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(Education - Program/Process Review)

BACKGROUND: Most medical students will never be exposed to or receive training in Aerospace Medicine. Aerospace Medicine is a small field with only four residencies (Civilian-University of Texas Medical Branch (UTMB); Armed Forces- Air Force, Navy, and Army) and one fellowship (Civilian- Mayo Clinic) available for trainees in the United States. Students with an interest must seek out resources on their own. Often finding resources is challenging and open access educational tools are rare. UTMB created a free online Aerospace Medicine Seminar Series to provide a readily accessible resource for students interested in pursuing Aerospace

Medicine. **OVERVIEW:** The field of Aerospace Medicine is growing. Commercial air travel, military operations, continued Low Earth Orbit and exploration operations by the National Aeronautics and Space Administration (NASA), as well as the emergence of commercial spaceflight necessitate the ongoing training of Aerospace Medicine specialists. Moreover, the FAA Extension, Safety, and Security Act of 2016 introduced BasicMed, a program in which select civilian pilots can be certified as medically safe to fly by providers with no formal training in aviation medicine. Despite this, medical students in the United States receive no training or exposure to the field of Aerospace Medicine unless, perhaps, they are co-located at an institution that provides Aerospace Medicine Residency training. Opportunities for exposure and training do exist but are by application only and have traditionally involved travel for approximately a month for an away rotation, limiting participation. As a leader in the field, UTMB is helping to fill this educational gap by providing an open access learning resource for medical students interested in Aerospace Medicine. UTMB designed and validated a series of six seminars introducing Aerospace Medicine training and career opportunities as well as key topics in the discipline. The series is available online at <https://www.utmb.edu/pmph/aerospace-medicine/aerospace-seminar-series> **DISCUSSION:** Open access educational resources in Aerospace Medicine are rare. UTMB is leading the way with their Aerospace Medicine Seminar Series, which is available online to interested students across the globe at no cost, whether military or civilian.

Learning Objectives

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

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

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(Education - Program/Process Review)

BACKGROUND: The Exploration Medical Capability (ExMC) Element of the NASA Human Research Program is working to determine the types of medical conditions that are likely to occur on exploration space missions, define the risks associated with these conditions, recommend medical system concepts needed to reduce the risks, and work within spacecraft design and human constraints to appropriately scope a medical system that lowers overall mission risk. This work requires the integration of the subject matter and clinical research expertise of physicians, pharmacists, and nurses with the technical knowledge of engineers, software designers, mission planners, statisticians, and other non-medical personnel. As a result, substantial translation is needed between the technical languages of each field and new processes need to be developed that address the integrated workflow structure.

OVERVIEW: Traditional medical education is not designed to prepare physicians to work in this type of cross-disciplinary environment, so ExMC decided to create an innovative elective research rotation. This rotation pairs students/residents with a mentor and assigns them specific cross-disciplinary projects combining medicine with subject areas like engineering, pharmacology, statistics, radiation physics, and human factors design. Student-led projects have included tracing medical conditions to required capabilities within a systems engineering model, designing processes and protocols for identifying high-yield medical conditions requiring risk mitigation, performing spacecraft volumetric assessments of medical procedures, designing spacecraft medical workstations, and building a database of spaceflight environmental effects on medications. **DISCUSSION:** During the rotation, trainees work with their mentor and other members of the project team to complete their portion of the project and develop a presentation of their work for

relevant stakeholders. Since ExMC resources and personnel are distributed all over the United States, the schedule and location of this rotation are flexible and negotiable. trainees are often able to work remotely, and take advantage of their home institution's resources while also learning about space medicine and advancing NASA's goals. This exposes the trainees to the unique challenges of cross-disciplinary research and provides a unique opportunity for the next generation of trainees passionate about human health and performance in space exploration.

Learning Objectives

1. Participants should understand that Space Medicine research and design is an interdisciplinary process
2. Participants should understand that medical system design has unique educational challenges and requirements

[441] MEDICAL AND ENGINEERING COLLABORATION FOR EDUCATION IN HUMAN SPACEFLIGHT: THE MEDICINE IN SPACE AND SURFACE ENVIRONMENTS COURSE

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(Education - Program/Process Review)

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

Learning Objectives

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

Thursday, 05/26/2022
Tuscany C,D,E

1:30 PM

[S-69]: SLIDE: TOPICS IN FUTURE SPACE MEDICAL ARCHITECTURE AND TRAINING

Chair: Michael Greene

[357] OVERVIEW OF NASA HRP CIPHER PROJECT, AND INSIGHTS FROM TEXT ANALYTICS ON SELECTED PROPOSALS

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(Original Research)

INTRODUCTION: As NASA contemplates human missions of unprecedented duration, issues of health and performance become critical. One issue is uncertainty in extrapolating from current (mostly) 6-month missions to much longer missions. To address this, the NASA Human Research Program assembled an integrated set of experiments to be performed on missions of short, medium (~6 month), and long (~1-year) duration. This will engender confidence in extrapolating to longer durations. The complement spans a range of health/performance domains, and is termed CIPHER: Complement of Integrated Protocols for Human Exploration Research. These include studies of organ structure, function and metabolism; telomeres; cognitive function; bone, muscle, and joint integrity; cardiac/respiratory physiology; ocular health; kidney tissue; fitness for duty standards; neurovestibular function, and sleep, performance, immune function, and intracranial fluids. **METHODS:** The scientific and statistical rationale for CIPHER will be presented; the latter is based on noninferiority statistics and the desire to know that health decrements at 1 year are not worse than those at 6 months. The identical complement will be performed on several ISS missions. This presents the opportunity to acquire compatible data on a large (N~30) cohort, allowing for investigations of correlations between measures, to identify synergies that might aid in furthering our understanding of human adaptation, and that might lead to efficiencies in countermeasure design. Initial work is currently underway, and involves text analytics on the CIPHER proposals to identify common themes, methods, or approaches across studies. **RESULTS:** First, we examined reference lists in each CIPHER proposal, for citations to common authors across proposals that might be unexpected (if proposals are in different disciplines) and might indicate unforeseen scientific connections. Second, networks were created to visualize how proposals are linked to each other through common terms relevant to HRP, such as its set of established hazards, risks, and environmental metadata. Third, Latent Dirichlet Allocation (LDA) was applied to identify underlying concepts that might connect different proposals. **CONCLUSIONS:** This investigation to date has provided some insights and few surprises, but establishes an infrastructure by which to understand and interpret CIPHER within the larger set of space life-sciences concerns.

Learning Objectives

1. Participants will better understand the need for integrated research and long-duration space flights for reducing the risk of future exploration-class flights.
2. The audience will gain an understanding of text analytics in searching for common themes and concepts across several related documents such as grant proposals.

[358] NON-INVASIVE INTRACRANIAL PRESSURE MONITORING AND ITS APPLICABILITY IN SPACEFLIGHT

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(Original Research)

INTRODUCTION: Neuro-ophthalmic findings collectively defined as Spaceflight-Associated Neuro-ocular Syndrome (SANS) are one of the leading health priorities in astronauts engaging in long duration spaceflight or prolonged microgravity exposure. Though multifactorial in etiology, similarities to terrestrial idiopathic intracranial hypertension (IIH) suggest these changes may result from an increase or impairing in intracranial pressure (ICP). Finding a portable, accessible and reliable method of monitoring ICP is, therefore, crucial in long duration spaceflight. **METHODS:** A review of recent literature was conducted on the MEDLINE/PubMed database using the search terms “non-invasive intracranial pressure”. Studies investigating accuracy of non-invasive and portable methods in human subjects on the past 5 years were included. The search retrieved different methods, that were subsequently grouped by approach and technique. **RESULTS:** Majority of publications included the use of ultrasound-based methods, with variable accuracies. One of which, non-invasive ICP estimation by optical nerve sheath diameter measurement (nICP_ONSD) presented highest statistical correlation and prediction values to invasive ICP, with area under the curve (AUC) ranging from 0.75 to 0.964. One study even considers a combination of ONSD with transcranial doppler (TCD) for an even higher performance. Other methods, such as near-infrared spectroscopy (NIRS) show positive and promising results (good statistical correlation with invasive techniques when measuring cerebral perfusion pressure (CPP): $r = 0.83$). **DISCUSSION:** Combination of methods, as well as recently introduced and innovative methods in the spectroscopy modality show promise in the field of non-invasive intracranial pressure monitoring. However, for its accessibility, portability and accuracy, ONSD presents itself as the up to date most reliable non-invasive ICP surrogate and a valuable spaceflight asset.

Learning Objectives

1. The participant will be briefed on what are the main techniques of non-invasive intracranial pressure monitoring being researched at the moment.
2. The participant will be able to understand, from the methods currently available, which ones appear to be most adequate to monitor intracranial pressure in spaceflight.

[359] THE TIME COST OF PROVIDER SKILL LEVEL: A PILOT STUDY OF MEDICAL OFFICER OCCUPIED TIME BY PROVIDER TRAINING LEVEL

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(Original Research)

INTRODUCTION: Expedition medical kits and space medical systems are typically designed to minimize patient risks such as death, evacuation, and disability. However, on missions with small crews, limited resources, and tight timelines considerations must also include the operating cost of the medical system on other mission aspects, such as crew time. Patient downtime is often accounted for since recovery time is expected and, by rendering care, the unavoidable time cost of injury or illness is minimized. Medical Officer Occupied Time (MOOT), however, is not often considered and may vary significantly depending on provider skill. This pilot study was designed to assess this MOOT skill effect, estimate its' magnitude, and identify areas for study design improvement. **METHODS:** A simulated patient and operating room were prepared in which an attending Trauma Surgeon (TS) (PGY11), PGY5 and PGY2 surgical residents, and an attending Emergency Physician (EP) (PGY9), but only 4 months of surgical training, performed simulated appendectomies and FAST scans. The EP performed the appendectomy twice under guidance, first with the TS in the room, and again with telemetric guidance on a 0.3-0.5 second time delay. Start and stop times were recorded for the procedures and sub-procedures. **RESULTS:** The TS performed the appendectomy in 419 seconds, the PGY5 in 456 seconds, the PGY2 in 644 seconds, and the EP in 949 seconds with in room guidance and 996 seconds via telemetry. The time vs. experience plot is a near perfect example of the logarithmic effect of learning with a

correlation coefficient of 0.986. The PGY2 performed the intubation in 73 seconds while the attending Emergency Physician averaged 31.5 seconds. For both the appendectomy and endotracheal intubation the novice's took 2.3 times longer than the expert. **DISCUSSION:** This pilot study demonstrates a method for capturing MOOT cost by provider skill level using simulated procedures. The magnitude of the MOOT skill effect is likely substantial and may significantly effect missions. This study is limited by small sample size, limited number of tested medical capabilities, a simulation set up that may not reflect real world conditions on Earth or in space, and sub-optimal camera angles.

Learning Objectives

1. Mission planners must account for the effects of operating medical systems on other aspects of the mission such as crew time in addition to traditional patient focused risks like mortality, disability, and evacuation risk.
2. Crew Medical Officer skill level may have a significant effect on a mission

[360] SKILLS AND QUALIFICATIONS SURVEY FOR A CREW MEDICAL OFFICER ON A MISSION TO MARS

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(Original Research)

INTRODUCTION: As space exploration extends beyond low-Earth orbit, medical systems needed to maximize crew health and mission success will require adaptation. A Mars mission would range from 750 to 1100 days with no medical evacuation capability. Regular resupply of medical consumables will not be possible, and asynchronous communication with Earth will pose unprecedented challenges to the medical system. Work on these unique problems is ongoing, but there remains a gap in knowledge about the skills, qualifications, and training necessary for a Crew Medical Officer (CMO) on a Mars mission. This study aims to advise these needs through a survey of subject matter experts. **METHODS:** Informed by expected in-flight medical conditions, a survey regarding the skills, qualifications, and training of a CMO for a Mars mission was developed. This survey was distributed to members of the NASA space medicine community including physicians, behavioral health providers, and medical operations support personnel. **RESULTS:** There were 21 respondents including 11 operational flight surgeons, 7 non-operational physicians, 1 non-physician operational medical support personnel and 2 behavioral health providers. 86% of respondents indicated a physician CMO should be a requirement for a Mars mission and that time should be allowed pre-flight for maintenance of a physician CMO's clinical skills. It was favored that all exploration crew members receive additional medical training at least to the level of a current ISS CMO specialist. 71% of respondents supported training to recognize futility of medical care, and 62% supported palliative care training if time allows. Additional questions evaluated need for procedural and critical care skills, behavioral health qualifications, and number and type of additional CMOs needed on exploration missions. **DISCUSSION:** Responses from the NASA space medicine community reflect the current shortcomings regarding details about the overall Mars mission design including habitat/vehicle specifics, medical concept of operations, and medical system capabilities. Consensus was found in the requirement for a physician CMO as well as desire for overall increased medical background among crewmembers and improved behavioral health skills. Continued discussion on this topic throughout the development of a crewed Mars mission design will help to inform the exploration medical capability.

Learning Objectives

1. The audience will have a high-level understanding of the unique medical challenges of an exploration Mars mission.
2. The audience will have an impression of the thoughts of subject matter experts on the skills, qualifications, and training necessary for a Crew Medical Officer (CMO) on a Mars mission.

[361] DESIGN FOR FUTURE OF HEALTH AND SAFETY IN COMMERCIAL HUMAN SPACEFLIGHT: TOWARDS HUMAN-CENTRED EXPLORATION MEDICAL ECOSYSTEM DESIGN INFRASTRUCTURE

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(Education - Program/Process Review)

BACKGROUND: In conventional practice, medical systems requirements for human spaceflight are considered towards the end phases of a space systems engineering project, leaving little room for the integral medical requirement codification within spacecraft design parameters (NASA ExMC, 2021). As mission character increases in length and remoteness, the level of care and required medical capabilities increase dramatically. The longer and more remote the mission, the greater is the need for human-centeredness. To address that, it is crucial to incorporate a human-centric approach at the early stages of defining key mission architecture parameters and constraints of mission and vehicle/habitat planning. '[Human] spaceflight has reached a critical moment where the transition to a human-centric mission architecture must become a reality if exploration missions are to succeed' (Antonsen, 2017). **DESCRIPTION:** Presently used NASA's system engineering approach to the design of complex space systems bears characteristics of the first-order cybernetics approach (Balint, 2017). To facilitate medical requirements-driven architectural design for future missions, the project augments the human-factors engineering methods with a transdisciplinary approach, by applying healthcare design methodologies and within a second-order cybernetics design research approach (Glanville, 2004). This process is enabling the development of the Exploration Medical Ecosystem Design Infrastructure (ExMEDI) - a new tool and method to define medical capabilities required for specific future spaceflight contexts, and optimize design requirements for healthcare systems, such as a medical workstation or medical bay, to best support crew's health. The ExMEDI will serve as a tool compatible with currently developed solutions to calculate health risk (e.g. probabilistic MedPRAT) and allow integration of human-centered parameters: crew profile, health needs, as well as medical capabilities, and materials, to optimize the solutions for specific mission contexts and characters, e.g. orbital lunar habitation, space hotel facility, or preparatory Mars mission. **DISCUSSION:** The ExMEDI would be used in future designs for different types of missions simulations, allowing to build alternative designs and compare them by defining the predicted success rate of individual components of the proposed medical system solutions in the context of crews' medical needs.

Learning Objectives

1. The audience will learn about the role human-centered design research methods can play in defining, incorporating, and translating key medical considerations into vehicle/habitat design requirements, including future design of space medical bay at the early stages of defining key mission architecture parameters and constraints.
2. The audience will learn about a rationale for the development of Exploration Medical Ecosystem Design Infrastructure (ExMEDI) as a tool and method to define medical capabilities required for specific future spaceflight contexts and optimize design requirements for healthcare systems, such as a medical workstation or medical bay.

[362] FROM NEEMO ENVIRONMENT TO LEO HABITAT; UNDERSTANDING LYMPHATIC AND ENDOTHELIAL GLYCOCALYX FUNCTION AND DYSFUNCTION

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(Education - Tutorial/Review)

Lymphatic and vascular endothelial glycocalyx (GCX) function in the deep sea environment and true weightlessness are under-researched domains. Recently, an enhanced understanding of lymphatic function within human health has been recognized. A missing element of many biological and physiologic pathologies associated with extreme environments may reside within the adaptation of the lymphatic system, GCX, and genetics. To gain perspective on lymphatic and GCX architecture and physiology in weightlessness, research will be required in sea and ground-based analogs for spaceflight, then progress to true weightlessness in Earth orbit (LEO), to understand the impact on human physiology through the perspective of lymphatic and GCX function in extreme environments. On Earth, body fluid compartments are maintained and balanced by the nano-scaled architectural integration of the endothelial glycocalyx, the vasculature, and the lymphatic system. The GCX is a carbohydrate-rich matrix composed of proteoglycans, glycoproteins, glycosaminoglycans, coagulation pathway and anti-inflammatory components, that is dynamic, functional, multi-level, and integrated to the cell membrane and cytoskeleton, regulating fluid, solute, and macromolecule transfer from the vessels into the sub-glycocalyx and interstitial spaces. The GCX, stimulated by luminal shear, results in mechanotransduction and eNOS production through coupling of eNOS and radical oxygen species (ROS) quenching. This educational program will review current sea, analog and true weightlessness research data of lymphatic physiology adaptation associated with fluid shifts, immune system, and cytokine alterations in the context of lymphatic function, the glial lymphatic system, and overall potential contribution to Spaceflight Associated Neuroocular Syndrome (SANS). To date, GCX shedding has been studied in one known head-down tilt study. A theoretical model of GCX shedding in weightlessness will be reviewed, with associated potential applications to human health. Potential effects of known countermeasures (Lower Body Negative Pressure) on lymphatic function and GCX restoration theory will be reviewed. Further detailed research regarding altered lymphatic and/or GCX function in weightlessness is indicated. Countermeasure development and incorporation into routine checklists to maintain nominal human physiology in extreme environments will have significant spinoffs to bedside patient care and outcome improvement.

Learning Objectives

1. The audience will be able to discuss current lymphatic research performed to date in head down tilt and animal models from weightlessness environments.
2. The audience will be able to describe the basic characteristics of the endothelial glycocalyx (composition and function) and factors associated with shedding and associated pathological consequences.
3. The audience will be able to discuss data to date on the microvasculature in weightlessness and theoretical impact on the endothelial glycocalyx.

Thursday, 05/26/2022
Tuscany A

1:30 PM

[S-70]: SLIDE: FACTORS IMPACTING HUMAN PERFORMANCE

Chair: Farhad Sahiar
Co-Chair: Susan Jay

[363] EFFECTS OF VOLUNTARY URINE RETENTION ON COGNITIVE PERFORMANCE

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(Original Research)

INTRODUCTION: Aircrew in-flight bladder relief systems have not kept pace with increases in mission duration. This forces many aircrew to engage in voluntary urinary retention for extended periods. An over-full bladder can be uncomfortable, distracting, and if prolonged, increases the risk of urinary tract disorders. This study investigated whether voluntary urinary retention negatively impacted cognitive performance to promote further advancement of in-flight bladder relief systems. **METHODS:** Participants (n=29) completed a psychomotor vigilance task (PVT) and working memory (WM) task at several time points. First, participants completed a baseline test on both tasks. Next, participants were asked to void their bladder and then drink 0.75L of water. The tasks were then performed again at 1, 2, and 3 hours post-void, and urgency to void one's bladder was assessed at regular intervals. A total of 17 participants were able to continue through all time points. **RESULTS:** Repeated-measures ANOVAs demonstrated that reaction time (RT) on the PVT was significantly impaired (slower) with longer urine retention time, $F(3,14)=2.90, p<0.05$, and participants also showed a significant increase in the number of lapses (RT>500ms) with increased retention time, $F(3,14)=3.96, p<0.05$. Together these results indicate that sustained attention was impaired with increased voluntary urine retention. We did not see significant changes in WM performance with our manipulations. Additionally, neural measures acquired with electroencephalography for both tasks also did not show any significant effect. **CONCLUSIONS:** The study demonstrated that sustained attention, as measured with the PVT, was impaired during 3 hours of voluntary urine retention. Furthermore, the experimental manipulations employed were temperate compared to a real-life experience of extended duration missions while being unable, for safety reasons, to remove the aircraft restraint system to void. Therefore, the adverse effects on cognitive performance in an operational setting are likely more severe and widespread than witnessed here in a controlled setting. The knowledge gained will help eliminate the practice of voluntary urinary retention and promote the compliance of being adequately hydrated by fueling advances in bladder relief systems suitable for all aircrew.

Learning Objectives

1. Learning objective 1: Understand the performance repercussions of voluntary urinary retention.
2. Learning objective 2: Consider the implications of insufficient bladder relief systems for aircrew.

[364] QUANTIFYING AIRCREW PERFORMANCE IN-FLIGHT WITH HEART RATE VARIABILITY ANALYSIS

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(Original Research)

INTRODUCTION As the aviation community attempts to maximize human performance, an objective tool to quantify aircrew status is needed. To date, no objective metric for quantifying physiological stress has been successfully implemented due largely to the lack of technology for gathering relevant, real-time biometric data in flight, and algorithms required to analyze such data. In this study, a baseline algorithm was tested, called Relative Performance Index (RPI), as a continuously computed metric normalized to a pilot's daily biometric baseline compared to historical performance. **METHODS** A photoplethysmography (PPG) sensor device, SPYDR®, validated to record reliable biometric data in tactical flight correlated with environmental parameters was installed as a functional replacement for earcups in the helmets of ten T-6 instructor pilots for a period of six weeks. Over 100 sorties worth of data were collected from fifteen minutes before takeoff through five minutes after landing. Heart rate, SPO2, acceleration (Gz), temperature, and cabin pressure were recorded with SPYDR at 1Hz and then analyzed post flight with custom analysis software, combining all variables into a Relative Performance Index (RPI). **RESULTS** Analysis of aircrew performance by RPI showed a significant increase in physiological stress from pre-flight to in-flight regimes ($p=0.001$), as well as a relative decrease in

stress post-flight ($p=0.005$). RPI showed a decline in cognition at the 15- and 25-thousand-foot levels. RPI at post-exposure period did not return to baseline levels, correlating well with the decline in cognitive function ($p=0.002$). When subjects flew twice in one day, their RPI decreased in the second sortie as compared to the first sortie ($p=0.03$). These results suggest that RPI may be a valid indicator of degraded performance both in-flight and intra-flight. **DISCUSSION** Using proprietary machine-learning algorithms, models of human performance delivering actionable metrics for fatigue analysis, impending physiological emergencies, and long-term risk mitigation techniques were tested for development of a quantifiable picture of aircrew performance. Analysis of SPYDR data collected in-flight by the RPI in this study yielded an objective assessment of human performance. By incorporating human biometric data with machine learning and artificial intelligence techniques, new, data-based techniques for operational risk mitigation may be achieved.

Learning Objectives

1. The participant will learn about current in-flight physiological monitoring techniques and signal analyses.
2. The participant will learn about current and novel techniques for human performance optimization and risk mitigation.
3. The participant will learn about heart rate variability and its significance for quantifying human performance parameters.

[365] EFFICACY OF STIMULANTS TO ENHANCE FUNCTIONAL PERFORMANCE

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(Original Research)

BACKGROUND: Considerable research has documented the optimization utility of stimulants in sleep deprived Soldiers and aviators. However, the civilian literature suggests that modafinil and mixed amphetamine salts (MAS) may be used to enhance cognitive processes however, the results have been mixed. There is consistent evidence suggesting that baseline performance and intelligence may moderate any enhancement effects. The present study is designed to establish whether this individual difference may limit application to a military population such that stimulants may prove unsuccessful with respect to performance enhancement for those with higher intelligence levels. **METHOD:** A double-blind, randomized, placebo-controlled, within-subjects design was employed to evaluate the main effects of pharmaceuticals (modafinil, MAS) and a potential moderator effect of intelligence on performance. Twenty-seven male, U.S. Army Soldiers participated in the study. Participants completed four test sessions: baseline and three experimental sessions where a test article was administered. At all test sessions, participants completed a standard marksmanship qualification task and cognitive tasks. **RESULTS:** First, participants were divided into low and high fluid intelligence groups using a median split (abstraction score). A mixed 2 X 3 repeated-measures analysis of variance with intelligence group (high, low) as the between-subjects variable, drug (modafinil, MAS, placebo) as the within-subjects variable, and total number of hits on the marksmanship task as the dependent variable revealed a significant interaction between group and drug. Specifically, the mean number of hits was greatest with MAS for the low intelligence group and lowest with MAS for the high intelligence group. The analysis was replicated using baseline marksmanship score to define groups and did not yield significant main or interaction effects. **CONCLUSION:** The findings suggest an effect of drug on marksmanship performance. However, this effect is moderated by intelligence level such that low performers experience a boost with MAS and high performers, a deficit. These findings suggest that the enhancement seen is not dependent on marksmanship skill level but rather one's intelligence level. When considering the generalizability and utility of stimulants for enhancement purposes, these findings hold particular significance in that they suggest efficacy is contingent upon one's level of fluid intelligence.

Learning Objectives

1. Participants will understand the degree to which pharmaceuticals may enhance functional performance.
2. Participants will recognize the role of mediating factors in performance enhancement.

[366] MOVING NAVAL ANTHROPOMETRIC EVALUATIONS INTO THE 21ST CENTURY: AUTOMATED DEVICE FOR ANTHROPOMETRIC MEASUREMENTS (ADAM)

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(Education - Program/Process Review)

BACKGROUND: Naval Aviation Schools Command (NASC) is the Model Manager for the Naval Aviation Anthropometric Accommodation Program, responsible for evaluating and certifying over 5,000 Naval aviation applicants and students across 14 affiliate locations. Accurate and consistent evaluations are an integral component of the Naval aviation selection process to ensure human-aircraft compatibility and flight safety. Even with a standardized training program for affiliate locations the diversity of experience among anthropometric technicians and the use of a handheld anthropometer and non-standardized measuring stations can lead to human error and measurement variability. **OVERVIEW:** In an effort to improve standardization and minimize the potential for human error, NASC collaborated with the TechSolutions program at the Office of Naval Research (ONR) Global to select Naval Surface Warfare Center Dahlgren Division (NSWCDD) to develop the Automated Device for Anthropometric Measurements (ADAM). ADAM uses a depth-sensing camera and the combination of a convolutional neural network and an artificial neural network to identify joint locations from two 3-Dimensional images of a participant and ultimately predict five target anthropometric measurements: stature, sitting height, sitting eye height, buttock to knee length, and thumb-tip reach. These measurements are referenced against a database of aircraft restriction parameters to immediately display aircraft and training pipeline restrictions which would require manual measurements. The manual measurements are entered directly into the interface and then all captured and entered data can be exported.

DISCUSSION: Use of the ADAM system does not require any specialized knowledge or training and was designed with an intuitive user interface. The system can accurately and consistently predict target measurements in roughly 96% of the current applicant and student population, substantially reducing the number of manual measurements required to be performed by an anthropometric technician, thereby, reducing the risk of human error.

Learning Objectives

1. The audience will learn about the development of the Automated Device for Anthropometric Measurements (ADAM) for the Naval anthropometric program.
2. The audience will learn how the Automated Device for Anthropometric Measurements is utilized at Naval Aviation Schools Command.

[367] BARRIERS FOR FEMALE AIRCREW IN THE COCKPIT

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(Education - Program/Process Review)

BACKGROUND: Despite a defined intent for greater female representation in all professions, the proportion of female aircrew within the Royal Air Force (RAF) remains less than 5%. Ambitions to improve gender diversity may be limited due to military anthropometric selection criteria which reflect the male oriented design of the cockpit/flight deck. Male design bias may additionally compromise operational capability, safety, and functional performance. To further investigate anthropometric barriers for female aircrew for entry or training we reviewed the current

literature. **OVERVIEW:** A literature review using the search terms "Anthropometry", "Female" and "Aircrew" was conducted using Scopus, PubMed and Google Scholar. Of the 32 papers identified, 13 were excluded as they did not focus on the impact of anthropometry on female aircrew. Three main issues were identified as creating an anthropometric barrier: 1) incomplete dataset, 2) inadequate fit of protective apparel and 3) cockpit design. **DISCUSSION:** Aircraft functionality is not influenced by gender, however, how an aircraft is flown is subject to engineering designs. Current RAF entry standards exclude between 60-85% of the female population. Aircraft cockpits are designed to incorporate the 5th to 95th percentile of the population based on the dimensions of solely male participants. Thus, selection based on anthropometry will exclude female pilots from the outset. Additionally, poorly fitting personal protective equipment is often apparent for female aircrew. Ill-fitting G-suits not only inadequately protect against G forces but can cause rib pain and breathing difficulties. Properly fitted G-suits doubled female G-tolerance and endurance to equal male subjects. Downsizing clothing is not acceptable as females are not simply smaller males. Even with adequate modifications to future aircraft, the design of training aircraft still poses a barrier for females. New aircraft must justify any limitations to ensure they are essential and not the result of previous biased data collection. Research to include female participants is a vital step in designing aircraft and equipment that support a wider population range and to improve gender diversity in aviation. Likewise, haptic technology, and virtual cockpits could reduce the anthropometric bias further. These anthropometric barriers were found to impact civilian and military aircrew internationally.

Learning Objectives

1. Audience will learn about how anthropometry can result in bias implemented into aircraft environments.
2. Audience will understand the impact of anthropometric barriers for female aircrew within the cockpit environment and protective apparel.

[368] CLOSING THE GENDER DATA GAP IN AEROSPACE MEDICINE

Jemma Austin, Peter Hodkinson

Centre for Human and Applied Physiological Sciences, King's College London, London, United Kingdom

(Original Research)

INTRODUCTION: In a world driven by data, ensuring we are making decisions based on accurate and applicable data is essential. Militaries worldwide have grown from male-centric origins, therefore a lot of the data we base aerospace medical requirements on has a male bias which may be disadvantaging female aircrew. The RAF is striving to add value to its organisation with an increased gender diversity of 20% female by 2030. An understanding of the gender data gap that may be present is required to ensure conditions are set for current and future generations of military aircrew to thrive. **METHODS:** The sex-disaggregation of data collected as part of a study into urination in aviation is used to demonstrate the phenomenon of the gender data gap in aerospace medicine. Data-sets of 234 anonymous survey responses (197 male, 37 female) from UK military aircrew were analysed. **RESULTS:** There was a significant gender difference found in all self-reported experiences of urination in aviation between male and female aircrew with a 4-fold greater mean self-reported fluid reduction on flying days of -581ml, (t(36)=-5.88, p=<0.001 and 95% CI -781ml to -380ml) compared with -150ml with a higher female prevalence of prolonged urine holding and distraction. Impact ratings revealed 60% of female versus 43% of male aircrew rated urination whilst airborne a moderate or serious physical problem and 52% and 23% respectively a moderate or serious psychological problem. Additionally, 75% of women (versus 14% of men) experienced shame or embarrassment when urinating in the airborne environment. The results demonstrate a significant and disproportionate effect on the experience of, and accessibility to urination in female aircrew and highlight the added consideration of menstruation. **DISCUSSION:** This research demonstrates that gender

inequity exists within some aspects of the airborne military environment. Many of the aircraft and aircrew equipment in service today were designed prior to women returning to military flying roles over 30 years ago. This gender data gap has introduced a bias that affects aerospace medicine. An intent to close gender data gaps in aerospace medicine is required, but first we must identify where they exist to ensure future success is enabled.

Learning Objectives

1. Understand what the 'gender data gap' is and how it may apply to aerospace medicine.
2. Apply considerations of gender-based differences analysed during the presentation to their own aerospace medicine practice around female considerations of urination and menstruation whilst airborne.

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1:30 PM

Tuscany B

[S-71]: PANEL: SARS-COV-2 VACCINATION: EFFECTIVENESS AND SAFETY, CERTIFICATION AND VACCINE "PASSPORTS"

Sponsored by AsMA Air Transport Medicine Committee

Chair: Alex Wolbrink

PANEL OVERVIEW: *Pre-flight screening for SARS-CoV-2 infections has been one of the foundations of resuming travel on international commercial airline flights. Since SARS-CoV-2 vaccinations became available, confirmation of vaccination status has also frequently been required. However, implementation and acceptance of these policies has varied widely across the world and also between passengers and flight crew. This panel will first review the current status of the pandemic, screening, and SARS-CoV-2 vaccines and will then review airline medical perspectives from around the world on how testing and vaccination policies have been implemented and accepted.*

[369] SARS-COV-2 PRE-FLIGHT SCREENING AND VACCINES – BASIC VIROLOGY AND VACCINOLOGY SCIENCE AND PREVENTION

Robert Orford

Mayo Clinic, Scottsdale, AZ, USA

(Education - Program/Process Review)

SARS-CoV-2 is the first coronavirus pandemic leading to endemicity since the OC43 coronavirus pandemic of the 1890s. SARS-CoV-2 variants have arisen such as the delta variant. Delta increased the flexibility of the spike protein, modifying viral transmissibility and severity. Neutralizing antibodies and activation of T-cells against live SARS-CoV-2 occur because of infection or vaccine administration. This has resulted in protective immunity against all SARS-CoV-2 coronaviruses, although lesser against newer variants. Standard precautions to limit coronavirus spread, which are also applicable to other viral infections, include the use of masks, sanitizers, physical distancing, and the use of lock downs to limit human interaction. As the current pandemic has progressed, the use of all spread-limiting strategies has deteriorated. Vaccine significantly reduces the severity of disease and death, but asymptomatic or mildly asymptomatic infection can still occur, placing unvaccinated individuals at risk. Infection with SARS-CoV-2 may be determined with high sensitivity by PCR nasal swab testing, and with lower sensitivity by rapid antigen testing. Both methods generally have high specificity. PCR is better at detecting the virus early, but may continue to detect dead viral particles for days or weeks after infection. Rapid testing is useful for determining if an individual is contagious at the time of the test. Both methods have been used by airlines to limit possible spread during flight. Detection of neutralizing antibodies is difficult and must be done in a BSL3 lab. Several vaccines are already available, and more are expected. International airlines in some cases will accept vaccine certificates in lieu

of testing, and this is expected to become the norm for several years in the future. Once everyone in the world has been infected or vaccinated, such passports should no longer be needed. It is likely that this process will take approximately five years, which was the duration of the earlier pandemic. The continued use of booster doses for the elderly and immunosuppressed is likely.

Learning Objectives

1. Describe the viral and social causes of the current SARS-CoV-2 pandemic, and the types of lab assays available for detecting infection with SARS-CoV-2.
2. Understand the the vaccines available to prevent disease from SARS-CoV-2, the basis for vaccine certificates. and other strategies to reduce risk of COVID-19 transmission among passengers and crew in international commercial air transport.

[370] SARS-COV-2 PRE-FLIGHT SCREENING AND VACCINES – INTERNATIONAL PERSPECTIVE (VACCINE PASSPORT AND MONITORING)

David Powell

International Air Transport Association, Auckland, New Zealand

(Education - Program/Process Review)

The airline industry has worked internationally to restore quarantine-free and unrestricted travel in the wake of the COVID-19 in a evidence-based way to manage risks of transmission during travel and of importation of cases. Two key aspects of this have been acceptance of vaccinated travellers, and SARS-CoV-2 testing around the time of the flight journey. These have been implemented variably around the globe. Both vaccination and test results need to be able to be recorded in a way that is verifiable, fraud-proof, and linked to reliable identification of the traveller, while meeting requirements to preserve privacy and confidentiality. Previous internationally available and accepted methods have been low-technology solutions such as the WHO "yellow card". The past year has seen the development and deployment of conetemporary digital solutions designed to meet the needs within the COVID-19 context. These will be discussed, against the backdrop of the outbreak and with reference to future developments.

Learning Objectives

1. The participant will be able to list the basic requirements for a system of documenting vaccine status and test results for a traveller.
2. The audience will learn about the challenges in creating and deploying digital vaccination certificates along with test result certification for travellers.

[371] AIRCREW EXPERIENCES WITH INTERNATIONAL TRAVEL, TESTING AND IMMUNITY VERIFICATION IN THE COVID-19 ENVIRONMENT

Quay Snyder

Aviation Medicine Advisory Service, Centennial, CO, USA

(Education - Program/Process Review)

Aircrew perspectives on continued international operations during the COVID-19 pandemic have evolved with the advent of testing modalities and vaccination availability. Conflicting and changing requirements for entry among different countries led to confusion, interruption of operations and aircrew anxiety. The advent of vaccine mandates imposed by either nations or employers reduced uncertainty but resulted in pushback from a segment of the aircrew population. Initial testing and quarantine requirement prior to vaccination were perceived as arbitrary and not based on science evidence available and at times, restrictive enough to lead flight crews to refuse flights to some countries, particularly for cargo crews early in the pandemic. Availability of vaccines in some countries sometimes lessened testing and quarantine requirements which facilitated resumption of more frequent operations and less disrupted scheduling of traditional flight routes. Efforts by ICAO's CAPSCA group led to improved guidance for all carriers and nation states, although this guidance was not always quickly or fully adopted.

Vaccine mandates and airline policies regarding masking and testing reduced some anxiety among aircrew, but also led to an increase in unruly passenger behavior. The emergence of variants of the SARS-CoV-2 virus and cycling infection rates with varying national experiences delayed reaching a consensus on global documentation, testing and quarantine policies. Aircrew unions and civil aviation authorities generally worked together with the common goal of returning air travel to pre-pandemic levels with safety and health of employees and passengers as a primary goal. This presentation will explore the evolution of challenges and solutions to returning "normal" air travel from the aircrew perspective.

Learning Objectives

1. The audience will learn about aircrew challenges faced with attempting to continue operations early in the COVID-19 pandemic including changing testing and quarantine policies among various countries, especially as related to cargo operations.
2. The audience will be aware of the impact of vaccine mandates and masking requirements on aircrew morale and on passenger behavior.

[372] SARS-COV2 PRE-FLIGHT SCREENING AND VACCINES - EU PERSPECTIVE (EU POLICY DEVELOPMENT AND IMPLEMENTATION)

Virgilijus Valentukevicius¹, Declan Maher², Cristian Ionut Panait¹, Janis Vegers¹

¹European Union Aviation Safety Agency, Cologne, Germany; ²Irish Aviation Authority, Dublin, Ireland

(Education - Program/Process Review)

MOTIVATION: SARS-CoV-2 pandemic had and still has a huge negative impact on the aviation industry in Europe and worldwide. Being a European Union regulator in aviation area, EASA was tasked to provide support to Member States' national authorities and aviation stakeholders to ensure, in a coordinated manner, the health and safety of passengers and the aviation personnel who serve them, by maintaining safe and secure operations whilst minimising the risk of SARS-CoV-2 transmission.

OVERVIEW: In cooperation with European Centre for Disease Prevention and Control (ECDC), EASA jointly issued detailed technical operational guidelines for the aviation sector "Aviation Health Safety Protocol - Operational guidelines for the management of air passengers and aviation personnel in relation to the COVID-19 pandemic" (AHSP) document, first published on the 20 May 2020. Currently, the third amendment of the AHSP was adopted on 17th June 2021. Its purpose is to provide a source of best practice on how airport operators, aircraft operators conducting both commercial and non-commercial passenger transport operations along with the National Competent Authorities can ensure the health and safety of air passengers, as well as of the aviation personnel who serve them, by maintaining safe and secure operations whilst minimising the risk of SARS-CoV-2 transmission. Impact of implementation on Competent Authorities in Europe. On 14 June 2021 the European Parliament and the Council adopted Regulation (EU) 2021/95310 on a framework for the issuance, verification and acceptance of interoperable SARS-CoV-2 vaccination, test and recovery certificates (EU Digital COVID Certificate) to facilitate free movement during the SARS-CoV-2 pandemic and Regulation (EU) 2021/95411 on a framework for the issuance, verification and acceptance of interoperable SARS-CoV-2 vaccination, test and recovery certificates (EU Digital COVID Certificate) with regard to third-country nationals legally staying or residing in the territories of Member States during the SARS-CoV-2 pandemic. **SIGNIFICANCE:** The implementation of standardized SARS-CoV-2 preventive measures, including testing and vaccination, combined with the internationally accepted vaccination certificates would facilitate faster recovery of the regular aviation activities.

Learning Objectives

1. The audience will learn about the development of the EU policy regarding SARS-CoV-2 transmission preventive measures.
2. The participant will be able to understand challenges of the implementation of SARS-CoV-2 transmission preventive measures in EU member state.

[373] SARS-COV-2 VACCINATION: EFFECTIVENESS AND SAFETY, CERTIFICATION AND VACCINE "PASSPORTS": GROUND-BASED MEDICAL SERVICES PERSPECTIVE

Neil Nerwich¹, Paulo Alves²

¹International SOS, London, United Kingdom; ²MedAire Inc., Phoenix, AZ, USA

(Original Research)

INTRODUCTION: All lines of service provided by ground-based medical services providers (GBMS) were directly or indirectly affected by the pandemic. On the passenger end, activity dropped in parallel with the overall passenger traffic. A heightened awareness around Covid-19 followed the WHO declaration of pandemic. We studied the prevalence of suspected infectious diseases (SID) on a weekly basis from 2019 to 2021, both for in-flight (IF) and pre-flight (PF) occurrences. Objective: To study the impact of Covid-19 in the in-flight and pre-flight profiles from a ground-based medical services provider (GBMS) standpoint. Methods: Data was retrieved between 01/01/2019 to 08/30/2021. A total of 72,558 in-flight events and 88,679 pre-flight passenger fit-to-fly assessments were available for analysis. Cases were categorized by medical professionals as SIDs or Non-SID. Results: Median weekly SID IF incidences for 2019, 2020, 2021 were respectively: 4.1% (range: 2.5-7.3%); 4.2% (0-18.9%); 2.8% (0.7-6.1%); and for PF: 4.0% (3.2-7.7%); 7.4% (1.3-15.7%); 3.5% (1.3-8.5%). Those differences were not statistically significant. Using 7-week rolling average IF returned to pre-covid levels while PF remained high for most of 2020, declining in 2021. Conclusion: The usual seasonal SID variation pattern was disrupted during Covid-19. SID levels initially increased for IF and PF following WHO announcements and decreased in different times. Heightened awareness seems to be underlying factor. It is possible that the increased levels of pre-flight assessment contributed to the lower than previous levels of SIDs occurring in-flight. The standardization of pre-flight requirements between countries will certainly contribute for a smoother experience for the passenger.

Learning Objectives

1. The audience will learn about the changing prevalence of suspected infectious diseases as witnessed by a ground-based medical services provider.
2. The audience will learn about the effect of public health declarations on the detection of suspected infectious diseases.

Thursday, 05/26/2022

1:30 PM

Tuscany F

[S-72]: PANEL: COLLABORATIVE DEVELOPMENT OF AIRCREW PHYSIOLOGICAL MONITORING, WARNING, AND MITIGATION SYSTEMS.

Chair: Stephanie Warner

PANEL OVERVIEW: Over the past several years, the Department of Defense (DoD) has dedicated much time and resources to develop devices to monitor the physiologic status and environmental conditions experienced by tactical aviators. Much of this effort has focused on the capacity to alert and warn these pilots of adverse conditions, allowing them critical time to enact emergency procedures. Researchers at IHMC, NAMRU-D, NAWCAD, and 711th HPW and have collaborated on a variety of projects across the breadth of these efforts. This panel will provide practicable information, lessons learned, and identified solutions associated with the DoD's physiological monitoring and warning system development, including how these devices function together during manned device verification and validation testing, how to interpret the data by parallel development of a threshold-based warning system that uses decision algorithms, artificial intelligence (AI) and vision machine learning, and finally what to do with the data through development of an autonomous adaptive breathing regulator. **PANEL STRUCTURE:** The first presentation describes simultaneous exposure testing at NAMRU-D in which multiple prototype physiological monitoring devices are evaluated during altitude chamber and centrifuge exposures. Human responses are used as truth data to

train AI in warning systems, as well as to compare device performance against each other and to reference devices. The second presentation describes an effort by NAVAIR, NAWCAD, and Athena GTX to integrate the various prototypes into a single wire-free hub to stream sensor data to assess pilot state and use already deployed Garmin watches to display warnings. The third presentation features a novel approach to use AI-based machine vision algorithms to develop a threshold-based warning system by IHMC. The final presentation by the 711th HPW provides an update on a Foreign Comparative Test program to develop an Autonomous Pilot Physiology-Based Life Support System (APLSS) to adaptively control LSS function based on human responses in real time.

[374] SIMULTANEOUS EXPOSURE TESTING AND DEVELOPMENT OF ENVIRONMENTAL AND PHYSIOLOGICAL MONITORING SYSTEMS.

Stephanie Warner¹, Barry Shender², Lloyd Tripp³, Paul Sherman⁴, Katherine Bear⁵, Lesley Lee⁶, Samantha Keller⁵, Jesse Leiffer⁵, Kiersten Compton⁵, Dain Horning¹

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(Education - Program/Process Review)

INTRODUCTION: The DoD is developing in-flight environmental and physiological monitoring systems. Identifying the optimal combination of devices is crucial to ensure system accuracy, acceptance, and usability. Additional effort is focused on the culminating pilot alerting and warning system by incorporating artificial intelligence and machine learning to algorithmically execute threshold-based computational decisions. NAMRU-D, NAWCAD, the 711th HPW, and IHMC are completing a comparative evaluation of multiple candidate devices under simultaneous exposure conditions representing aviation-specific environmental extremes. **METHODS:** After providing their informed consent, each volunteer was outfitted with 3-13 candidate devices, and additional reference devices for performance verification, for the duration of the testing conditions. Devices included the Thera Tactics Enhanced Pulse Oximeter, Athena GTX Holistic Modular Aircrew Physiologic Status (HMAPS) Monitoring System, Elbit Canary, and others contracted for development through the Defense Innovation Unit or a Cooperative Research and Development Agreement. To date, simultaneous exposures have included arterial blood gas evaluation (completed, n=12) and altitude chamber and centrifuge testing (in-progress, n=18 & n=15). **RESULTS:** Common statistical techniques (e.g., Bland-Altman analysis, linear regression) are being used to analyze the data from the candidate devices to determine device interference, accuracy and correlations across devices. Participant feedback and visible inspection provide subjective acceptance and usability criteria. Outcome data are also being leveraged to provide "truth" information to enhance algorithm development. **DISCUSSION:** Introduction of the human element into any testing, application, or design immediately increases the complexity. Couple this with the multifaceted constraints of the tactical aviation environment and it becomes increasingly challenging to accomplish the goal of developing a physiological monitoring and alerting system. To accomplish these efforts efficiently and effectively, flexibility and cooperation across the joint research labs and commercial organizations is required. Execution of this testing will yield ranked qualifications of candidate devices, and the outcome data will support critical algorithm development and technology advancement. All of which are necessary to achieve the optimal environmental and physiological alerting and warning system.

Learning Objectives

1. The audience will be able to understand the various logistical nuances associated with simultaneous exposure testing.
2. The audience will learn about the performance of several leading candidate devices for inclusion in a physiological monitoring, warning, and mitigation system.

[375] HSHUB: AN INTEGRATED COMMUNICATION PLATFORM FOR AIRCREW PHYSIOLOGIC MONITORING AND WARNING

Barry Shender¹, Raisa Marshall¹, Bridget Rinkel¹, Nicholas deBlois², John Elson², Amanda Muller², Sean Mahoney², Phillip Whitley³, Maya Hoagland³

¹Naval Air Warfare Center Aircraft Division, Patuxent River, MD, USA; ²Athena GTX, Johnston, IA, USA; ³Criterion Analysis, Inc., Miami, FL, USA; ³Naval Air Systems Command, Patuxent River, MD, USA

(Education - Program/Process Review)

BACKGROUND: The US Navy has mounted a considerable effort to evaluate physiologic and environmental sensors to develop an aircrew monitoring and warning system (AMWS). This involves a collaborative effort with the US Air Force that is partially funded through the Defense Innovation Unit. Several prototype devices designed to operate independently were tested and evaluated. None of which was a complete AMWS. What is needed is a unified system that integrates these devices to determine aircrew status in real time that reliably functions in the jet aircraft environment. A proof of concept effort to create this system began in June 2021.

DESCRIPTION: AMWS tracks tissue oxygenation (cerebral and blood), heart rate and variability, breathing rate and patterns, aviator mask gas and pressure, acceleration, and ambient pressure and temperature. It takes these data and estimates aircrew physiologic state, physical workload, fatigue from G-exposure, and cognitive status. The wire-free Bluetooth Low Energy (BLE) protocol links the sensors. The challenge is to connect and time sync these signals from different BLE transmitters, determine signal quality, input them into the status algorithms, determine if a warning is needed, and communicate the status. **DISCUSSION:** The core of the system is the "HsHub" derived from Athena GTX's Holistic Modular Aircrew Physiologic Status (HMAPS) monitoring system that has been successfully tested in-flight. This serves as the communications nexus and status arbiter. Athena GTX is demonstrating the prototype HsHub with its HMAPS peripheral devices (including an updated environmental sensor and wire-free ECG patch), Honeywell Biosensing Apparel (compression t-shirt and bra), Intelligent Optical Systems in-mask sensors, and NIRSense cerebral tissue oximeter. Each device has an Interface Control Document that outlines the BLE requirements and the types and rate of data transmission. An app has been created and bench tested to display the information on Android and Garmin smartwatch platforms. HsHub function and life support equipment compatibility will be dynamically tested in the altitude chamber, centrifuge, and in-flight with the assistance of the Patuxent River Flight Test Squadron.

Learning Objectives

1. The audience will learn about the next step in the evolution of developing and validating an aircrew physiologic monitoring and warning system.
2. The audience will learn about the types of sensors considered core to an aircrew physiologic monitoring system.

[376] MULTI-SENSOR SIGNAL INTEGRATION AND DATA PROCESSING USING VISUAL INFORMATION OUTPUT AND IMAGE ANALYTICS

David Fries, Jeffrey Phillips

Florida Institute for Human and Machine Cognition, Pensacola, FL, USA

(Original Research)

BACKGROUND: Monitoring the physiological status of military operators in-situ requires real-time data integration and analysis across devices, from various manufacturers. Such data fusion is challenging due to bandwidth limitations, varying data formats, embedded systems access, and requirements for high processing capability to provide data analytics in real-time. Multi-sensor signal integration and data processing using visual information output and image analytics can help eliminate bandwidth issues and convert varying data formats into a common vernacular. Visual analytics can be performed instantly and in real-time and possess logical decision trees to offer decision-support to inform operators of multivariate trends that indicate relevant physiological changes. Deep learning can be employed to discover new relationships between important variables and desired outcomes. CPUs located within the central data hub may be configured to preprocess critical information from data collection nodes further reducing bandwidth requirements.

METHODS: Thirty-five participants were exposed to four different levels of carbon dioxide (1%, 2.5%, 4%, 5.5%) for 15 minutes each through a standard aviation flight mask. Participants were monitored throughout the exposure with a pulse oximeter and a transcutaneous carbon dioxide monitor. A hardware-software integrated machine learning based camera (IDS NXT), was aligned with the two instruments and deep learning optical character recognition (OCR) applied to the displays of the monitors. The camera acquired images and OCR was applied to four parameters: pCO₂, pO₂, heart rate, and vO₂. The OCR analysis was performed in Open eVision Software using the deep learning OCR library which has built-in trained models for detection and classification of text. A second, deep learning image processing layer was applied to the captured images for classification of hypercapnia. **RESULTS:** After the deep learning was constructed, initial sample data were used to evaluate and obtain classification output. Initial classification results from sample images yielded patient condition scoring and classification accuracy greater than 90% for classifying participants with hypercapnia.

DISCUSSION: Multi-sensor signal integration and data processing using visual information output and image analytics can help eliminate bandwidth issues, fuse data formats into a common vernacular, and provide multi-layer decision support.

Learning Objectives

1. Learn the common issues associated with data fusion across multiple devices.
2. Understand how multi-sensor fusion and analytics can be carried out without overburdening processing ability.
3. Learn about decision support and analytics that can be imbedded.

[377] AUTONOMOUS PILOT PHYSIOLOGY-BASED LIFE SUPPORT SYSTEM (APLSS) TO ADAPTIVELY CONTROL LSS FUNCTION BASED ON HUMAN RESPONSES IN REAL TIME

Lloyd Tripp¹, Stephanie Warner²

¹711 Human Performance Wing, Wright-Patterson AFB, OH, USA; ²Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, USA

(Education - Program/Process Review)

BACKGROUND The flight environment has always posed physiological hazards to aircrew who fly high-performance aircraft. This has recently come to light for both the US Air Force and US Navy with reports of hypoxic like symptoms in-flight. The US Air Force Research Laboratory, Navy Medical Research Unit Dayton and multiple international and U.S. commercial have teamed up to develop an array of physiological monitoring and warning systems. These physiological monitoring devices measures arterial oxygen saturation, pulse rate and head-level blood perfusion Expired O₂ and CO₂. This system is designed to monitor and warn of impending hypoxia, hypo- and hypercapnia cabin altitude, acceleration. **DESCRIPTION** Elbit Canary helmet measured arterial oxygen saturation, heart rate cabin altitude. Additionally, a MBU-20/P oxygen mask modified with the Cobham Vigilox Inhalation and exhalation sensor blocks, which will measured inhaled oxygen partial pressure, flow and mask pressure & temperature. The exhalation sensor

block measured exhaled oxygen and carbon dioxide partial pressure, flow and temperature. The Autonomous Breathing Regulator computer accepts physiological data from the Canary helmet and Vigilox systems. These data are then analyzed and the computer algorithm makes real-time changes to oxygen concentrations and flow. Additionally, head level perfusion is monitored during high-G exposure. **DISCUSSION** Current aircraft systems contain thousands of sensors dedicated to monitoring the state of the aircraft, but none are allocated to monitoring the state of the pilot. The Autonomous Life Support System in not only dedicated to monitoring both respiratory physiology and hemodynamics and providing these data to breathing regulator which seamlessly controls the concentration of oxygen to the pilot. The system is designed with the capability to warn the pilot that they are experiencing hypo- and hypercapnia, hypoxia as well as to provide auditory feedback to the pilot when head-level perfusion is approaching a critical state and warns the pilot to perform the anti-G straining maneuver.

Learning Objectives

1. The participant will be able to understand how in-flight physiology can aid the aircraft life support system function.
2. The audience will learn how the application of autonomous systems can be utilized to enhance performance of pilots of high performance aircraft.
3. Participant will learn how these technologies represent a new beginning in the application of autonomous technology and how their role in pilot protection will be expanded in the future.

Thursday, 05/26/2022

1:30 PM

Tuscany 3

[S-73]: PANEL: HEADACHES IN AVIATORS

Chair: Joseph Connolly

Co-Chair: Aven Ford

PANEL OVERVIEW: INTRODUCTION: Headache is a common cause of neurologic disability affecting up to half of the world's population. Migraines and other headache types are potential disqualifying conditions. Little is known about the epidemiology of headache in aviators or the prevalence of in-flight headaches. Many medicines used to treat migraines are not approved for aviators. **TOPIC:** The epidemiology of USAF pilots and flight surgeons who have been granted waivers for Migraine will be presented, including trigger factors and management strategies. The prevalence of in-flight headache in a cohort of high-altitude pilots will be presented, along with a proposed algorithm for the differential diagnosis of headache in flight. Case reports presented will include a pilot with migraines, demonstrating common challenges to military aviators and flight surgeons in diagnosing and treating headaches, as well as an in-flight incapacitating headache with subsequent FAA certification. Modern headache treatment recommendations which are or are likely aeromedically acceptable or waiverable will be presented. **APPLICATION:** Headache is the most common neurologic condition, and it's prevalence in aviators is likely underestimated. The necessarily conservative aeromedical disposition practices initially precluded medical certification for many with migraines. The characteristics and management of USAF and civilian pilots waived or certified will be presented. Aviators with headaches have continually advocated for return to flying activities. The differential diagnosis of in-flight headache includes the terrestrial differential diagnosis as well as physiologic events from the stressors of flight, a proposed algorithm of in-flight headache will be presented. There are a myriad of lifestyle, non-prescription and prescription medications and devices that are great treatment options for aviators with headaches of various types.

[378] MIGRAINE MANAGEMENT AND OUTCOMES IN US AIR FORCE PILOTS

Roger Hesselbrock¹

¹USAFSAM, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Migraine is a commonly-encountered condition that has significant aeromedical implications. Accurate assessment of future risk is imprecise due to variability and unpredictable nature of occurrences. Management is limited to aeromedically-compatible medications and non-pharmacologic treatments. Consequently, a necessarily conservative approach to aeromedical recommendations may lead to over-restrictive dispositions. Additional information on aeromedically-compatible management strategies and long-term outcomes would be useful in aviators with migraine. **TOPIC:** This presentation will cover results from a recent retrospective study of 159 trained US Air Force pilots and 44 flight surgeons with migraine who had received aeromedical waivers. Migraine with aura and isolated migraine aura without headache accounted for the majority of migraine subtypes. Subjects reported an average of only 3 migraine attacks in the previous year. Long-term follow up indicated continued aeromedical waiver in 91% of subjects. Potential triggering factors were self-identified in 62% of subjects. The most commonly reported migraine triggers were dietary factors, sleep disturbances, stress, caffeine intake, and hormonal factors. 54% of subjects reported a positive response to trigger factor modification. **APPLICATION:** These findings can be incorporated into individualized aeromedically-compatible management strategies to clarify symptom impact on aviation safety, improve symptom control and increase the possibility of safe return to fly recommendations. Information from this presentation is primarily applicable to military aviators, but also can be used in migraine management of civilian aviators. **RESOURCES:** Hesselbrock RR, Haynes JT. Migraine History and Outcomes in Military Pilots and Flight Surgeons. *Aerosp Med Human Perf* (in press).

Learning Objectives

1. Identify the most commonly reported triggering factors for migraine headaches.
2. Note the potential salutary effect of trigger factor modification in migraine management.

[379] HEADACHE PREVALENCE IN FLIGHT FROM A CADRE OF HIGH ALTITUDE PILOTS

Mike Lang¹, Joseph Connolly¹, Aven Ford¹, Jared Haynes¹, Paul Sherman²

¹USAFSAM, Wright-Patterson AFB, OH, USA; ²Department of Aerospace and Operational Medicine, Wright-Patterson AFB, OH, USA

(Original Research)

BACKGROUND: Headache is a common cause of neurologic disability affecting up to half of the world's population, little is known about the prevalence of various headache types in aviators, or the prevalence of headaches in flight. Headaches of various types/etiologies occur in aviators during flight, but the prevalence of this phenomenon is unknown.

METHODS: A cohort of 100 U-2 pilots answered medical, occupational and recreational questionnaires and subsequently underwent brain high resolution MRI. The prevalence of affirmative responses to headache questions and headache patterns were tabulated. Categories of rare versus often, and mild versus moderate were used to describe headache patterns. Headaches were compared with history of Decompression Sickness (DCS) and responses were compared to volume and number of brain White Matter Hyperintensities (WMH). Subgroup analysis was accomplished with linear and logistic regression models, investigating trends and odds ratios respectively. **RESULTS:** Among 100 enrolees, 99 completed an MRI scan.

Among the 99 scanned, one did not complete a questionnaire. 28 of the 98 respondents endorsed headache during flight. Among those experiencing rare headaches, 9 of 24 had been treated for DCS. Among those experiencing headaches often, none (0 of 4) had been treated for DCS. Rare headaches were more common (24%) than frequent headaches (4%) for cohort enrolees. **DISCUSSION:** A framework for a differential diagnosis of headache in flight will be proposed.

Learning Objectives

1. Aviators with existing headache syndromes experience headaches during flight, and their headache syndromes are not indicative of an episode of DCS.

2. New headache syndromes during flight in the context of an appropriate cabin altitude should be considered DCS unless an alternative etiology is readily apparent.

[380] THE PREVALENCE OF HEADACHE IN GENERAL AVIATION PILOTS STRATIFIED BY FLIGHT ALTITUDE: AN ONLINE SURVEY

Michael F. Harrison¹, William P. Butler², M. Hassan Murad³, Gary N. Toups³

¹Mayo Clinic, Jacksonville, FL, USA; ²711th Human Performance Wing, Wright-Patterson AFB, OH, USA; ³Mayo Clinic, Rochester, MN, USA

(Original Research)

INTRODUCTION: General aviation (GA) aircraft capability is increasing with multiple single-engine, unpressurized piston aircraft now capable of flight at altitudes >18,000'. Headache (HA) remains a nebulous symptom that may be multifactorial. The impact of HA on a pilot may range from being benign and self-limiting to serious and incapacitating. We present the results of an online study of headache in GA pilots flying above and below 18,000'. **METHODS:** A web-based survey was distributed to an online pilot's forum. The tool surveyed flight history with respect to altitude (>18,000') and its associated physical and neurological symptoms in pilots and passengers. **RESULTS:** Forty-five pilots completed the survey. Twenty-five (56%) reported flight >18,000' in the preceding year. Among these pilots, in-flight HA was reported by 7 (n=25, 28%), as the most common symptom. During flight <18,000', HA was reported by 12 (n=35, 34%), again, the most common symptom. **DISCUSSION:** HA was the most common in-flight complaint among pilots and passengers during flight >18,000' and <18,000'. No safety events were reported among the survey respondents and the etiology of the HA went undetermined. However, possible causes may include dehydration, hypoxia, and decompression illness. The seeming high prevalence of HA in GA suggests future research should focus resources and attention on in-flight HA.

Learning Objectives

1. The participant will learn about the prevalence of in-flight headache in general aviation pilots and the associated differential diagnoses to be considered.
2. The participant will learn about the association with flight altitude with in-flight headache in general aviation pilots.

[381] CASE PRESENTATION: MIGRAINE HEADACHES OVER A PILOTS CAREER

Joseph Connolly

USAFSAM, Wright-Patterson AFB, OH, USA

(Education - Case Study)

INTRODUCTION: Headache (HA) is a common cause of disability affecting up to half of the world's population. Migraines are disqualifying in the USAF. This case report outlines the diagnoses, treatment and pitfalls of one pilot's migraine headaches. **CASE DESCRIPTION:** In 2011 the pilot had a daily posterior HA after a Cold, relieved with Excedrin and denied fever/stiff neck/aura; treated with NSAIDs. There was no mention of HA in eight yearly Periodic Health Assessments. In Dec 2018 the aviator presented with daily headaches for six weeks, the pain traveled from the top of head to neck with no associated symptoms; diagnosed as tension headaches and referred to Chiropractic. On pre-deployment screening February 2019 the pilot noted no medical concerns and denied Ibuprofen in the last week. August 2019 he was returned from deployment due to new unrelated condition, and noted to have a normal MRI of his brain. November 2019, the pilot stated he had headaches frequently daily for 10 years and just put up with it, also chronic sleep issues. On the deployment he had daily holocranial headaches worse crown to occiput, occurred upon awakening, denied were visual aura, nausea and emesis; provoked by poor sleep, stress and eating meat. He would treat his headaches by taking ibuprofen and laying down in a dark room. His maternal grandmother had migraines. He was started on Topamax for his other condition and over several months his migraines decreased to

once a week. A month later he was diagnosed with Obstructive Sleep Apnea and started on CPAP. By 2021 he has failed Topiramate and Magnesium as prophylaxis, is taking propranolol and erenumab and is interested in Botox. He has comorbid depression and anxiety treated with fluoxetine and lamotrigine. **DISCUSSION:** Globally Migraine is underdiagnosed. Anxiety, depression, sleep disturbance and OSA are common Migraine co-morbidities. There is an incentive for aviators to under report headaches and to over report at Service separation.

Learning Objectives

1. The audience will understand some of the challenges in communicating with aviators experiencing headaches.
2. The audience will learn about the importance of looking for comorbid conditions in aviators with frequent migraine.

[382] VIDEO FOOTAGE OF A POSSIBLE IN FLIGHT HEADACHE INCAPACITATION

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¹FAA, Oklahoma City, OK, USA; ²FAA, Seattle, WA, USA

(Education - Case Study)

INTRODUCTION: Headaches are common, however in-flight incapacitation from headache is rarely reported. We present a case video recording possible in-flight incapacitating headache and discuss the aeromedical implications. **CASE PRESENTATION:** A YouTube aviation enthusiast posted a seemingly harrowing experience of a severe headache while piloting a small aircraft, with an uneventful off-airport landing. A viewer reported to the FAA safety hotline. Later, comments on the video state the events were acted out. The airman was flying a light experimental aircraft, apparently in the descent phase to land, after a cross-country flight. Video shows his apparent distress, holding the left side of his head. Following a successful off-field landing, he is seen pushing the aircraft without apparent discomfort, discussing having some headaches in the past, though "not for a long time". A Neurologist reports about 2 headaches per year, typically mild and not requiring treatment. Mild TBI reported 3 years prior when he sustained a traumatic occipital condyle fracture. Current MRI brain showed no gliosis or hemosiderin; a sphenoid mucous retention cyst is seen on MRI and CT. ENT evaluation notes chronic sinusitis as well as the cyst, opining possible association with the event. Other seemingly risky actions were reported to the FAA and investigated with no action. One accident was reported with aircraft damage, fortunately no injuries. **DISCUSSION:** Differential Diagnosis: 1) Migraine, cluster and atypical headache. These are unpredictable. Risk assessment depends almost entirely on history and reporting of all disabling symptoms. 2) Post traumatic headaches are relatively common after all types of head injury. Features often resemble, and have prognoses similar to, the respective primary headache syndromes. 3) Sinus headache. Risk assessment depends on the underlying condition and treatability. For common allergic sinusitis, use of pre and/or in-flight decongestants are allowable as needed to treat or prevent sinus symptoms. 4) Embellishment. While high aeromedical risk for incapacitation is not expected, there are concerns about situational appropriateness and aeronautical decision making. **RESOURCES:** <https://youtu.be/PtHpvQ2vPb>

Learning Objectives

1. Identify risks of potential incapacitation and other hazards to the aviation environment of headache syndromes.
2. Differentiate causes of incapacitating headaches that may present in the aviation environment.
3. Plan the diagnostic evaluation of incapacitating headache that allows risk determination and appropriate mitigation.

[383] AEROMEDICALLY-ACCEPTABLE TREATMENTS FOR HEADACHE

Aven Ford

USAFSAM, Wright-Patterson AFB, OH, USA

(Education - Tutorial/Review)

INTRODUCTION: Many of the available headache medications are not appropriate for use in aviators. Fortunately, there is mounting evidence that shows that lifestyle interventions such as diet change, sleep hygiene counseling, mindfulness, and movement practices/physical exercises that can effectively decrease the impact of headaches. In addition, rational use medications may provide a way forward for the aviator with headaches. **TOPIC:** In the non-aviator, having a few migraines per week may be considered an adequate response; however, in the aviator more intensive management is required. The management of headache in the aviator requires an aggressive and multi-faceted approach. The most efficacious treatments will combine early use of highly-effective acute headache treatments with lifestyle interventions, vitamins/supplements, and often preventive medications. A recent study of Air Force aviators found that more than half of the aviators studied found modification of behavioral and dietary factors effective for reducing the impact of migraines. Other non-pharmacologic measures that maybe effective include vitamins/supplements and interventions related to sleep, mindfulness, and physical exercise. Regarding pharmacologic prevention, many FDA-approved headache preventive medications, including the anticonvulsants and older antidepressant medications are not appropriate. Antihypertensive medications can be considered for migraineurs in non-high performance platforms. Treatment with chemodenervation (usually with botulinum toxin), external stimulator devices, and calcitonin gene-related polypeptide (CGRP) antagonists and modulators are relatively new, but may provide a well-tolerated alternative for headache prevention and should be considered on a case-by-case basis. Aviators should be instructed to track their headaches closely to ensure adequate response to treatment and identify effective lifestyle interventions. **APPLICATION:** This presentation will discuss the appropriate approach to an aviator with headaches, focusing on the acute treatment and prevention of migraines. It aims to provide a framework for a multifaceted approach to the aviator with headaches.

Learning Objectives

1. Discuss a rational approach to the aviator with headaches.
2. Discuss appropriate acute and preventive treatment strategies for the aviator with headaches.
3. Discuss strategies for implementation of these interventions.

Thursday, 05/26/2022
Tuscany 4

1:30 AM

[S-74]: SLIDE: AEROMEDICAL POLICY: IF YOU TRY, SOMETIMES YOU GET WHAT YOU NEED

Chair: Alden Hilton

Co-Chair: Elizabeth Eekhoff

[384] PRE-FLIGHT MEDICAL SCREENING IN THE COMMERCIAL SPACEFLIGHT PARTICIPANT

Maia Gummer¹, Lauren Church¹, Nina Purvis², Eleonor Frost³
¹King's College London, London, United Kingdom; ²Barts and the London School of Medicine, London, United Kingdom; ³University of Aberdeen, Aberdeen, Scotland, United Kingdom

(Education - Program/Process Review)

INTRODUCTION: With the advent of commercial spaceflight, the safety of commercial spaceflight participants (CSPs) is paramount; there is currently no commercial spaceflight-specific medical standard. Each CSP will need to be fit-to-fly to ensure their own and others' safety. This research considers anticipated and studied medical conditions that may be aggravated by the suborbital spaceflight environment (SSE), and proposes a possible pre-flight medical screening for medical professionals. **METHODS:** A suborbital vehicle profile is defined, detailing the environment a participant would experience; including G-force acceleration, microgravity, radiation, noise and confinement. A

three-phased approach was used to hypothesise medical checks. A literature review was conducted to better understand the physiological changes in the SSE, and then to identify conditions with which a CSP may present and how these would respond in the SSE. Medical conditions were categorised according to the limitation they might impose on a CSP to fly with parameters for fit-to-fly where appropriate. Certain conditions were subject to extra scrutiny if they were believed to disproportionately affect the predicted demographic. Concurrently, a survey was distributed to aerospace medicine professionals (responders n=19) to assess current knowledge and identify unthought of considerations. **RESULTS:** Literature review and questionnaire results are collated and presented. There are conditions which might be prohibitive, such as recent surgery (14 days), ventricular arrhythmia, or severe inflammatory bowel disease. There are conditions, where appropriately managed, which might be permissible, such as controlled hypertension (150/90mmHg), diabetes mellitus types 1 and 2 (ideally below 48mmol/mol), and asthma (no recent hospital admissions). An extensive table of conditions is presented with parameters for fitness-to-fly, along with guidance for pre-flight medical history taking, examination and investigation – to be personalised according to the CSP. **DISCUSSION:** It is hoped that the proposed pre-flight medical screening will serve as an aid to aerospace physicians and the wider medical community to screen for prohibitive and permitted conditions in order to ensure the safety of CSPs, ensuring full informed consent of the risks of participation. Further research studies into the tolerance of the SSE in participants with pre-existing medical conditions is advocated.

Learning Objectives

1. The delegate will be familiarized with the environment experienced by participants during suborbital spaceflight and how this may impact on disease states.
2. The delegate will read guidance collated from existing literature and professional opinion on pre-flight medical checks for commercial spaceflight participants.

[385] USAF CADET MEDICAL ACCESSIONS: DISQUALIFYING CONDITIONS, WAIVER RATES AND RATIONALE

Hernando Ortega, Eduardo Rizo, Rodger Vanderbeek
USAF Recruiting Service, San Antonio, TX, USA

(Education - Program/Process Review)

BACKGROUND: Department of Defense (DOD) Instruction (DODI) 6130.03 authorizes the Service Secretaries waiver authority to the medical standards applied by DODMERB (DOD Medical Examination Review Board) for cadet accessions. In 2019, the Vice Chief of Staff of the AF (VCSAF) established an Accession Medical Waiver Division (AMWD) to consolidate entry waiver authorities for all components of the Air Force (AF) (Active Duty, Reserves, Air National Guard, USAF Academy, USUHS). DAFMAN 48-123 delegates the Surgeon General's waiver authority to AMWD for application of medical standards for accession and flying/special duty exams for the USAF. **OVERVIEW:** The AMWD performs occupational suitability assessments through four program branches focused on Enlisted, Officer, and Cadet accessions, as well as a Flight and Operational Special Duty branch for specific AF Specialty Codes. The Operations branch integrates data sets for analysis to shape waiver protocols and ultimately create a feedback loop to shape medical standards for the changing landscape of AF combat operations and improved medical treatments. The Cadet Accessions Branch is the primary office that deals with DODMERB examinations and waivers for officer accessions into the USAF Academy and ROTC programs. The primary data system used to document risk analysis and decisions is the Physical Examination Tracker (PETrack) module within the Air Force Recruiting Information Support System-Total Force (AFRISS-TF) program. **DISCUSSION:** The AMWD documents occupational risk determinations on medical standards waivers in PETrack. This allows identification of disqualifying diagnoses, waiver rates and some outcomes by applicant type, specifically for AF ROTC applicants, as well as the USAFA class of

2025, the DODMERB populations. The Operations branch performed a retrospective descriptive analysis of the cadet/officer applicant pool and will present the most frequent disqualifying diagnoses presented for waiver determination along with waiver rates. The analysis of waiver requests and rates are subject to the bias of medical standards themselves; however, the USAF risk rationale parameters, including estimates of probability/frequency/severity of adverse events, estimated time horizons, expected longevity, operational mission impact severity from occurrence of such events and return on training investment considerations, will be introduced in preparation for case study and discussion.

Learning Objectives

1. The audience will learn about the Officer accession processes involving DODMERB review of applicants for USAFA and AFROTC cadet medical standards application.
2. The audience will learn about the types of disqualifying medical conditions that are encountered in the accession of cadets into the USAFA and AFROTC.
3. The audience will learn about the waiver rates and medical rationale that are produced by the Waiver Authority in the accession of cadets into the USAFA and AFROTC.

[386] DODMERB E-MEDICINE BUSINESS MODELING PROCESS FOR OFFICER APPLICANT MEDICAL QUALIFICATION DETERMINATION

Michael Rappa, Glenn Dowling, Kenneth Kuhn, William Mann, Lawrence Mullen
Defense Health Agency, Colorado Springs, CO, USA

(Education - Program/Process Review)

BACKGROUND: Aerospace medical professionals may be aware of the use of process improvement, modeling and process reengineering in the business world. These same concepts can be effectively applied to organizations in the aerospace medicine enterprise. This presentation provides aerospace medical professionals a practical example of how to apply these modern business techniques in their organization to improve services. **OVERVIEW:** The Department of Defense Medical Examination Board (DoDMERB), a division of the Defense Health Agency, schedules and evaluates screening medical examinations for determination of medical qualification or disqualification for approximately 95% of applicants to commissioning programs of the U.S. Uniformed Services, to include all five Service Academies, all Reserve Officer Training Corps programs, the Uniformed Services University of the Health Sciences, and other programs as assigned by the Assistant Secretary of Defense for Health Affairs. For the armed services, an overwhelming majority of officers going on to flight training arise from this screening pool. Department of Defense Instruction 6130.03, "Medical Standards for Appointment, Enlistment, or Induction into the Military Services," provides the framework and standards. However, the process by which these medical qualification determinations are made is not specified. Rather, the DoDMERB has continued to improve and refine this process for the past two decades, now delivering about 45,000 qualification/disqualification determinations annually. Using modern techniques of business process reengineering and modeling methodologies, this process is reviewed. Included is an overview of a process, process mapping, and modeling using process flow charts, swim-lane cross-function flow charts, and the SIPOC (suppliers, inputs, process, outputs, customers) tool. **DISCUSSION:** The e-medicine business modeling process is an effective method for understanding organizational workflow and the resources required for services provided by an organization. This process can be effectively utilized across virtually any organizational setting in support of operations. The application of the business modeling process uncovers opportunities for improvement of services in a manner that may not have been recognized previously. This is operationally significant as acting on these opportunities is a way that aerospace medicine organizations can improve services and position them to thrive in the future.

Learning Objectives

1. The audience will learn about the Department of Defense Medical Examination Review Board process for determining officer applicant medical qualification or disqualification.
2. The audience will be able to apply the concepts of modern business techniques in their organization to improve services.

[387] NAVIGATING PREGNANCY AND PROPELLING WOMEN'S CAREERS WITHIN AEROMEDICAL WORK

Heather Storey¹, Peter Hodkinson², Jemma Austin², Natalie Davies-White³

¹Barts and The London NHS Trust, London, United Kingdom;

²King's College London, London, United Kingdom;

³LifeFlight Australia, Brisbane, Australia

(Education - Tutorial/Review)

INTRODUCTION: Women of child-bearing age make up an ever-increasing element of the aeromedical workforce. However, policy relating to the management of risk for pregnant employees in this sector is often missing or inadequate. The current approach of employers may seek to minimise risk to employees by grounding pregnant employees, but we advocate this reflects an overly simplistic risk-management model that unnecessarily restricts workforce availability and needs modernising. Updated reflections on this important topic will empower the audience to allow informed discussions around pregnancy in aeromedical evacuation roles.

TOPIC: Applying principles from literature surrounding commercial, military and medical aviation, the risks to pregnant employees and the foetus have been reviewed. These risks are complex and dynamic depending on gestation and underlying medical problems, thus individualisation of risk-management is of key importance. In low-risk pregnancies, incapacitation risk is below the usual threshold adopted for safety-sensitive aviation activities, and historical concerns regarding cosmic radiation and hypoxia are of limited relevance to the rotary-wing aeromedical environment. The greatest unknown surrounds the impact of vibration and dynamic forces – these were reviewed, and suggestions given for assessing this risk.

Understanding of maternal physiology and the aviation risk factors provide context to challenge the current misconceptions about the magnitude of the risk to pregnant employees. Case law and anecdotal evidence also show that current policy to ground expecting employees is outdated, and requires individualised discussions. This will also enable employers to retain high calibre members of their workforce during and after pregnancy. Based on available evidence we have quantified risks where possible and provide guidance on the relevant factors to consider in creating a holistic risk-management framework. There is limited evidence in some key areas that require further study, which we highlight in our evidence review.

APPLICATION: Based on a literature review we have generated a framework for understanding and assessing the risks to pregnant employees in the aeromedical sector. This is intended for use by aeromedical service organisations, pregnant employees, and their treating medical practitioners to provide rational and sensible policy and guidance.

Learning Objectives

1. To stimulate reflection and discussion around an important topic which needs updating, and to empower the audience to have more informed discussions around pregnancy in aeromedical evacuation roles.
2. To understand the need for creating a framework for assessing individual risk assessment based on the person or pregnancy considerations.
3. To understand why fixed wing and commercial considerations are not appropriate or applicable when formulating policy for rotary wing aeromedical work.

Thursday, 05/26/2022
Tuscany 12

1:30 PM

[S-75]: PANEL: ETHICAL CHALLENGES IN AEROSPACE MEDICINE: A PANEL DISCUSSION

Sponsored by American Society of Aerospace Medicine Specialists

Chair: Jeff Jones

Co-Chairs: Bruce Bohnker, Nora Johnson, Keith Ruskin

PANEL OVERVIEW: **INTRODUCTION:** *Flight Surgeons, Aerospace Medicine Specialists, Aviation Medical Examiners and other practitioners of Aerospace Medicine may be faced with ethical conundrums in their professional lives. Management of such dilemmas remains a challenge for aerospace medicine providers; therefore ethical standards have been developed by the Aerospace Medical Association and the American Society of Aerospace Medicine Specialists to assist our organizational members. Topic: The panel will initially review data regarding ethical concerns in medicine and the guiding principle of ethics in medical practice. Subsequently the panel will discuss some relevant cases that affect aerospace medicine providers. There is an expectation that providers of aerospace medicine practice their specialty according to the highest ethical standards of the medical profession; as well as according to federal, state, local, and international associations, which provide oversight and guidelines for medical practice. Reviewing ethical case challenges should assist the flight surgeon, aviation medicine examiner, aviation physician assistant and other providers in recognizing potential ethical conflict of interest, as well potential ethical concerns. Application: The case studies will be selected to provoke discussion by the panel and members of the audience. Possible strategies to manage and mitigate ethical challenges will be provided, including possible legal implications. Case examples have been brought forth by flight surgeons, aviation medical examiners and even airmen themselves. After participation, the attendee of the session should have a better appreciation of ethical medical practice, and have some potential tools to assist the practitioner should they encounter situations of an ethical nature. Resources: WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects World Medical Association, 1975.*

[388] ETHICAL DILEMMAS IN AEROSPACE MEDICINE

Jeffrey Jones

Baylor College of Medicine, Houston, TX, USA

(See Overview)

Thursday, 05/26/2022
Tuscany 5/6

1:30 PM

[S-84]: POSTER: DIVERSITY AND TECHNOLOGY IN AEROSPACE MEDICINE: PEOPLE, MODALITIES, AND ENVIRONMENTS

(This is out of numerical session order. Apologies for any inconvenience this may cause.)

Chair: Matthew Doubrava

Co-Chair: Anthony Tvaryanas

[442] DIVERSITY IN AEROSPACE MEDICINE: WHERE WE ARE AND WHETHER IT MATTERS

Andrew Lam

Inova Fairfax Family Medicine, Fairfax, VA, USA

(Education - Program/Process Review)

BACKGROUND: While it may be common knowledge that certain racial and ethnic groups (e.g., Black, Hispanic/Latinx, Native American) have

been historically underrepresented in medicine (URIM) relative to their numbers in the general population, little work has been done to assess and foster the ethnic, gender, and sexual diversity of the aerospace medicine field in particular. The Aerospace Medicine Student and Resident Organization (AMSRO) has recently formed a Diversity Committee to tackle this exact issue, but before spending time and energy on ambitious diversity initiatives, it is worth clarifying whether and why increased diversity would be a valuable asset for the field in the first place. As the aerospace market explodes due to commercial space development and planetary exploration, it is crucial that aerospace medicine practitioners quickly come to agreement on these questions in order to effectively recruit new colleagues to care for our growing consumer base. **OVERVIEW:** Increased workforce diversity confers certain advantages, like novel perspectives for solving problems, while introducing other challenges, such as increased interpersonal conflict when perspectives clash. The history of aerospace activity itself has provided examples of both the positive and negative aspects of diversified teams. A case can be made that as the world globalizes and the aerospace industry inevitably demands heightened cooperation in diverse teams, it is increasingly important that aerospace medicine practitioners train in diverse settings to acquire the necessary cross-cultural skills for the international teams they will find themselves working in. The AMSRO Diversity Committee is actively engaging in research to evaluate the current state of diversity in aerospace medicine and investigate the factors contributing to decreased representation of certain minority groups.

DISCUSSION: The research and outreach of the AMSRO Diversity Committee have the potential to contribute to diversification of the aerospace medicine workforce. While AMSRO's efforts can improve recruitment of students to the field, however, it will likely take other movements, such as increased training opportunities, to truly build a workforce that represents the general population and strengthen the effectiveness of aerospace medicine to solve global problems facing all of humanity.

Learning Objectives

1. The participant will recognize certain demographics as potentially underrepresented in aerospace medicine.
2. The participant will be able to process arguments for and against the increased diversity of the aerospace medicine workforce.
3. The participant will learn about current initiatives being undertaken by the AMSRO Diversity Committee.

[443] THE 'RIGHT TO HEALTH' - A HUMAN RIGHTS-BASED APPROACH TO HUMAN SPACEFLIGHT ACTIVITIES

Jonathan Lim¹, Rowena Christiansen², AJ Link³

¹Jus Ad Astra, Melbourne, Australia; ²The University of Melbourne, Melbourne, Australia; ³Jus Ad Astra, Oxford, MS, USA

WITHDRAWN

[444] WORLD WAR I BRITISH FLYING ACE EXTRAORDINAIRE, MAJOR EDWARD "MICK" MANNOCK, VC, DSO, MC: DID HE REALLY HAVE ONLY ONE GOOD EYE?

Adrien Ivan¹, Douglas Ivan², Thomas Tredici³

¹Vernon College, Wichita Falls, TX, USA; ²ADI Consultants, San Antonio, TX, USA; ³(Posthumously) University of Texas Health Sciences, San Antonio, TX, USA

(Education - Tutorial/Review)

How much depth perception capability is needed, particularly binocularly derived spatial awareness (*stereopsis*), to be a successful aviator has remained under perpetual debate ever since World War I (WWI). Good binocular function was continuously aggravated by additional stressors associated with combat operations of the day, including long periods of time at hypoxic altitudes without supplemental oxygen, the *Oxygen Paradox*, unrestrained flight hours, extreme fatigue, and *psychasthenia*. Compounding the problem was the general attitude amongst period pilots that facing such adversity was sport, a challenge to be met head-on without complaint. Field studies and laboratory investigations during WWI almost

universally supported the need for good ocular muscle control, particularly to avoid double-vision or loss of stereopsis. Vision experts of that period on both sides of the conflict were absolutely convinced that pilots needed normal stereopsis to survive flying training and aerial combat. With rare exception, it is difficult to argue that two normal eyes are much better than one, especially when trying to avoid injury and stay alive. Nonetheless, a few notable exceptions to that premise emerged during WWI, often used to challenge that two normally functioning eyeballs might not necessarily be an absolute requisite. Two of the more well-known "*exceptions*," who later became combat aces, were American William "*Bill*" Thaw II with 5 confirmed aerial kills (possibly 7) and British ace Edward "*Mick*" Mannock with possibly 73 total enemy kills (61 confirmed/12 unconfirmed). Of the two, it was Mannock who was far more productive in terms of aerial warfighting tallies and nicknamed the "*One-Eyed Ace*." In reality, neither of these individuals was actually one-eyed, but each was thought to have impaired vision in one eye. However, some historians have recently challenged whether Mannock, in particular, had any persistent eye problem at all and that his boastful claim to have memorized the visual acuity test chart to avoid detection of a poorly seeing eye during his medical examinations may not have been accurate. This presentation will explore the available records and events, including Mannock's own diary entries, to help determine whether he had enough of an eye problem to warrant the "*one-eyed*" moniker, or that possibly, he may not have had any significant eye affliction at all.

Learning Objectives

1. The audience will learn about the pertinent historical background of the extraordinarily successful British World War I Ace, Major Edward Mannock, often labelled "The One-Eyed Ace," and the role that a longstanding eye problem may or may not have played in his aviation career.
2. The audience will learn about binocular function in the early days of combat flying and its role in vision performance in aerial dog-fighting during World War I.

[445] USE OF PODCAST TECHNOLOGY TO FACILITATE EDUCATION IN AVIATION AND AEROSPACE MEDICINE

Rohan Sant¹, Daniel Olaiya²

¹Ipswich Hospital, Ipswich, United Kingdom; ²University College London Hospital, London, United Kingdom

(Education - Program/Process Review)

The first podcast was developed in 2004 and since then the field of podcasting has ballooned; with over 1.5million podcasts available as of late 2020. Similarly, the field of Aviation and Aerospace medicine has also expanded, with specialist training programmes in the field developing in the US, UK and Australia. We created the Aerospace Medicine podcast with the goal of bringing inspiring stories from experts in the field which might appeal to a vast and varied audience whilst allowing stimulating conversation on which to hinge teaching on topics such as space medicine, human factors and developing research. Within six months the podcast has achieved 1500 listens and 20 5-star reviews on Apple podcasts, demonstrating its reach and worth.

Learning Objectives

1. Understand the value of podcasts in the education of aerospace medicine.
2. Understand the value of podcasts to promote aerospace medicine internationally.

[446] DESIGNING RESTRAINT SYSTEM FOR SIMULATING LATERAL ACCELERATION

Parul Goel¹, Anupam Agarwal²

¹Indian Air Force, New Delhi, India; ²Indian Air Force, Allahabad, India

(Original Research)

INTRODUCTION: Super maneuverable aircraft are capable of executing maneuvers involving multiaxial acceleration. Consequentially,

there is a need to evaluate effects of multiaxial acceleration on human performance. However, the restraint systems available in the centrifuge seat was found largely ineffective in preventing sideways movement of the torso, as well as neck snap under lateral (Gy) acceleration. Thus an additional restraint system was designed for participants undergoing lateral acceleration. **METHODS:** The present study was conducted on High Performance Human Centrifuge (HPHC). 28 healthy male volunteers participated in the study. A restraint was designed specifically for this acceleration profile. A combined acceleration profile +Gz/+2Gy was utilized to test the newly designed restraint system. Effectiveness of the restraint was tested both subjectively and objectively. **RESULTS:** Subjects were found to be comfortable with the new restraint and it was found to be very effective in restraining subjects while undergoing lateral acceleration. **DISCUSSION:** The study brings out a new effective system for restraining subjects during lateral acceleration simulation in centrifuge. The operational significance of installing a restraint system in addition to the five-point harness in aircraft capable of executing significant Gy is also highlighted.

Learning Objectives

1. The participants will be able to appreciate nuances of simulating a lateral acceleration profile.
2. The difficulties faced with using an existing five point harness system when exposed to Gy acceleration will become evident.
3. Role of innovative thinking in solving aeromedical issues will be highlighted.

[447] SPACEFLIGHT ADVANCED TRAUMA AND LIFE SUPPORT: A TRAUMA MODEL FOR EXPLORATION CLASS MISSIONS BASED ON THE PRINCIPLES OF BATLS

Lisa McNamee¹, Shawna Pandya², Philip Brady³

¹Royal College of Surgeons in Ireland, Dublin, Ireland; ²University of Alberta, Alberta, Canada; ³Trinity College Dublin, Dublin, Ireland

(Original Research)

The provision of immediate patient care in low Earth orbit and beyond requires the adaptation of existing management strategies and the development of novel approaches. The unique environmental conditions associated with spaceflight often mean it is not feasible to employ conventional terrestrial equipment and diagnostic techniques in the trauma setting. Factors influencing patient care may include altered gravity environments, pressure and temperature discontinuity hazards, adverse effects of radiation including electromagnetic interference, environmental contaminants as well as physical space limitations. These may increase the ambient risk of injury including likelihood of ballistic injury, blast trauma, crush injury, burns, major haemorrhage, and airway compromise. Medical responders will be further limited by their protective equipment, available skill sets and the limited resources available to them. Care may also be complicated by a complex pathway to definitive treatment that may have a prolonged timeline. These factors may also lead to complex ethical challenges for the treating medics. As a traditional trauma team will not be available, all members of an astronaut crew must be proficient in a systematic approach to emergency trauma treatment. This is pertinent due to the potential challenges that a major trauma occurring during an exploration class mission might entail. The Battlefield Advanced Trauma and Life Support (BATLS) model provides a suitable paradigm that can be adapted for spaceflight. Relevant components of BATLS include adaptation to austere and hazardous environments, the anticipation of significant trauma, resource limitation and potential for multiple casualty scenarios. The model also predicts difficulty or a prolonged timeline in reaching definitive care which can be a feature of both military and space environments. This poster explores how the BATLS model can be adapted to function as a Spaceflight Advanced Trauma and Life Support (SATLS) model.

Learning Objectives

1. The audience will learn about the appropriate systematic approach to trauma in the spaceflight environment appropriate to available skill sets and resource limitations.

2. The audience will consider the expectant management category used in the BATLS model and in what scenarios this might be appropriate in an exploration class mission.

[448] MEDICAL LESSONS FROM THE UNDERWATER NEPTUNE MISSION

Shawna Pandya¹, Dr. Joseph Dituri², Paul Bakken³, Doug Campbell⁴, Kyle Foster⁵

¹University of Alberta, Edmonton, Alberta, Canada; ²International Board of Undersea Medicine, Tampa, FL, USA; ³Bakken Offworld Research Products, Eagan, MN, USA; ⁴Saskatchewan Health Authority, Saskatoon, Saskatchewan, Canada; ⁵George Mason University, Fairfax, VA, USA

(Original Research)

INTRODUCTION: Dive saturation complexes offer several medical challenges owing to their isolation, confinement, resource-limitedness, risk, and space/power constraints. During the NEPTUNE (Nautical Experiments in Physiology, Technology and UNDERwater Exploration) scientific mission, 5 individuals performed studies in a dive saturation complex at a depth of 22 feet over 5 days. In the present study, we review the medical approach to anticipating, packing for, incidence of, and treatment of medical issues in such an environment. **METHODS:** Five subjects (4M, 1F; ages 18-65) self-selected to take part in a 115-hour scientific aquanautic mission in an underwater dive complex at a depth of 22 feet. As preventative measures, the crew physician surveilled all members as to their dive history, medical history, medications, and allergies prior to the mission. The crew was briefed on the evacuation plan in case of fire. During the mission, each crew member applied a 50-50 acetic acid-isopropyl alcohol mixture nightly to prevent otitis externa. The crew medical supplies across the crew physician's medical kit, the habitat's first aid kit, and crew members' personal medical effects included basic first aid materials, and analgesics, decongestants, antihistamines, antiseptics and antibiotics. All medical incidents were recorded, treated and anonymized. Data collection was previously approved by IRB. **RESULTS:** Documented medical pathologies included headache (incidence=1), abrasion/minor cuts (i=9), bruises/contusions (i=5) congestion (i=7), back pain (i=1), bite/sting (i=3) and insomnia (i=5). All pathologies were treated in-situ. No medical issues necessitated evacuation or intervention from surface support. **DISCUSSION:** All medical incidents on this mission were successfully treated with the medications and supplies on hand. Medical kits for longer and/or larger missions should increase the quantity of both supplies and medications. Based on the pathologies seen, a basic medication kit should include antibiotics, analgesics, decongestants, antihistamines, antiemetics, and sleep aids. In this particular mission, severe pathology would result in immediate evacuation and mission termination for the affected crew member, as the habitat depth of 22 feet did not require a decompression period prior to surfacing. For habitats where a decompression time is required due to the habitat depth, more advanced in-situ medical capabilities are recommended.

Learning Objectives

1. By the end of this presentation, the audience will gain insight into the most common medical events that can occur during an underwater expedition, and the challenges associated with anticipating medical events during such a mission.
2. By the end of this presentation, the audience will gain insight into the most useful medical kit contents and medications for an underwater expedition.
3. By the end of this presentation, the audience will gain insight into the challenges associated with packing for an underwater expedition.

[449] SELECTION OF AIR TRAFFIC CONTROLLER TRAINEES

Krisztina Szabo, Mate Petrekanits, Botond Szucs
PHARMAFILIGHT International Science and Service Center, DEBRECEN, Hungary

(Original Research)

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

Learning Objectives

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

[450] CAROTID INTIMAL-MEDIAL THICKNESS: LITERATURE REVIEW WITH ASSESSMENT OF CLINICAL USE AND PREDICTIVE CAPABILITY FOR ASTRONAUT CORPS

Zachery Campbell¹, James Locke²

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(Original Research)

INTRODUCTION: Atherosclerosis is key in the development of cardiovascular disease (CVD). Physiologically it is characterized by the thickening of the tunica media and intima of arterial walls. Carotid artery intima-medial thickness (cIMT) is a biomarker detected via ultrasonography representing changes from atherosclerosis. cIMT is a proven independent predictor for future cardiovascular events. The NASA flight medicine clinic collects cIMT and plaque data from active and retired astronauts as part of the annual medical exam. We conducted a literature review on the clinical use and predictive capability of cIMT and evaluated available data from the Johnson Space Center (JSC) EMR. **METHODS:** Assessment of cIMT and plaque astronaut data was conducted. 570 cIMT tests were available in the JSC EMR. Average cIMT values for right and left carotid artery taken. Data was stratified by active vs. retired status at time

of test. Plaque presence from 44 astronauts was used to classify plaque severity. **RESULTS:** Average cIMT values were 0.9mm>, only 56/570 tests were above 0.9mm with 0 tests 1.5mm <. Plaque presence in 44 astronauts evaluated; 3 recorded as minimal and 41 with no plaque presence. Literary review indicated use of cIMT is not recommended for future CVE prediction. Current literature suggest one-time cIMT adds minimal benefit to traditional risk scores and is not a recommended use for asymptomatic individuals. Serial cIMT progression correlates to systemic changes in age more than CV risk factors and is not recommended for subclinical use. Plaques are a more powerful predictor of future CVEs compared with cIMT alone. **DISCUSSION:** Generally, astronaut data reflected minimal plaque presence and the majority of cIMT tests within low-risk zones. Based on findings, the inclusion of cIMT via ultrasonography in the annual medical exam might be re-evaluated and further exploration in the available data from the astronaut corp is needed.

Learning Objectives

1. Literary review of current recommendations and how to apply to astronaut corp annual medical exam.
2. Assessment of current data from JSC EMR to re-evaluate use.

[451] CREATING A RESEARCH DATABASE TO CULTIVATE A COLLABORATIVE ENVIRONMENT IN THE FIELD OF SPACE SURGERY

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(Education - Program/Process Review)

BACKGROUND: Researchers in nascent fields often struggle to find others working in the same niche. Surgery in space is a blossoming field in which researchers often still find it difficult to find colleagues with whom to collaborate or students to help with projects. The Space Surgery Association (SSA) aims to bridge the gaps between principal investigators (PIs), research teams, and students looking to get involved in Space Surgery. To fulfill this need, we created a system that collects PI and project information to actively facilitate collaboration. **OVERVIEW:** We created a Google Forms questionnaire to gather information about PIs and their research projects. Our questionnaire consisted of two forms: one for PI registration and one for research projects. Some data points collected pertaining to research projects include: research field, research summary, expected research output, type of research (e.g. basic science, translational), and whether or not PIs were looking for collaborators or student help. If student help was desired, additional space was provided to collect information about the specific type of help requested, including things such as the type and complexity level of help requested, availability of student funding, points of contact, geographic location, and desired weekly time commitment. The results of the forms were shared with members of the SSA via a read-only Google Spreadsheet. **DISCUSSION:** We created a database that is highly accessible, readily searchable, and easily modifiable without a risk of data loss. We believe that this database will help connect researchers and their colleagues as well as researchers with students to facilitate the involvement of the next generation of Space Surgery researchers. This process can be generalized for use in other settings, such as connecting mentors and mentees. Lessons learned from this database will inform the creation of future databases with similar goals and will provide benefit to fields beyond Space Surgery.

Learning Objectives

1. Understand the process of compiling research in a growing field to facilitate research collaboration and utilize this template to compile research in other research fields beyond Space Surgery.
2. Learn about the Space Surgery Associations Research Database designed to facilitate collaboration and student engagement in the field of Space Surgery.

[452] ADVANCED HEADS UP DISPLAY TECHNOLOGY FOR ENHANCING HUMAN PERFORMANCE IN COMPLEX EXTRAVEHICULAR ACTIVITY OPERATIONS

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(Education - Program/Process Review)

BACKGROUND: The CU Technology for Extreme Environments (CUTEE) club participates annually in the NASA SUITS competition to develop heads up displays for extravehicular activities (EVA). Through this design competition, our team investigates human factors for operational environments associated with planetary surface EVA. **OVERVIEW:** The primary objective of this project is to design and build a user interface that will assist astronauts in EVA. Current systems for displaying procedures, navigation and informatics are difficult to use resulting in a frustrating and time-consuming experience. Our augmented reality (AR) design will help astronauts perform tasks efficiently and effectively. This will be accomplished by developing a user interface that works with a head mounted display to deliver information through both visual and auditory pathways, accompanied by wearable peripherals. We focus on incorporating strong human factors principles to ensure clear, concise communication while maintaining the informational context. EVA procedures for tasks and relevant informatics most critical to the astronaut will be displayed, and the astronaut will also have the ability to switch between displays to retrieve other information. The display can be personalized based on user desires. We will use voice command, and NOVA will be the name and trigger for the keyword listener to avoid triggering the voice recognition system. We explore design concepts using wearable technology in the form of facial electromyography headwear, novel navigation techniques, and flexible autonomy solutions delivering an unobtrusive, symbiotic virtual assistant to support safe and efficient EVA. Finally, we will develop and evaluate our informatics system design with human subjects in a simulated EVA operational environment consisting of hard upper-torso spacesuits and surface habitat structures. **DISCUSSION:** This educational project has enabled students from backgrounds in engineering, physiology, and computer science to engage in human factors design and evaluation. Core design principles include adaptable displays, intuitive interfaces, and natural control mechanisms are taught, and students are enabled to explore the technology development most of interest to their educational objectives. Ultimately, the displays developed by the CUTEE club and other teams around the country to contribute to safe, effective planetary surface exploration with improved heads-up information display.

Learning Objectives

1. Identify multi-faceted approaches for information display using augmented reality, wearable sensors, and auditory information.
2. Understand the challenges of information display in planetary surface environments.

[453] HEALTH MOLECULAR TESTING FOR COMMERCIAL SPACE MISSION

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(Original Research)

INTRODUCTION: Successful mid-term and long-term Space expeditions need on-board diagnostics to monitor the crew health conditions. An ideal platform in space diagnostics (ISD) should be rapid, user-friendly, instrument-free, miniaturized, multiplex, and compatible with microgravity. Vertical flow immunoassays (VFI) are

paper-based diagnostics that fit these requirements. Here, we describe a configuration of All-Capillary-Driven Vertical Flow Immunoassay tested by commercial astronauts in the SpaceX Inspiration4 mission. **METHODS:** The device integrated multiple fluidic components allowing solutions to be preloaded in sponge-based cartridges and stored in nonpermeable capsules. Membrane housing, pad holder, magnifying cap, and buffers' caps were 3D printed. Capture antibodies were immobilized on membranes by Nanoplotter microarray printing. A pump-less microfluidic device was used to separate plasma and transfer it to the VFI. The multiplexing capability was evaluated by simultaneous detection of C-Reactive Protein (CRP) and total immunoglobulin M (IgM) as stress, cardiovascular and inflammatory biomarker models. An iPhone App was developed to capture an image of the membrane through a magnifier and automatically detect the biomarker spots. **RESULTS:** The device was optimized to run the assay in less than 30 minutes against gravity. Stack layers of multiple pad materials from the sample collection to detection were assembled to transfer plasma, purify plasma, store detection antibody, provide enough time for biomarker/detection antibody interaction, and direct the solution to the membrane area containing capture antibodies for detection. In-flight experiment during Inspiration4 mission showed that samples and buffers were transferred between pad and membranes demonstrating the VFI ability to operate in microgravity environment through capillary force. **DISCUSSION:** Although blood specimens were collected, inaccurate volumes were transferred into the devices resulting into low signal intensity further confounded with limited control of logistical and environmental storage conditions that affected the stability of gold conjugated antibodies. Since there is a restricted list of chemicals certified for use in a spacecraft, further study is required for improving reagents stability and device packaging. In the meantime, a blood separation module has been re-designed for higher-level VFI integration and simplified user-interface. This will be validated in future missions.

Learning Objectives

1. The audience will learn about the preparation of health monitoring technology platforms for commercial crew flight missions.
2. The audience will learn about rapid multiplex molecular testing from biofluids.

[454] COMPARISON OF AEROMEDICAL EVACUATION FOLLOWING TRAUMATIC BRAIN INJURY (TBI) WITH OR WITHOUT HEMORRHAGIC SHOCK IN A PORCINE MODEL

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(Original Research)

INTRODUCTION: Aeromedical Evacuation (AE) is the main strategy in use to rapidly transport wounded warriors to higher echelons of care. However, this method of transportation includes risks of potential physiologic and metabolic derangements. Patients who have sustained a traumatic brain injury (TBI) may be more sensitive to the effects of exposure to hypobaric. We evaluated the impact of simulated AE in a TBI swine model with and without hemorrhagic shock (HS). **METHODS:** Sixteen Yorkshire swine (32.7±4.6 Kg) were divided into 4 groups (TBI normo, TBI hypo, TBI-HS normo, TBI-HS hypo). A fluid percussive device was used to create a TBI in all animals while under anesthesia (24.0±6.9 PSI). They underwent (TBI-HS) or did not (TBI) undergo arterial controlled hemorrhage of 30% estimated blood volume. Following injury, the animals were either exposed to a 4-h simulated transport hypobaric to 8,000 feet (hypo) or at ground level (normo). Physiologic monitoring and laboratory values were measured. Animals were euthanized at the end

of the flight. **RESULTS:** Intracranial pressure (ICP) peaked (24.1 ± 7.1 mmHg) following injury but then returned to baseline and remained stable throughout the simulated AE in all groups. Brain oxygen levels were comparable across groups. While the number of animals observed in this study does not permit statistical analysis, the following trends were detected. Decreased mean arterial pressure (MAP) due to hemorrhage was seen in both TBI-HS groups compared to TBI groups; however, those exposed to hypobaria had lower MAP by the end of the flight compared to those that were not. The average heart rate (HR) of the TBI-HS hypo group was similar to the TBI groups whereas animals in the TBI-HS normo group appropriately compensated with relatively elevated HR compared to the TBI-HS hypo group. Lactatemia and leukocytosis were seen in HS groups independent of hypobaric exposure. A trend towards thrombocytosis was observed at the end of the flight in both TBI and TBI-HS Hypobaria groups.

DISCUSSION: While hemorrhagic shock caused the expected MAP trend in this TBI model, exposure to hypobaria exacerbated this effect. Specifically, animals exposed to hypobaria after HS demonstrated lower HR, suggesting a reduced capacity to compensate for hypovolemia. Ongoing experiments should bring statistical significance to the trends observed and future projects should be directed at evaluating cardiovascular response to hypobaria.

Learning Objectives

1. The participants will get familiar with animal aero-evacuation-strategy and the relevance of animal model to study hypobaria.
2. The audience will understand the effect of injury severity and polytrauma of wounded patients during aero-evacuations.
3. The audience should consider the importance of large animal models.

Thursday, 05/26/2022

3:30 PM

Tuscany C,D,E

[S-76]: PANEL: CLINICAL DECISION SUPPORT FOR EXPLORATION SPACE FLIGHT: SOFTWARE AUGMENTATION TO ENHANCE PROGRESSIVELY EARTH-INDEPENDENT MEDICAL OPERATIONS

Chair: Dana Levin

PANEL OVERVIEW: This panel identifies the challenges of supporting medical events in deep space using integrated systems software to augment existing capabilities during increasingly Earth-independent missions where an asynchronous communication environment becomes routine. An interdisciplinary team of software designers, physicians, human factors engineers, and computational modelers applied their respective expertise to develop a roadmap for supporting the crew making medical decisions in more autonomous fashion with time-delayed ground support. The first presentation describes predictive modeling implemented to assist medical system design and address risk reduction using robust clinical decision support software. The second presentation details how operational and environmental challenges guide assumptions and, in turn, by what means requirements for medical decision-making in deep space are derived. The third presentation describes and defines the skills and capabilities an exploration spaceflight medical officer will need to perform effectively during extended-duration spaceflight missions. The fourth presentation covers the potential models and function of the software element for supporting clinical decisions. The final presentation covers how these elements may work together with ground support to provide comprehensive care despite deep space travel's extreme challenges and limitations.

[389] PREDICTIVE MODELING TO ASSESS AND ADDRESS CHALLENGES AND LIMITATIONS ASSOCIATED WITH CLINICAL CARE AND DECISION SUPPORT IN DEEP SPACE

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(Education - Program/Process Review)

BACKGROUND: Probabilistic risk assessment (PRA) is a method for assessing and integrating the risk of failure in a multivariate system. While it is often applied by engineers designing complex machines, it could also be applied to humans to assess the probability of a health "failure" treating diseases as the multiple "variables" and the human as the "complex machine." The Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT) was developed to apply PRA to assess medical risk for exploration spaceflight and inform the design of medical systems for space flight. The NASA engineering community utilizes event-driven and fault tree probabilistic techniques to classify risk in the space flight environment by leveraging the inherent knowledge of complex space flight system design and testing to quantify risk. However, in harmonizing the risk of human space flight, answering the question of "How do we balance astronaut health, performance and resource risks with other engineering risks on exploration space missions?" remains a profoundly challenging and largely qualitative practice. The Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT) is one aspect of the Human Research Program's efforts to represent space flight human health and performance risks quantitatively. **OVERVIEW:** While initially developed to support risk quantification and mitigation strategies, the predictive nature of MEDPRAT can be combined with clinical decision support (CDS) processing to inform real-time assessments of medical risk as events occur and consumable resources are depleted throughout a mission. MEDPRAT's capability can be combined with CDS tools to: inform resource rationing based on predicted use, balance the chance of a successful evacuation with existing supply levels vs. the risk to the crew of continuing a mission, characterize the risks associated with caring for unpredictable and unanticipated conditions, and even help quantify medical futility. **DISCUSSION:** Quantifying such values can be extremely helpful to medical teams making decisions about aborting a mission, evacuating the crew, and medical futility. These are often exceptionally complex and qualitative decisions made with limited data under extremely stressful conditions along short timelines. Adding model-simulated data and outcomes to CDS

Learning Objectives

1. Probabilistic Risk Assessment Modeling can assist with medical system design by predicting event occurrence and helping to prioritize resources and estimate amounts.
2. Applying probabilistic risk assessment models in real time can estimate supplies remaining, weigh it against risk of potential medical events and help inform medical futility and need for evacuation.

[390] HOW ENVIRONMENT AND OPERATIONAL CONSIDERATIONS GUIDE REQUIREMENTS DEVELOPMENT FOR CLINICAL DECISION SUPPORT BEYOND LOW EARTH ORBIT

Barbara Burian¹, Brian Russel², Dana Levin³

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(Education - Program/Process Review)

BACKGROUND: The Aerospace Medical community is acutely aware of the need for automated cognitive systems to support astronauts in responding to and making critical decisions about assessing – and treating - medical conditions and assuring wellness during exploration spaceflight missions. Clinical Decision Support Systems (CDSS) will be critically important to mission success as we venture farther from terrestrial settings (particularly low-earth orbit platforms) and encounter increasingly Earth-independent medical decision-making scenarios and requirements. This presentation will address some of the fundamental considerations and their implications that must be fully understood by CDSS requirement developers early in the system lifecycle. **OVERVIEW:** Many fundamental considerations underpinning earth independent mission operational (EIMO) requirements fall in the category of CDSS

“context of use.” This includes where the CDSS will be displayed (e.g., number and size of displays, fixed/mobile), who and how many crew members will be using the CDSS (e.g., novice-to-expert, working on the same issue in parallel/sequentially), and the environment wherein the CDSS will be used (e.g., IVA/EVA, lighting conditions). CDSS guidance to users must also reflect the most common and most concerning clinical and wellness issues, the specific functionality of other devices integrated with the CDSS (e.g., electrocardiogram sensors), and the accessibility of medical equipment and supplies within the physical environment. CDSS concept of operations are used to develop requirements, which are informed by context of use, likely clinical events, available equipment, and accessibility. **DISCUSSION:** Those who construct EIMO related CDSS requirements are often unaware of the depth and breadth of issues associated with the context and use of clinically relevant information or attendant issues. Examples of relevant issues to be determined before requirements development include medical logistics (equipment, expendable and non-expendable supplies), crew member training and capabilities, and medically/behaviorally related human factors including accessibility. These issues are critical and must be fully considered by all in the operational and user community for the resulting CDSS requirements to ultimately yield a functional and beneficial system that enhances crew performance and execution of medically related critical tasks and decision making.

Learning Objectives

1. Those who construct Earth Independent Mission Operations (EIMO) related Clinical Decision Support Systems (CDSS) requirements are often unaware of the depth and breadth of issues associated with the context and use.
2. Human factors within the context of use are critical to design and must be fully considered by all in the operational and user community.

[391] STARFLEET MEDICAL: KNOWLEDGE SKILLS AND ABILITIES OF CREW MEDICAL OFFICERS ON EXPLORATION MISSIONS

Jon Steller, Levin Dana, Kreykes Amy, nelson Ariana, Arian Anderson, Chip Dukes, Chris Zahner, David Hilmer
¹ASA, Houston, TX, USA

(Education - Program/Process Review)

INTRODUCTION: Exploration missions increase the risk and consequences of medical events and require increased crew autonomy. This project makes use of an existing evidence base to determine the Knowledge, Skills, and Abilities (KSA) that an ExpLoration Medical Officer (ELMO) will need. **METHODS:** A multi-disciplinary team of physicians reviewed the list of medical conditions designed to inform the requirements for deep space medical systems. Each team member was assigned a subset of conditions based on expertise. The assigned physician generated a proposed list of capabilities, definitions, and resources needed to treat each condition based on terrestrial practice guidelines, medical literature, and expert clinical opinion. The team consulted additional specialists on conditions where resident expertise was not present within the dedicated physician cadre. Each capability was rated based on the minimum level of training necessary to perform it. The proposed list was then evaluated by the broader peer review team and modified as needed. The final list of capabilities and associated training levels was used to estimate the capabilities needed by an ELMO. **RESULTS:** The team compiled a list of 579 clinical capabilities together with their definitions. While no single terrestrial specialty encompasses all required KSA, there is a significant degree of overlap with Emergency Medicine, Family Medicine, and Critical Care specialty curricula. **DISCUSSION:** This list is specific to exploration missions involving a small crew in a low-volume spacecraft. While the list will change as we gain experience and improve vehicles, it represents a solid foundation for the KSAs needed by ELMO. The methods used permit the rapid modification and improvement of the process as more information is obtained, similar to how terrestrial medical boards define the scope of practice for

evolving standards of care on Earth. This list of capabilities may serve as a basis for ELMO training and inform clinical decision support tools and just-in-time training material. It may also be helpful in future crew members' selection.

Learning Objectives

1. Participants will understand the need for additional training for Exploration Medical Officers.
2. Participants will learn how the educational requirements for exploration medical officers can be derived and some of the skills likely to be essential in their work.

[392] CLINICAL DECISION SUPPORT SOFTWARE: MODELING AND CAPABILITIES

Brian Russe¹, Barbara Burian², Dana Levin³

¹Auckland University of Technology, Auckland, New Zealand; ²NASA, Mountain View, CA, USA; ³NASA, Houston, TX, USA

(Education - Program/Process Review)

BACKGROUND: With its distance from Earth and communication delays, exploration space flight will place new demands for crew autonomy. Crewmembers operating during such missions require a dedicated Clinical Decision Support System (CDSS) that enhances their earth independence by augmenting their knowledge, skills, and abilities in different medical scenarios. **OVERVIEW:** The NASA Exploration Medical Capability ExMC CDSS project has been researching the capabilities required of a software tool to provide remote assistance to astronauts under emergency, routine, and preventative clinical scenarios. The CDSS must perform naturalistic decision-making akin to that presented by a trained medical provider performing clinical analysis in the diagnosis phase, drawing on knowledge to provide treatment options and enable observation to reassess if the patient is not recovering. Underpinning these advanced analytics is a framework of clinical-grade databases, alert levels, and communication channels with appropriate personalized health information (PHI) security and capabilities that enable bidirectional transmission of information between the vehicle and Earth. **DISCUSSION:** The CDSS's role is to assist the crew in the prevention, detection, diagnosis, and treatment of countless medical conditions that could arise in spaceflight, exacerbated by known decrements in sleep, cognition, nutrition, and exercise. These demands will increasingly shift to the crew as missions extend farther from Earth, requiring increasing crew independence. The preparation of these CDSS tools will require a change of practice on Earth and in the vehicles and will need a process to gather sufficient information to build computational models that are validated, explainable, reliable, and support the crews. Operational practices will change based on acuity, need for hands-on care, and communication delays. Much work is required on the development of appropriate software models that will underpin this critical tool.

Learning Objectives

1. Crewmembers operating during exploration class missions require a dedicated Clinical Decision Support System (CDSS) that enhances their earth independence by augmenting their knowledge, skills, and abilities in different medical scenarios.
2. A CDSS must perform naturalistic decision-making akin to that presented by a trained medical provider performing clinical analysis in the diagnosis phase, drawing on knowledge to provide treatment options and enable observation to reassess if the patient is not recovering.

[393] COMPUTER IN THE LOOP: A PARADIGM FOR SOFTWARE AUGMENTATION OF TERRESTRIAL MEDICAL SUPPORT IN ASYNCHRONOUS COMMUNICATION ENVIRONMENTS

Dana Levin¹, Barbara Burian², Brian Russe³

¹NASA, Houston, TX, USA; ²NASA, Mountain View, CA, USA; ³Auckland Institute of Technology, Auckland, New Zealand

(Education - Program/Process Review)

BACKGROUND: As humans plan for missions beyond the reach of real-time communication supported by terrestrially-based crews (i.e., increasingly earth-independent spaceflight missions), we need to consider how to maximize this effectiveness despite asynchronous communication with Earth. Medical events – especially those involving the sparing of life, limb, or eyesight - often need to be acted on immediately, in real-time. Often the expertise necessary to successfully complete such action covers an enormous range of training that is unrealistic to expect from crews engaged in exploration spaceflight. Thus, the medical support paradigm for asynchronous environments must account for both the limitations and coordinate seamlessly among ground-based expertise, the need for real-time interventions, and the limited crew time and knowledge resources. **OVERVIEW:** This effort proposes a new paradigm for software-based clinical decision support tools capable of filling this gap. This paradigm includes using spacecraft integrated software designed to provide critical guidance, just-in-time training, monitoring, and limited software-based diagnostic capability. When combined with the ability to recommend treatments that enable real-time, “as needed” medical support, such a system could simultaneously coordinate and integrate support across the spectrum of direct guidance from terrestrial experts (when adequate communications allow engaged support) to fully autonomous software decision assistance throughout the entire range of scenarios, distances, and challenges encountered during the assigned mission profile. **DISCUSSION:** This paradigm leverages present-day technology to build a “temporal bridge” that spans the gap in asynchronous communication between the ground and distant spacecraft. Such a system cannot replace the invaluable contributions of a physician. However, just as paramedics can extend the reach of a physician outside of the hospital during an emergency, this paradigm can develop the expertise of ground-based flight surgeons beyond the reach of real-time communication. However, since this particular effort has never been attempted before, testing this system in a real-time communication environment is necessary before full operational deployment.

Learning Objectives

1. Participant will understand how deep spaceflight will challenge the current paradigm of medical support and how these challenges may be solved by augmenting ground support and crew medical officers with on board software tools.
2. Participants will understand how an on board clinical decision support tool can create a “temporal bridge” to account for asynchronous comms in addition to off loading some routine tasks from ground and crew providers.

Thursday, 05/26/2022
Tuscany A

3:30 PM

[S-77]: PANEL: MACHINE EVOLUTION AND HUMAN ADAPTATION: AEROMEDICAL RESEARCH AND PILOT-PHYSICIANS

Sponsored by International Association of Military Flight Surgeon Pilots

Chair: Chris Bates

Co-Chair: Joe Zhang

PANEL OVERVIEW: INTRODUCTION: *Multidis-ciplinary aeromedical research continually strives to optimize human and aircraft performance in aerospace endeavors. The impact of technology on the role of humans in aviation, the field of aerospace medicine, and human performance is highly dynamic. **BACKGROUND:** By maintaining dual qualification in both their assigned aircraft and as clinicians, civilian and military Pilot-Physicians are subject matter experts in the integration of Human and Weapon Systems performance for their respective aircraft and those with similar capabilities. They also provide a unique perspective from the inside out in regard to*

*advancing aerospace medicine through research and understanding firsthand the rapidly evolving technology. **CASE PRESENTATION:** This panel will present case studies from both military and civilian organizations that demonstrate how Pilot-Physicians help advance aerospace medicine through research in the face of everchanging and expanding technology. **DISCUSSION:** The presentations will demonstrate how these experiences were used to develop specific aeromedical research projects, and how results for these research efforts were used to improve operation capability, thus contributing to the body of aerospace medicine knowledge and human performance optimization.*

[394] A PROFESSIONAL PILOT'S PERSPECTIVE ON FLIGHT SURGEON TRAINING; A TALE OF TWO PROGRAMS

Thomas Powell¹

USAFSAM Wright-Patterson AFB, OH, USA

(Education - Program/Process Review)

BACKGROUND: Both the United States Air Force and the United States Army operate large, well equipped and trained aviation operations which require aviation medicine providers to supervise the aviator's medical readiness, missions, and their health care concerns. Charged with unique missions, and even operating some similar aircraft, each uniformed service has chosen to set up their own individual flight surgeon training courses in order to furnish their services with aviation medical providers to tailored to their unique mission concerns. In this presentation, a professional pilot's viewpoint of the differences between these two courses and their flight training will be discussed. **OVERVIEW:** The presenter attended both the Army and Air Force courses in March of 2019 and October of 2020 respectively. The Army course training gave hands-on control for approximately 30 minutes in a high fidelity simulator, 10 minutes in a disorientation device, and 2 hours in the rear of a CH-46 as their flight training experience. The Air Force course placed its candidates through a 7-flight abbreviated training program to include night, IFR, low level, formation, aerobatic, and rotary-wing flight. Additionally, a 6-7 G centrifuge experience was also performed. **DISCUSSION:** Although both programs are training providers to be familiar with aviation and the mission of their patients who perform some of the most challenging aerospace tasks in the world, the quality of the training found in the Air Force program far exceeds that of the Army. The lack of hands-on flight training, especially for rotary wing aircraft, fails to impress upon the trainees the dangers inherent in rotary-wing, low level, and IFR aviation which their patient population accomplishes every day. As helicopter fatality per hour rates are much higher than fixed-wing aircraft, an understanding of these important topics is of paramount import to any aeromedical provider caring for patients who operate rotary-wing aircraft. This lack of training could easily be resolved with more dedicated simulation time in their high-fidelity simulator facility installed nearby.

Learning Objectives

1. The US Army flight surgeon course does not provide adequate hands-on training experience to aeromedical providers.
2. Rotary-wing aircraft are at special risk for spatial disorientation events. Familiarity with these in a hands-on yet safe manner from simulator training is important to ensuring a well-trained rotary-wing aeromedical provider.

[395] OPERATION BLOOD RAIN PROOF OF CONCEPT FOLLOW-UP: EVALUATION OF THE EFFECT OF AIRDROP ON FRESH AND STORED WHOLE BLOOD

Evan Shawler¹, William Smith¹, Roselyn Clemente Fuentes², Robert Tong³, Anthony Mitchell⁴, William Barnes¹, Manuel Moncada⁵, Cody Bohlke³

¹*Air Force Special Operations Command, Hurlburt Field, FL, USA;* ²*Air Force Material Command, Eglin AFB, FL, USA;* ³*Air Force Special Operations Command, Duke Field, FL, USA;* ⁴*8th Medical Group, Kunsan AFB, Democratic People's Republic of Korea;* ⁵*96th Medical Group, Eglin AFB, FL, USA*

(Original Research)

INTRODUCTION: Transfusion of whole blood (WB) is a life-saving treatment that prolongs resuscitation until definitive surgical intervention can be performed; however, collecting WB is a time consuming and resource-intensive process. Furthermore, it may be difficult to collect sufficient WB at the point-of-injury to treat critically wounded patients or multiple hemorrhaging casualties. This study is a follow up to the initial proof-of-concept pilot on the effect of airdrop on WB. It shows the statistical significance for the plausibility of using airdrop to deliver WB to combat medics treating casualties in the pre-hospital setting when FDA approved cold stored blood products are not readily available. **METHODS:** 48 units of WB were collected and then loaded into a blood cooler which was dropped from a fixed-wing aircraft under a Standard Airdrop Training Bundle (SATB) parachute. 24 of these units were dropped from a C-145 and 24 of these units were dropped from a C-130. A control group of 15 units of WB was stored in a blood cooler which was not dropped. Baseline and post-intervention labs were measured in both airdropped and control units, including complete blood count, PT/PTT/INR, pH, lactate, potassium, indirect bilirubin, glucose, fibrinogen, lactate dehydrogenase, and peripheral blood smears. **RESULTS:** The blood cooler, cooling bags and all 48 WB units did not sustain any major damage from the airdrop. There was no evidence of hemolysis. With the exception of the one slightly damaged bag that was not sampled, all air dropped blood met parameters for transfusion per the JTS Whole Blood Clinical Practice Guidelines and the AABB User Guide for the Circular of Information for the Use of Human Blood and Blood Components. **DISCUSSION:** Airdrop of Fresh or Stored WB in a blood cooler with a SATB parachute is a viable way of delivering blood products to combat medics treating hemorrhaging patients in the pre-hospital setting. This study also demonstrated the portability of this technique for multiple aircraft.

Learning Objectives

1. The audience will learn about the feasibility of airdrop as a means of delivering fresh and stored whole blood to combat medics treating casualties in the pre-hospital setting when FDA approved cold stored blood products are not readily available.
2. The audience will learn about the portability of this technique for multiple aircraft of opportunity including the potential for UAV air drop.

[396] OPERATIONAL IMPACT AND PREVALENCE OF NECK AND BACK PAIN IN USAF FIGHTER PILOTS

Joe Zhang

USAF, Langley AFB, VA, USA

(Education - Tutorial/Review)

INTRODUCTION: Neck and back pain has been a chronic problem in the fighter aircrew community. This population has been studied in the past and have been found to have higher rates of pain and injury compared to a standard population sample adjusted for age. In an effort to better categorize these pains, a survey modeled after the NATO HFM RTG 252 recommendations was conducted across the entire USAF fighter aircrew population, one of the largest of its kind. **METHODS:** All USAF fighter aircrew received an on-line anonymous survey based on the core questions within the NATO Aircrew Neck Pain Prevention and Management Human Factors and medicine research task group 252 report. All crews were allowed to participate including instructors, students, actively flying or those currently in non-flying roles. The primary inclusion criteria was that members were classified within the USAF personnel system as having achieved an 11F (Fighter Pilot) or 12F (Fighter Weapons Officer) designation. **RESULTS:** 5,934 anonymous surveys were sent to all active duty and reserve 11F or 12F aviators from rank of O-2 to O-10 with 1,962 respondents combined resulting in 32.7% response rate but the aggregate number of responses is one of the highest total numbers captured for this population using this type of survey. 91.6% and 77.3% of aircrew cited flying related neck pain and back pain respectively during their career with 66.3 to 64.9% reporting current pains. 73.1% reported difficulty moving their head while pulling G's.

66.0% of aircrew state that they modified their flying activities due to pain. 69.0% stated that these pains affect their quality of life at home. 40.0% have never reported their neck pains and 31.6% did not report their back pains to any medical authority but paid out of pocket for self-administered care. 42.6% have taken themselves off the flying schedule at least once. **DISCUSSION:** These results confirm that neck and back pains continue to be significant issues affecting USAF fighter pilots. It is also clear that these musculoskeletal issues are often underreported. Older published data sets suggests that newest generation of air frames with increasing weight of gear likely contributes to these trends. This information can be utilized to further research and development of strategies to minimize these problems in fighter aircrew.

Learning Objectives

1. Gain an understanding of prevalence of neck and back pain in USAF fighter aircrew.
2. Gain an understanding of the operational impact of chronic pains on USAF fighter aircrew.

[397] AEROMEDICAL RESEARCH IN SUPPORT OF FUTURE VERTICAL LIFTIan Curry¹, Steve Gaydos², Amanda Kelley¹¹U.S. Army Aeromedical Research Laboratory, Fort Rucker, USA; ²HQ Army Air Corps, Middle Wallop, United Kingdom*(Education - Tutorial/Review)*

INTRODUCTION: Army Modernization Strategy describes systematic, methodical efforts to transform the total Army for multi-domain operations (MDO) in order to retain global military dominance throughout the operational spectrum from limited contingency operations to large-scale combat operations (LSCO). The Army has identified six modernization priorities to drive material development for MDO capability including Future Vertical Lift (FVL). FVL aerial platforms will possess significant advances in speed, maneuvering, range, lethality, and survivability enabling the Army to compete and win in LSCOs and throughout the MDO spectrum. The expanded performance envelope and capabilities of these aircraft demand careful attention to the human operator including capacity, performance, communication, workload, fatigue, and safety.

TOPIC: Utilizing a top-down strategic planning approach, the planning pathway for research and development begins with identification of capability gaps. End-state goals supported by functional and technical objectives address these gaps through identifying and solving technical challenges, sub-activities, and ultimately specific research projects in mutual support of deliverables that address and close identified gaps.

APPLICATION: With down-selection of final aerial platforms pending, FVL research continues with major thematic elements of health hazard and risk mitigation; safety, protection and survival; selection and retention; regulation and policy; operational enhancement and performance; mission equipment and novel technologies; and automation and scalable autonomy. Representative examples of current and projected research in support of FVL aircrew and the human operator are of broad academic interest to aerospace medical professionals and specifically provided within this pilot-physician forum for unique perspective and discussion regarding aeromedical and human factors challenges.

Learning Objectives

1. Participants will broadly recognize advanced capabilities of the U.S. Army's FVL platforms.
2. Participants will appreciate unique aeromedical and human factors challenges presented by FVL capabilities.
3. Participants will be apprised of the collaborative research efforts in this novel requirement.

[398] COMPARISON OF AUTOMATION IN T-37B AND C-17A AS A PRIMER ON AIRCRAFT AUTOMATION

Christopher Backus

55 Medical Group, United States Air Force, Omaha, NE, USA

(Education - Tutorial/Review)

INTRODUCTION: Automation in manned aircraft systems is a tool to help solve problems inherent in aviation and enable greater mission effectiveness. This discussion contrasts the United States Air Force T-37B as an example of a minimally automated aircraft with the C-17A as an example of a more automated aircraft in order to demonstrate automation as a tool and create a knowledge base to assist the audience to consider automation in other cases. **TOPIC:** Automation can be misunderstood as simply referring to autopilot, but modern aircraft use automation to ease many tasks. The T-37B, a 1950's-60's era aircraft, is an example of a minimally automated aircraft that can be used to demonstrate flying tasks done without automation. The C-17A, a 1990's era aircraft, is an example of a more automated aircraft that can be used to demonstrate how these same tasks are aided by automated systems. This discussion will attempt to highlight as many examples of diverse automation of otherwise manual tasks as possible in order to create a general awareness in the audience to allow application to other cases. Examples where automation can enable the operator will be demonstrated and examples where loss of automation can create hazards due to dependence will be shown as the disadvantage of automation.

APPLICATION: Understanding aircraft automation permits medical experts to contemplate the human-aircraft system more fully and empowers them to think about human factors issues in a variety of scenarios, such as mishap investigation. Ideally, this understanding creates opportunities to contribute to aviators' greater preparation to skilfully utilize automation or adapt to failure of automation.

Learning Objectives

1. The participant will be able to describe examples of manned aircraft automation.
2. The participant will be able to contrast minimally automated aircraft with more automated aircraft.
3. The participant will understand advantages and disadvantages of aircraft automation.

Thursday, 05/26/2022**3:30 PM****Tuscany B****[S-78]: SLIDE: HUMAN FACTORS & AVIATION/
FLIGHT PLANNING****Chair: Chuck DeJohn****Co-Chair: Douglas Boyd****[399] SEARCHING FOR RESILIENCE: SELF-ASSESSED
COGNITIVE AND PSYCHOMOTOR FACTORS RELATED TO
THE PERFORMANCE OF DAMAGE CONTROL SURGERY IN
WEIGHTLESSNESS**Andrew Kirkpatrick¹, Jessica Mckee¹, Heather Wright Beatty²¹University of Calgary, Calgary, Alberta, Canada; ²NRC-CNRC, Ottawa, Canada*(Original Research)*

INTRODUCTION: The performance of resuscitative surgical procedures is an extremely technically and psychologically demanding undertaking. Even terrestrial surgical training programs, are concerned about the ability of surgeons to maintain skills and manage stress. Performance of such interventions may be required as humans explore and undertake construction in space. This could lead to potentially overwhelming cognitive and psychometric challenges in providing surgical skills while managing the human factors of involved personnel. We analyzed the self-perceived stress and perceptions of trained surgeons undertaking simulated damage control laparotomy (DCL) in weightlessness. **METHODS:** Ten surgeons performed DCL on a simulator in weightlessness during parabolic flight. Surgeons provided demographic, Dundee Stress State information (DSSQ) and psychological and physiological experience data. **RESULTS:** In terms of the subjective

physiological performance and the relative subjective difficulty of DCL, surgeons rated both their personal overall ability to perform in parabolic flight and their overall abilities to physiologically perform DCL as harder(2/5) in 0g compared with 1g. These feelings were likely more impacted by subjective feelings of nervousness(7/16) and motion-sickness (median Likert, 6/16) than by dizziness(2/16) or disorientation (median Likert, 3/16). Motion-sickness being the most challenging if the surgeon was unable to finish due to incapacitation with vomiting. However, when examining DSSQ statements despite feelings of nervousness participants were determined to succeed(3.8/4), felt in control(2.5/4), had their attention directed towards the task(3.6/4), were confident about their performance(3.1/4) and felt that they could handle any difficulties they may encounter(2.9/4). **DISCUSSION:** Despite significantly increased subjective stress and anxiety regarding their own performance the general psychological response was to focus on the task and the mission and to minimize any personal motives to focus upon mission success. Ultimately these perceived coping strategies appear to have succeeded as despite self-rated perceptions of increased technical and psychological difficulty in performing DCL, the objective performance was adequate. We therefore recommend that further studies of resiliency characteristics in extreme environments attempt to deduce successful coping strategies potentially including the role of telemedicine in improving confidence.

Learning Objectives

1. The audience will learn about some factors that contribute to psychological and physical resiliency when performing complex tasks in austere environments such as weightlessness.
2. The audience will appreciate the role of psychological and physical stress in austere environment and the potential role for telemedicine.

**[400] AVIATION SAFETY AND PSYCHOLOGICAL STATUS:
WHAT REALLY MATTERS?**Chris Front

FAA, Washington, DC, USA

(Education - Tutorial/Review)

INTRODUCTION: Accident data for the airlines and general aviation in the United States, and their causes as determined by the National Transportation Safety Board (NTSB), will be reviewed with a focus on accidents that were attributed to various types of failures in pilot performance. Research by human factors scientists from the National Aeronautics and Space Administration (NASA) and others will demonstrate the relationship between such failures in pilot performance and psychological status. The role of deficient executive functions and/or maladaptive personality traits as the root causes in most accidents attributed to pilot error will be examined. The various psychological conditions that pose a hazard to aviation safety due to their deleterious impact on neurocognitive performance and aeronautical decision making (ADM), and the importance of screening for such condition in aviation medical examinations, will be summarized. **APPLICATION:** Recognition of the various psychological conditions that pose a hazard to aviation safety due to their deleterious impact on neurocognitive performance and aeronautical decision making (ADM) is vital. This information will benefit all clinicians involved in the examination of pilots, including Aviation Medical Examiners (AMEs), aerospace clinical psychologists, and aerospace neuropsychologists.

LEARNING OBJECTIVES: 1. The participants will be able to describe the role of executive functions in aviation accidents and aviation safety. 2. The participants will be able to describe the role of personality traits in aviation accidents and aviation safety.

Learning Objectives

1. The participants will be able to describe the role of executive functions in aviation accidents and aviation safety.
2. The participants will be able to describe the role of personality traits in aviation accidents and aviation safety.
3. The participants will be able to list several of the most common psychological conditions that pose a hazard to flight safety.

[401] RELIABILITY AND VALIDITY OF NASA'S HUMAN FACTORS AND BEHAVIORAL PERFORMANCE EXPLORATION MEASURES (HFBP-EM) IN ISOLATED, CONFINED, AND EXTREME TEAMS

Carolyn Cunningham¹, Nathan Smith², Emma Barrett², Pete Roma³, Robert Wuebker⁴

¹University of Warwick, Coventry, United Kingdom; ²University of Manchester, Manchester, United Kingdom; ³Leidos/Naval Health Research Center, San Diego, USA; ⁴University of Utah, Salt Lake City, UT, USA

(Original Research)

INTRODUCTION: Navigating the complexities and risk of human space exploration requires optimal team performance. Drawing from the NASA Behavioral Core Measures and Human Factors and Behavioral Performance Exploration Measures (HFBP-EM) projects, the HFBP-EM in ICE suite is a brief survey instrument that captures a range of behavioral health and performance domains in extreme operational teams, to correlate individual performance with composite team outcomes. The goals of this study are to validate the individual performance measures assessed by this tool, and correlate these measures to team performance. **METHODS:** Thirty-three participants, from 8 missions completed the survey tool daily (5-24 consecutive days). Multi-level analyses were used to test a series of models depicting how basic need satisfaction and frustration predict self-performance and team dynamics, and whether these factors predict overall team performance. This included linear models with daily total basic need satisfaction and frustration predicting self-performance and team dynamics (i.e., team processes, team cohesion, group living), before examining self-performance and team dynamics as predictors of overall team performance. **RESULTS:** Higher daily individual needs satisfaction scores were significantly positively associated with self-performance (Est=9.27, $p < .001$), team processes (Est=7.76, $p < .001$), team cohesion (Est=6.33, $p < .001$), and group living (Est=6.41, $p < .001$). Higher daily need frustration scores were significantly negatively associated with self-performance (Est=-5.62, $p = .001$). Self-performance and team dynamics were significantly positively associated with all team performance measures: Self-performance (Est=.35, $p < .001$), team processes (Est=.16, $p = .004$), team cohesion (Est=.52, $p < .001$), group living (Est=.21, $p = .017$).

DISCUSSION: Higher scores on daily need satisfaction in individual team members were associated with increases in self-performance, team process, team cohesion, and group living. Higher daily need frustration scores were associated with reductions in self-performance. These findings provide initial validation of the HFBP-EM in ICE suite. They also support psychological needs as an important antecedent of individual and team dynamics in extreme environments. This data supports the use of these measures for monitoring crew function, which could inform interventions that reduce the risks of space missions.

Learning Objectives

1. The audience will learn about how the HFBP-EM in ICE monitors individual needs satisfaction during expeditions.
2. The audience will learn how individual needs satisfaction and dissatisfaction influence long-term individual and composite team performance.

[402] HELICOPTER PILOT PERFORMANCE WITH A HELMET-MOUNTED DISPLAY IN A DEGRADED VISUAL ENVIRONMENT

Wietse Ledegang, Erik Van der Burg, Pierre Valk, Mark Houben, Eric Groen

TNO, Soesterberg, Netherlands

(Original Research)

INTRODUCTION: Helicopter pilots operating in degraded visual environments (DVE) primarily rely on cockpit instruments to maintain

situation awareness. This might require more cognitive demands compared to flying in a good visual environment (GVE). In a simulator study, we investigated the impact of DVE on flight performance, attention and workload during a low-altitude following task over sea. In addition, we examined whether the effects of DVE could be mitigated by presenting flight parameters with a helmet-mounted display (HMD). **METHODS:** Sixteen military helicopter pilots participated in this study, which was conducted in a fixed-base helicopter simulator with a dome projection. The HMD was simulated with an head-slaved projection of symbology in the out-the-window visuals. The pilots' task was to follow a maneuvering go-fast vessel in GVE and DVE (fog that obscures a clear horizon), with and without an HMD, cumulating to four conditions. The order of conditions was randomized and counterbalanced between pilots. The experiment was conducted with approval of the institutional ethics committee in accordance with the (revised) Helsinki Declaration. **RESULTS:** We found main effects of both the visual environment and the HMD on objective and subjective measures. The most important effects of DVE are that, compared to GVE, pilots stayed closer to the go-fast, while there were more situations with a combined low airspeed, high torque and fast descend rate. Furthermore, the pilots indicated that it took more effort to fly stable parameters. The most prominent effects of the HMD were that pilots needed less cross-checks of the cockpit instruments, such that they could direct more attention to the outside environment, and could keep the go-fast vessel at an optimal bearing. **DISCUSSION:** The results confirm that helicopter pilots experience higher workload during a low-altitude interception task in DVE as compared to GVE. Situations with low airspeed, high torque and a fast descend rate are indicative of impaired situation awareness in DVE. The HMD allowed for better performance on the flight task as well as the interception task. The absence of interaction effects implies that the positive contribution of the HMD was a general effect, independent of the visual environment.

Learning Objectives

1. The audience will learn that helicopter pilots experience higher workload and impaired situation awareness during a low-altitude interception task in Degraded Visual Environment (DVE) as compared to Good Visual Environment (GVE).
2. The audience will learn that a Helmet-Mounted Display (HMD) allows for better performance on the flight task and interception task, independent of the visual environment.

[403] WEATHER PRODUCT INTERPRETATION TEST: GENERAL AVIATION

John Kleber, Cassandra Domingo, Jacqueline McSorley, Robert Thomas, Thomas Guinn, Amber Cole, Elizabeth Blickensderfer
Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Original Research)

INTRODUCTION: Hazardous weather is one of the primary threats to safe operations in aviation. Pilots receive weather information through displays (i.e., weather products). Previous research has shown General Aviation (GA) pilots have difficulty interpreting these products. This study evaluates the effectiveness of a truncated version of a previously developed weather product interpretation assessment.

METHODS: Thirty-four instrument-rated pilots ($M_{age} = 57.13$, $SD = 8.73$), Median flight hours = 2000) from a professional organization for high-performance aircraft participated. Participants were randomly assigned to one of two multiple-choice assessments—Test 1 (33 questions) assessed Winds Aloft, Radar, PIREPs, GFA, Satellite, and METAR, and Test 2 (32 questions) assessed Station Plots, GTG, Low-Level Sig Weather, Surface Prog Charts, SIGMETs, CIP, TAF, G-AIRMET, and Thunderstorms. The assessments and demographics questionnaire was administered using the online survey system, Qualtrics. **RESULTS:** Independent-measures t-tests assessed equivalency of experience (flight hours) and scores (percent correct) between the two groups/tests. Researchers then conducted a repeated-measures analysis of variance (ANOVA) to determine differences within tests among product types. Following

initial assumptions testing, three outliers on flight hours were removed, and subsequently, no statistically significant difference occurred in flight hours between pilots who took Test 1 and Test 2 ($p > .05$). There was a statistically significant difference in scores, with pilots taking Test 1 ($M = 77.58$, $SD = 8.32$) averaging higher scores than those taking Test 2 ($M = 64.45$, $SD = 14.65$). One-way ANOVAs on each test indicated statistically significant differences existed between products. The highest scoring products were GFA and PIREPs. The lowest scoring products were Station Plots and TAF. **DISCUSSION:** The results of this study followed a pattern similar to prior research that used a longer version of the test. Specifically, that satellite and METARs scored low, and PIREPs and GTG scored high. Regarding the test, the results indicate that the shortened Weather Product Interpretation Test is a viable measure for assessing a pilot's ability to interpret weather products. Furthermore, results indicated that pilots operating high-performance aircraft also have some difficulties interpreting weather products. Limitations of this study include the small sample size.

Learning Objectives

1. The audience will learn about a new version of an assessment tool for evaluating the ability of pilots to interpret weather products.
2. The audience will learn about the threat posed by hazardous weather to general aviation operations and the difficulties associated with weather product interpretation.

[404] WHO YOU GONNA CALL?: AN EVALUATION OF PREFLIGHT WEATHER BRIEFING PERCEPTIONS IN GENERAL AVIATION

Cassandra Domingo, Jacqueline McSorely, John Kleber, Dylan Dupree, Bethanie Trees, Elizabeth Blickensderfer
Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

(Original Research)

INTRODUCTION: Prior to embarking on a flight, General Aviation (GA) pilots perform preflight planning during which they obtain weather information relating to their flight. Historically, pilots did so by calling Flight Services (FS) and receiving a brief by telephone. Technology has advanced, and today GA pilots can perform weather "self-briefings" where they review pertinent weather information themselves through online websites or apps. However, research indicates that weather interpretation errors occur in pilots of all levels of flight certificate and ratings (Blickensderfer et al., 2021). This study examined GA pilots' perceptions of preflight weather planning methods (i.e., self-briefing or calling FS) and their current briefing habits. **METHODS:** Thirty pilots (mean age = 20.11, $SD = 1.45$; median flight hours = 195) participated in semi-structured interviews. The interviews were conducted through Zoom in either a focus group (up to five participants) or individual meeting. All interviews were audio-recorded, and the recordings were later transcribed. Three researchers coded the data using a coding scheme with 10 codes. Consensus was used to identify the final codes. **RESULTS:** Several common themes occurred regarding preflight weather planning. Challenges with FS briefings included that the process was time-consuming and that FS specialists talked too fast. Challenges with self-briefing included that weather products were confusing, that the process is reliant on Wi-Fi access, and that the technology suffered from frequent, unwanted updates. Participants generally perceived self-briefing as easier and faster than calling FS and that it contained helpful visual information. Participants also stated that FS was helpful, thoroughly described the weather and related weather products, and is a trustworthy source. **DISCUSSION:** Advancements in technology have caused a fundamental shift in how GA pilots conduct their preflight weather briefings. In general, GA pilots appear comfortable conducting weather self-briefings and speak highly of its benefits. With prior research indicating that GA pilots struggle with interpreting weather products, pilot perceptions about weather self-briefing may not match their actual performance.

Learning Objectives

1. Understand the implications of current GA pilots' perceptions of different methods of preflight weather briefing.
2. Learn how focus groups can be utilized in general aviation research.

Thursday, 05/26/2022
Tuscany F

3:30 PM

[S-79]: SLIDE: MAKING SENSE OF PHYSIOLOGY

Chair: Leon Hrebien

Co-Chair: Jaime Harvey

[405] UNDERSTANDING OXYGENATED BLOOD PULSE TRANSIT TIMES DURING HYPOXIA INDUCTION FOR DETECTION OF COGNITIVE IMPAIRMENT

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¹University of Florida, Gainesville, FL, USA; ²NASA Langley, Hampton, Virginia, USA

(Original Research)

INTRODUCTION: A pilot's performance is impacted by stress and increased cognitive workload. The human physiological response to stress and workload involves sympathetic nervous system activation including vascular constriction. The development of features for machine learning algorithms that characterizes these cardiovascular dynamics could potentially provide better performing algorithms for cognitive state detection (e.g., cognitive impairment). Our aim is to capture and characterize a surrogate measure of vascular constriction and improve understanding features such as heart rate and perfusion dynamics in predicting cognitive impairment. **METHODS:** Our approach leverages the coupling of the photoplethysmogram (PPG) and electrocardiogram (ECG) signals to derive novel features indicative of blood perfusion and vascular dynamics. The underpinning of this work examines the timing delays of the systolic phase of the PPG signal and the contraction phase of the left ventricle of heart (detectable in the ECG). Thus, the time from the moment the left ventricle contracts to perfusion of the subject's extremities as detected by the PPG sensor, is the "Blood Pulse Transit Time." We have examined the implications of these timing delays through traditional statistical analyses and entropic methods analyses. The data was collected from 57 pilots involving simulated altitudes of sea level (21.0% O₂) and 15,000 feet (11.2% O₂) induced by an EnviroNics, Inc. Reduced Oxygen Breathing Device (ROBD). **RESULTS:** Preliminary results comparing the hypoxic and non-hypoxic cohorts demonstrate significant changes in blood pulse transition time mean values and complexity (sample entropy), respectively ($p < 3 \times 10^{-5}$, $p < 0.0298$). However, the variance of the blood pulse transit times was not significant. Preliminary analyses reveal trends indicating that as induction of hypoxia proceeds for 10 minutes and oxygen levels drop, the blood pulse transit time decreases. **DISCUSSION:** The results indicate that the impact of induction of hypoxic episodes on perfusion of blood and the vascular physiological response can be characterized and predicted. The implications of these results include updating current thinking about the cardiovascular dynamics and physiology stressors within aeromedical applications in which perfusion of oxygenated blood is critical. A potential application of these predictive capabilities includes the development of real-time non-obtrusive systems controlling G-suits to regulate optimal oxygen perfusion and demand.

Learning Objectives

1. The coupling of novel noninvasive sensors can be utilized as a surrogate measure of vascular constriction and response to sympathetic change.
2. The important differences within the cardiovascular analysis between heart rate complexity and heart variability. Thus, the differences between variance and complexity.

[406] VALIDATION OF AN ABBOTT I-STAT IN ANALYSING CAPILLARY AND VENOUS SAMPLES FROM RETURNING AIRCREW FOLLOWING REPORT OF AN IN-FLIGHT PHYSIOLOGICAL EPISODE

Anthony Schiemer, Adrian Smith

Royal Australian Air Force Institute of Aviation Medicine, Adelaide, Australia

(Original Research)

INTRODUCTION: The Royal Australian Air Force (RAAF) has determined the Abbott i-STAT be implemented as a testing device for assessment of aircrew following the report of an in-flight physiological episode (PHYSEP). Other militaries investigating this phenomenon have identified arterial blood gas measurement as their preferred assessment. Given the invasive nature of an arterial collection, the RAAF Institute of Aviation Medicine (IAM) were requested to assess the suitability of the Abbott i-STAT device in analysing capillary and venous samples across a time frame simulating an in-flight PHYSEP, followed by a return to base and landing with immediate airside testing to follow. **METHODS:** We collected paired capillary and venous blood samples taken from eleven healthy Australian Defence Force volunteers, before and after voluntary hyperventilation leading to two symptoms present for at least 15 seconds. The parameters assessed included $p\text{CO}_2$, pH, anion gap, HCO_3^- and total CO_2 ($t\text{CO}_2$). Samples were collected at baseline, when the participant had developed symptoms, and at 5 and 30 minutes following normalisation of breathing. As an adjunct, transcutaneous CO_2 ($t\text{cpCO}_2$) monitoring was also conducted on each participant throughout the assessment. **RESULTS:** A statistically significant (ANOVA $p < 0.001$) mean drop in capillary $p\text{CO}_2$ and an increase in capillary pH was noted at the point of symptomatic hyperventilation when compared to baseline, although these changes had normalised at the five-minute mark, with no changes evident at the 30-minute interval in any of the assessed parameters. The $t\text{cpCO}_2$ monitoring noted a distinct drop during the hyperventilation phase in all participants, which similarly normalised within 5 minutes following cessation of hyperventilation. **DISCUSSION:** These results highlight the rapid normalisation of certain blood gas values following removal of the insult (in this case, hyperventilation). Given the operational time frames involved, the usefulness of waiting to assess the venous/capillary blood gases upon return of the aircrew member following report of a PHYSEP is questionable. However, the ability of the i-STAT to detect blood gas changes during the symptomatic phase suggest that it could provide a useful adjunct in the investigation of a PHYSEP if samples are collected when symptoms occur, as may $t\text{cpCO}_2$ monitoring.

Learning Objectives

1. The participant will be able to understand the statistically significant capillary and venous blood gas changes occurring in a healthy hyperventilating patient, when measured by a point-of-care blood gas analyzer.
2. The participant will appreciate the limitations inherent in using a point-of-care blood gas analyzer on the ground for assessing the cause of in-flight physiological episode in returned aircrew.
3. The participant will understand the changes that occur in transcutaneous $p\text{CO}_2$ in a healthy hyperventilating patient.

[407] VALIDATION OF WIRELESS, WEARABLE E-TATTOOS FOR IN-FLIGHT OPERATOR STATE MONITORING

Jason Boggs¹, Ryan Mackie¹, Colby Matthews¹, Sarnab Bhattacharya², Philip Tan², Katie Feltman¹, Nanshu Lu²

¹United States Army Aeromedical Research Lab, Fort Rucker, AL, USA; ²The University of Texas, Austin, Austin, TX, USA

(Original Research)

BACKGROUND: Researchers at the U.S. Army Aeromedical Research Laboratory (USAARL) continue to validate a series of proprietary lightweight wireless wearable physiological sensors named "e-tattoo" developed by a team at The University of Texas (UT) at Austin. The USAARL is implementing a series of test plans to validate the signal

fidelity, aircraft compatibility, and user comfort for several wireless, wearable sensors. The first iteration of sensors were designed to be worn on the neck and measured respiration rate, heart rate, heart rate variability, oxygen saturation (SpO_2), and temperature. The results of the initial phase are reported here. **METHODS:** The first phase involved testing an early prototype neck e-tattoo in an effort to guide design and fabrication of the second version (V2) neck tattoo prototype. Testing consisted of three aviators wearing the neck tattoo for 24 hours while completing an initial morning testing session, an evening testing session 12 hours later, sleeping with the tattoo on, and then a final morning testing session. Participants completed wearability surveys, performed a check-ride in a full-motion UH-60 Black Hawk simulator, and were exposed to temperatures ranging from -13 and 41 degrees Celsius for 30 minutes. To validate the signal fidelity, participants wore BioPak electrocardiogram and respiration belt sensors during each of the three test sessions. **RESULTS:** In phase one, UT Austin analyzed the quantitative sensor data and the USAARL analyzed the qualitative data. The combined results indicated the need to reduce the sensor size, enhance Bluetooth capability, add an accelerometer to aid in reducing signal noise, make the tattoos self-adhesive rather than requiring them to be taped on, and improve the software to allow faster data extraction. **DISCUSSION:** Results suggested the viability, with improvements, of wearable sensors to monitor aviators in real-time. Phase one of the test provided substantive data to incorporate into the design of the V2 neck e-tattoo. The V2 e-tattoo has been successfully fabricated and is scheduled for testing in late October of 2021. A forehead e-tattoo measuring electroencephalogram signals is being designed for phase three testing that is slated for fiscal year 23.

Learning Objectives

1. The audience will learn about the validity, viability, and user experience of "e-tattoos."
2. The audience will learn about the limitations and safety parameters for utilizing the e-tattoos in-flight.
3. The audience will learn about how to balance the comfort and movement needs of the aviators with the ability to gather relevant real-time data.

[408] PRE-SYMPTOMATIC WARNINGS OF HYPOBARIC HYPOXIA DURING HIGH-ALTITUDE FLIGHT ABOARD TACTICAL AIRCRAFT BY A STANDALONE PHYSIOLOGICAL MONITORING SYSTEM

Brad Everman¹, Brian Bradke²

¹Spotlight Labs, Haddonfield, NJ, USA; ²Spotlight Labs, Barre, VT, USA

(Education - Case Study)

INTRODUCTION: Understanding and addressing Unexplained Physiological Episodes (UPEs) has posed numerous challenges. Current strategies for mitigating UPEs, such as training pilots how they feel to then take corrective action, are purely subjective and speculative making them very risky. Furthermore, research indicates that cognition and decision-making are impacted *prior* to symptom onset. This emphasizes the importance of establishing real-time monitoring technology to monitor, assess, and understand critical biometrics. From August 2020 through August 2021, The USAF conducted Operational Test of SPYDR, a standalone physiological and environmental monitoring system aboard F-16, F-15C/E, A-10 and F-22 aircraft. **CASE PRESENTATION:** During the operational test flight period, three different test pilots (2x F-15C, 1x F-22) experienced a marked case of hypobaric hypoxia during tactical flight. Each event occurred at high altitude, with cabin pressure altitudes of 16k, 14k, and 14.5k. In each case, SPYDR's predictive hypoxia algorithms gave the aviators an audible alert before the aviator felt their individual symptoms. Despite "feeling normal", post-flight data analysis process revealed a clear case of hypobaric hypoxia consistent with clinical and experimental findings. **DISCUSSION:** These events demonstrate the applicability and functionality of SPYDR as an accurate continuous physiological

monitoring device for warning of physiological emergencies in real-time, further preventing the effects of cognitive degradation on mission outcomes. On multiple occasions, aviators were experiencing early stages of cognitive degradation caused by hypoxic exposure, yet were unable to recognize any symptoms of hypoxia. In all three cases, the aviator responded to a distinct, unambiguous, and persistent audible warning resulting from the on-board processing of multiple data streams being captured with medical-grade accuracy and processed in real time. Further, these multiple data streams were contrasted and compared amongst multiple redundant sensors inside the system to determine a true hypoxic condition. Although each aviator had the option to ignore or silence the warning, each elected to take corrective action, and the missions recovered without incident.

Learning Objectives

1. The participant will learn about current physiological monitoring systems flying with the USAF to prevent physiological episodes in flight.
2. The participant will learn about ongoing hypoxic events occurring during flight aboard tactical aircraft.
3. The participant will learn about advanced alerting algorithms used for detecting hypoxia with reduced rates of false alerts.

[409] BREATHING RHYTHM COMPLEXITY AS AN INDICATOR TO RESPIRATORY COMPROMISE FOR FUTURE FLIGHT DECK SYSTEMS

Jeremy Prieto¹, Rheagan Horne¹, Chad Stephens², Kellie Kennedy², Nicholas Napoli¹

¹University of Florida, Gainesville, FL, USA; ²NASA Langley Research Center, Hampton, Virginia, USA

(Original Research)

INTRODUCTION: Detecting the impact of respiratory loads and stressors on the respiration system is critical to understanding the dynamics within the respiratory system and the stresses imposed on the human within flight deck systems. Analysis of breathing rate, frequency, and period has been a commonly conflated terminology that is utilized in evaluating breathing. We propose a new approach in analyzing respiratory compromise using the induced of hypoxia, called Breathing Rhythm Complexity. **METHODS:** Professional pilots served as test subjects (n=57, 49 males) in a study involving simulated altitudes of sea level (21.0% O₂) and 15,000 feet (11.2% O₂) induced by an Environics, Inc. Reduced Oxygen Breathing Device (ROBD). Each subject experienced both non-hypoxic and hypoxic (SPO₂ ≤ 95%) exposures while performing three 10-minute tasks (computerized neuropsychology tests, computerized multitasking battery, and fixed-based flight simulation). The quantitative approach leverages our understanding that the respiratory signal is not composed of a pure sinusoidal wave. The waveform is decomposed at its zero-crosses to calculate individual inspiratory and expiratory times. The difference between these times are calculated using sample entropy, producing Breathing Rhythm Complexity. **RESULTS:** Preliminary results comparing the hypoxic and non-hypoxic cohorts demonstrated no significant changes in time of inspiration and time of expiration variance and complexity (sample entropy). However, when observing respiratory rhythm complexity, a comparison between the cohorts demonstrated significant changes in respiratory rhythm complexity (sample entropy), achieving $p < 0.0214$. **DISCUSSION:** The preliminary results indicate the induction of hypoxic events and their impact on breathing rate, frequency, period, and rhythm under respiratory stress. The implications of these results suggest that a subject's breathing rate, frequency, and period may not always distinguish respiratory stress, but the dynamic nature of the breathing rhythm can. This understanding of breathing rhythm complexity can provide beneficial information into the nature of how human physiological systems (e.g. respiration) compensate under respiratory stress.

Learning Objectives

1. [The audience will learn about...] the importance of breathing rhythm complexity and its impact on respiratory compromise.

2. [The audience will learn...] the importance of extrinsic loads and environmental factors, such as hypoxia, and its impact on the respiratory system.

Thursday, 05/26/2022

3:30 PM

Tuscany 3

[S-80]: PANEL: RESIDENT GRAND ROUNDS: USAFSAM

Chair: Paul Newbold

Co-Chairs: David Miller, Thomas Jarnot

PANEL OVERVIEW: Resident Grand Rounds consists of 6 Case Presentations. Each Case Presentation is presented by current USAF School of Aerospace Medicine RAMs who will review the clinical case presentation, diagnosis, treatment pathway and current policies from different agencies. They will discuss the clinical and waiver outcome (if appropriate). These unique Case Presentations describe clinical aviation medicine as well as policy updates for common medical and mental health conditions encountered in the practice of our specialty.

[410] CEREBRAL ANEURYSM IN AN AIR FORCE TACTICAL AIR PATROL PARTY MEMBER

Catherine Blasser¹

¹United States Air Force, Wright-Patterson AFB, OH, USA

(Education - Case Study)

INTRODUCTION: This case report describes a Tactical Air Control Party (TACP) member who presented with vague neurologic symptoms leading to the discovery of a significant cerebral aneurysm.

BACKGROUND: TACP Airmen are the lead precision strike experts for USAF Special Warfare career field. They track, target, and engage enemy forces in close proximity to friendly forces with precision airstrikes. Not all are jump qualified, however, those that are will often perform static line as well as high altitude, low opening parachute duties wearing gear weighing approximately 80lbs. TACP physical requirements exceed those of many other career fields in the USAF. Although cerebral aneurysm in a young adult without a known familial predisposition is rare, and most aneurysms never bleed, this condition is disqualifying for members of the SWA career field. **CASE PRESENTATION:** This case involves a 24-year-old TACP who presented with two weeks of dysgeusia after abrupt onset unilateral, left-sided numbness. The numbness resolved within 24 hours but the metallic taste in his mouth persisted. He denied neurologic symptoms aside from transient numbness. Magnetic resonance imaging of the brain showed a posterior cerebral artery (PCA) aneurysm in the right ambient cistern impressing upon the adjacent cerebral peduncle with evidence of hemosiderin deposition. Computed tomography angiogram showed a fusiform aneurysm in the right PCA measuring 1.2cm x 0.7cm x 0.7cm. The Airman was referred for pipeline stent placement. **DISCUSSION:** This case highlights the potential vague and non-specific presentation of intracranial abnormalities. The primary differential diagnosis for persistent dysgeusia is poorly controlled gastroesophageal reflux, however, the near-complete unilateral numbness that had resolved by the time of presentation raised concerns for intracranial pathology. There is a myriad of factors, such as physical strain, which may contribute to aneurysm rupture. This Airman had a type of aneurysm which is not typical of congenital etiology, but one associated with arteriosclerotic disease. Given his age, high physical activity level, relatively high risk for head trauma in the course of his career, and the concern that he had already experienced bleeding to some degree, he was stented immediately.

Learning Objectives

1. Identify several possible occult neurologic manifestations of unruptured cerebral aneurysms.
2. Understand the physical and operational limitations that can result from cerebral aneurysms.

[411] PERNICIOUS ANEMIAMaryrose Chuidian¹, Kent Boucher²¹USAFSAM, Dayton, OH, USA; ²Cannon AFB, Clovis, NM, USA*(Education - Case Study)*

INTRODUCTION: This case report describes a 24 yo female aviator who presented after a syncopal event, reporting approximately one month of worsening fatigue within a deployed setting. She was eventually diagnosed with pernicious anemia and required emergency evacuation due to the severity of her presentation. **BACKGROUND:** Pernicious anemia is the most common cause of vitamin B₁₂ deficiency anemia. It is principally caused by intrinsic factor deficiency secondary to autoimmune destruction of gastric parietal cells. Its prevalence is estimated to be 150.9/100,000 in the US with a preponderance for females. It is a challenging disease to diagnose due to its variable clinical presentation and wide range of symptoms, often leading to a delay in diagnosis. Uncontrolled or undiagnosed conditions causing a wide array of symptoms, such as those caused by pernicious anemia, is concerning within the aerospace environment. **CASE PRESENTATION:** A 24 yo female loadmaster presented to the medical bay at her deployed location following a witnessed syncopal episode. She stated she was in her living quarters, stood up to reach for a box on a shelf and passed out. The aviator admitted to worsening fatigue for approximately one month and recently nausea, an episode of emesis and decreased urine output. Her past medical history was significant for anemia, gluten-free diet, and hypothyroidism. The evaluation progressed to include a bone marrow biopsy which was negative for malignancy, but additional workup confirmed pancytopenia and severe vitamin B₁₂ deficiency. She was treated with vitamin B₁₂ infusion leading to resolution of symptoms and stabilization of pancytopenia. The aviator is currently restricted from flying and being treated for pernicious anemia with weekly intramuscular injections of vitamin B₁₂. **DISCUSSION:** This case highlights how an aviator's medical condition can quickly decline in an austere location. This loadmaster's fatigue culminated in a syncopal episode, thankfully occurring while not performing flying duties. Had she lost consciousness while airborne, the consequences may have led to a mishap. Multiple factors led to severe Vitamin B₁₂ deficiency and ultimately, pernicious anemia. This case emphasizes the importance of aviators being educated and aware of their known medical conditions, understanding worrisome signs and symptoms, and reporting to the flight surgeon early.

Learning Objectives

1. Understand the link between pernicious anemia and vitamin B12 deficiency.
2. Understand early signs and symptoms of anemia and implications of severe and safety concerns related to flying community.

[412] WHEN A HEADACHE IS NOT JUST A HEADACHEMatthew Hoyt¹, Raeann Macalma²¹USAFSAM, Wright Patterson AFB, OH, USA; ²JBPHH, Honolulu, HI, USA*(Education - Case Study)*

INTRODUCTION: This case report describes a military C-17 pilot who experienced headache symptoms without red flags lasting for three days prior to the acute onset of neurologic symptoms. Rapid evaluation with computed tomography (CT) led to the discovery of a cavernous malformation. **BACKGROUND:** Headache assessment typically focuses on ruling out red flags, and then identifying the headache type to target an appropriate treatment or prevention strategy. Red flags may prompt a more extensive evaluation and are utilized to identify more serious causes of headache. In the absence of these red flags, conservative management is the evidence-based practice of choice when evaluating and treating aviators with headaches. **CASE PRESENTATION:** The subject is a 32-year old male US Air Force pilot. He is an experienced pilot with 2200 total flying hours including 200 hours in the C-17 and presented during an acute clinic visit with the squadron flight surgeon for evaluation of his headache which had not resolved after typical

conservative measures. The aviator then experienced an acute change in symptoms including left sided numbness and tingling. He was transported to a higher level medical treatment facility via emergency medical services. CT imaging was obtained which identified a cavernous malformation. He was treated with surgical excision and physical therapy which resulted in an uncomplicated recovery. The etiology of this pilot's cavernous malformations was determined to be genetic. He is completing all required surveillance imaging and follow-up evaluations with a desire to retrain as a remotely piloted aircraft pilot. **DISCUSSION:** This case highlights the limitations of the currently accepted headache evaluation standard using red flags. The genetic nature of this member's malformations, and the amount of time the member remained asymptomatic presents a challenge when trying to determine when the malformations initially appeared. Additionally, the absence of red flags on initial clinical presentation and follow up potentially led to a delay in diagnosis of the underlying cause. This case illustrates the need for an appropriate index of suspicion for aviators who present with what is often considered a routine complaint. Clinicians must be familiar with the proper evaluation to identify red flags in aviators presenting with the chief complaint of headache.

Learning Objectives

1. To learn and discuss about red flags for headache evaluation.
2. Discuss the aeromedical standards which apply to aviators diagnosed with intracranial lesions.

[413] UNPROVOKED AORTIC DISSECTION IN A HIGH-PERFORMANCE AVIATOR

Steven Nordeen

USAFSAM, Wright-Patterson AFB, OH, USA

(Education - Case Study)

INTRODUCTION: This case describes a military aviator who experienced leg pain due to an acute aortic dissection. **BACKGROUND:** Aortic dissection (AD) is uncommon, but has potentially life-threatening outcomes that typically occur in older males with a known incidence of 2.6 to 3.5 per 100,000 person years. AD poses risk to life and limb and may present with a triad of tearing thoracic/abdominal pain, blood pressure/pulse difference between two limbs and mediastinal widening on chest x-ray. Chest or back pain is the most common presenting symptom and hypertension is the most common risk factor. A literature review revealed only one case report of acceleration-induced AD in a pilot. While the case presented did not occur during flight, it did occur in a high-performance aviator. **CASE PRESENTATION:** A mid-20's male high-performance aviator underwent military training that involved heavy exertion in an austere location. During training, he developed bilateral lower leg pain limiting his ability to walk. Field medical staff were on-scene within 15 minutes. He denied trauma or prior history of problems pulling high Gs. Review of systems was otherwise negative. Past surgical history included repair of a patent ductus arteriosus at birth and family history was unremarkable. Vitals revealed a blood pressure in the 200s/100s. Initial extremity exam demonstrated intact sensation, pulses, and capillary refill. During the evaluation, he noted worsening right leg pain extending to his pelvic region and was noted to have weak right distal pulses. He was transported to the nearest emergency department. Computed tomography scan demonstrated an AD from his ascending aorta to his iliac artery. He developed cyanosis of his right leg and was flown to a large medical center for surgical repair. **DISCUSSION:** Aortic dissection is uncommon in younger patients, but must be considered in aviators with a history of aortic aneurysm, aortic valve diseases such as bicuspid aortic valve, history of certain heart surgeries and coarctation of the aorta. Available resources such as the Air Force Aircrew Waiver Guide and the Federal Aviation Administration's Guide for Aviation Medical Examiners address conditions that increase risk, but not specifically what to do with an aviator following an AD. This is an area for future consideration to help guide aerospace medicine clinicians moving forward.

Learning Objectives

1. Ensure aerospace medicine clinicians keep aortic dissection in their differential diagnosis when evaluating aviators with lower extremity pain or signs of decreased distal circulation.
2. Review the common considerations for aortic dissection as it pertains to the aeromedical environment.

[414] INITIAL PRESENTATION OF GLIOBLASTOMA MULTIFORME IN A REMOTELY PILOTTED AIRCRAFT PILOT

William Timberlake¹, Gregory Trifilo²

¹USAFSAM, Fairborn, OH, USA; ²Buckley SFB, Aurora, CO, USA

(Education - Case Study)

INTRODUCTION: This case report describes a remotely piloted aircraft (RPA) pilot who presented to clinic with new onset headache that was persistent over three days and changed in quality with vagal-type maneuvers concerning for an intracranial mass. MRI imaging was obtained and interpreted on the same day with an unfavorable diagnosis. **BACKGROUND:** Glioblastoma Multiforme (GBM) is a severe and rapidly deteriorating neurological condition caused by a rapidly expanding mass effect. The prognosis is poor with a median survival of approximately 10 to 12 months. Additionally, one-year survival rates range from 38 to 50 percent with five-year survival rates ranging from 5 to 10 percent. These rates may be influenced by age at the time of diagnosis, biological sex, O⁶-methylguanine-DNA-methyltransferase (MGMT) methylation status, as well as the Karnofsky Performance Status (KPS). Maximal surgical resection with preservation of neurologic function is the initial step in management. **CASE PRESENTATION:** The subject was a 27-yr old, right-hand dominant male who complained of three days of new onset headache described as a pressure behind his right eye. Neurological examination was without focal nor gross deficits and history was unremarkable for any potential contributing events such as concussion or whiplash. However, the patient was questioned regarding changes in the character of the headache, especially if engaging in any vagal-type maneuvers. The subject noted that during defecation, the pressure behind his eye would temporarily change from a dull ache to a more intense throbbing. Given this concerning feature the subject was referred for an MRI of the brain. Within 24 hours radiology reported that a 4.7 cm x 6.5 cm mass was found in the right median lobe of the brain with a 1 cm right-to-left midline shift. Initial surgical resection and biopsy confirmed suspicion of a GBM. **DISCUSSION:** This case highlights a unique neurological condition which unfortunately is not compatible with continued aviation duties. While other types of intracranial masses may be approved for continued duties provided the lesion is not causing aeromedically significant neurological deficit(s), the natural course of this particular mass does not allow for such certification. Headaches pose a challenge given the wide variety of underlying etiology, which unfortunately in this case was a severe and deteriorating condition.

Learning Objectives

1. To learn about GBM, indications for earlier imaging in the disease process, and review the differential diagnosis for new onset headaches.
2. To discuss the implications of GBM on continued performance of aeronautical duties.

[415] SERONEGATIVE RHEUMATOID ARTHRITIS IN A FLIGHT ENGINEER

Robert Wright¹

¹USAFSAM, Wright-Patterson AFB, OH, USA

(Education - Case Study)

INTRODUCTION: This case report describes a military flight engineer (FE) with an atypical presentation of rheumatoid arthritis (RA). **BACKGROUND:** RA is a chronic autoimmune disease characterized by progressive joint destruction with the potential for severe extra-articular manifestations and medication side effects of aeromedical concern. Early treatment with novel disease-modifying antirheumatic drugs (DMARDs)

can prevent long-term progression/disability and comorbidities. **CASE PRESENTATION:** This case report describes a 38-year-old male FE with a few months history of atraumatic bilateral pain in his shoulders and hips, intermittent nighttime awakening, night sweats and fatigue. His physical examination was unremarkable. Evaluation to rule out bony and hematologic malignancy, chronic infection, fatigue, and inflammatory/rheumatologic etiologies were normal except for mild edema on hip/shoulder MRI. His pain was mildly improved with naproxen 500mg BID for 2 weeks. He returned 6 weeks later with acute onset of diffuse edema and joint swelling of the upper and lower extremities. A search for underlying renal, liver, and cardiac disease was negative so a rheumatology consultation was requested. He was ultimately diagnosed with seronegative RA following laboratory testing and MRI gadolinium scan. The aviator's RA flare was initially managed with a combination of DMARDs, including prednisone, methotrexate (MTX), and hydroxychloroquine (HCQ) with significant improvement in symptoms. **DISCUSSION:** This case highlights a severe rheumatologic condition affecting ~0.5% of US adults, with higher prevalence in women and adults over 50 years-old. Aeromedical risks are numerous, variable in severity, and can occur due to disease progression and/or treatment adverse effects. Progressive loss of fine-motor function and disability due to small joint damage can impair flight performance over time and be prevented with early treatment. Risks include spinal cord/brainstem compression due to neck flexion/extension with high +G secondary to cervical disease (e.g., AAI/AAS, cranial settling), which affects ~86% of RA patients, as well as MTX-pneumonitis, HCQ-retinopathy, and steroid-induced neuropsychiatric effects. Aeromedical standards vary by agency (e.g. FAA allows prednisone and MTX, but the USAF does not). Early diagnosis of RA is critical because prompt treatment with novel DMARDs can improve symptoms and prognosis, and enhance return to flight status.

Learning Objectives

1. Participants will be able to discuss the aeromedical concerns surrounding the RA disease process and treatment modalities.
2. Participants will learn aeromedical standards associated with RA in the U.S. FAA, US Air Force, US Navy, and US Army.

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3:30 PM

[S-81]: PANEL: STILL THE RIGHT STUFF?: AEROSPACE IMPLICATIONS POST-COVID-19

Chair: Michael F. Harrison

PANEL OVERVIEW: The impact of the COVID-19 pandemic on the aerospace industry has been immense. Commercial air travel volume to domestic and international locations was significantly reduced and many professional pilots were furloughed or laid off. Tourism was restricted and recreational activities such as mountaineering and SCUBA diving were also reduced. As the latest wave recedes following the delta-variant and vaccination rates increase, it is possible to be optimistic about the prospects of life returning to "normal". This panel will describe the challenges faced by healthcare providers practicing in the aerospace and extreme environment realms. Panelists will describe specific nuances of mitigating risk, managing care, and returning patients to the aviation, SCUBA diving, high altitude climbing, and spaceflight environments after an acute infection. Panelists will describe appropriate screening processes for asymptomatic individuals following resolution of symptoms as well as the management plan for individuals suffering from Long COVID.

[416] STILL THE RIGHT STUFF?: AEROSPACE IMPLICATIONS POST-COVID-19

Michael F. Harrison, Leigh Speicher
Mayo Clinic, Jacksonville, FL, USA

(Education - Tutorial/Review)

INTRODUCTION: Overall 300 million people worldwide have been infected with SARS-CoV2, the virus that causes COVID-19, and over 5 million people have died as a result. The spectrum of the disease ranges from mild illness that can be managed in an ambulatory setting to critical illness requiring admission to the intensive care unit; furthermore, some of the individuals infected with COVID-19 have lasting effects following the resolution of the acute infection. Pilots have not been immune and many are included among the COVID-19 cases. The challenged faced by medical professionals caring for professional and private aerospace patients is how to medically assess and certify them for return to duty or activity following COVID-19 infection. **TOPIC:** COVID-19 and post-COVID-19 sequelae can have detrimental effects on multiple organs and systems including the cardiovascular, cerebrovascular, nervous, pulmonary, ophthalmologic, psychologic, and hematologic systems. Prolonged sequelae to one or more of these organ systems may impair a pilot's ability to operate their aircraft and have a negative impact on flight safety. This represents a significant public health concern. This panel will present what is currently known about COVID-19 and summarize the standards applied to multiple flight environments ranging from general aviation to high-performance and military aviation in assessing a pilot's health and ability to meet the standard for medical certification. Presenters will discuss the implications and management options for "Long-COVID" patients who are pilots and discuss the standards in comparable industries and activities including SCUBA diving and high-altitude expeditions. Lastly, presenters will discuss the efforts used to keep COVID-19 from traveling off the planet to the International Space Station with both professional astronauts and private spaceflight participants. **APPLICATION:** The information presented in this panel will provide information for aeromedical examiners and other physicians who are seeking guidance related to a pathway to certification for their post-COVID-19 patients as well as seeking more information about pitfalls and risks that need further evaluation and management prior to certification.

Learning Objectives

1. The audience will learn about the particular concerns in clearing asymptomatic patients for return to duty or activity in extreme environments following COVID-19 infection.
2. The audience will learn about the particular concerns in clearing patients with "Long COVID" for return to duty or activity in extreme environments following COVID-19 infection.
3. The audience will learn about concerns associated with specific organ systems (cardiovascular, pulmonary, etc) and specific activities and environments (Aviation, SCUBA diving, high-altitude climbing, spaceflight) related to COVID-19 prevention and post-infection.

[417] MEDICAL CERTIFICATION CONSIDERATIONS AFTER RESOLUTION OF COVID-19

Leigh Speicher¹, Dana Herrigel¹, Wiaam Elkhatib¹, Kamal Shair¹, Joshua Kwon¹, Anshika Singh², Jordan Dutcher³, Sheena Fletcher³, Michael Harrison¹

¹Mayo Clinic Florida, Jacksonville, FL, USA; ²Naples Community Hospital, Naples, FL, USA; ³Mayo Clinic Alix School of Medicine, Jacksonville, FL, USA

(Education - Tutorial/Review)

INTRODUCTION: To maintain aviation safety, pilots should be medically certified that they are fit to return to flight duties after COVID-19. This novel disease process affects multiple systems and may cause ongoing or long term consequences despite a self-reported return to baseline status. The COVID-19 pandemic has necessitated the formulation of return to flight screening recommendations for civilian and military pilots. Uniform standards do not yet exist for these recommendations or the acceptable thresholds for return to flight operations. **TOPIC:** Cardiac, pulmonary, neurologic, hematologic, psychiatric, ophthalmologic, and gastrointestinal sequelae are all possible after the acute COVID-19 infection. Unrecognized changes in function on the ground may create significant hazards in the aviation environment. This review summarizes available literature on the pathophysiology and manifestations of

COVID-19 as it relates to the fitness of pilots and proposes guidelines for evaluation of pilots after recent infection. Recommendations are divided into three categories: those managed as an outpatient, those requiring hospitalization, and critical illness related to COVID-19. Thresholds for diagnostic testing results can be further divided into general and high performance aviation environments. **APPLICATION:** Eliciting the potential ongoing but unrecognized effects of COVID-19 is vital for aviation safety. The framework established here could be utilized to standardize certification and safely return pilots to aviation duty who have recovered from COVID-19.

Learning Objectives

1. Describe potential unrecognized lingering effects of COVID-19 that could affect performance in the aviation environment.
2. Recall a screening framework to return pilots to aviation safely after recovery for COVID-19.

[418] LONG HAUL COVID - THE NEW FRONTIER

Greg Vanichkachorn

Mayo Clinic, Rochester, MN, USA

(Education - Case Study)

INTRODUCTION: 32-year-old Caucasian, male paramedic, with no prior medical history, developed sudden syncope episodes following a work related COVID-19 infection. **BACKGROUND:** Post-Acute Sequelae of SARS-COV-2 (PASC) is now a defined entity by the World Health Organization. This is not a rare condition, with studies showing 30-50% of patients experiencing ongoing symptoms even a year after acute infection. While this condition has typically been associated with severe fatigue and dyspnea, there can be many other symptoms, including impaired cognition and autonomic dysfunction. **CASE PRESENTATION:** Prior to his infection, the patient did not have any chronic medical conditions and did not use any prescription medications. The initial SARS-COV-2 infection was uncomplicated, not requiring hospitalization. Syncope episodes began soon after the acute infection resolved. Additional symptoms included extreme fatigue, shortness of breath, myalgia, dizziness, constipation, and fluctuating blood pressure. In depth neurological and cardiovascular evaluation did not reveal a specific etiology. A diagnosis of sleep apnea and pelvic floor dysfunction was made after completion of an overnight polysomnogram and anorectal manometry. With initiation of continuous positive airway pressure and pelvic floor dysfunction therapy, the patient's symptoms resolved. Due to the safety sensitive nature of his work, the patient has not been able to return to his work as a paramedic. **DISCUSSION:** PASC can be associated with both sudden and prolonged impairments in function. Undiagnosed PASC in aviators can possibly be a significant aeromedical concern. Additional research into the proper diagnosis and management of this condition is needed to ensure aeromedical safety.

Learning Objectives

1. Recognize the true and varied presentation of long haul COVID.
2. Understand the basic tents of care, including multidisciplinary evaluations and rehabilitation.
3. Use diagnostics such as advance imaging and blood analysis appropriately and judiciously.

[419] CARDIOVASCULAR CONCERNS FROM COVID-19 IN PILOTS

Wiaam Elkhatib, Dana Herrigel, Michael Harrison, Thomas Flippe, Leigh Speicher

Mayo Clinic Florida, Jacksonville, FL, USA

(Education - Tutorial/Review)

INTRODUCTION: The capacity for significant cardiovascular sequelae with potentially imperceptible clinical symptoms elicits concern both during and following resolution of acute COVID-19 in pilots. Specific medical risk factor evaluations and clinical management considerations warrant deliberation prior to aviation duty return. A comprehensive review of these cardiovascular implications applied to the aviation environment

remains a critical gap in understanding their significance towards flight safety. **TOPIC:** Cardiovascular disease, now complicated by the COVID-19 pandemic, remains a leading cause of death and risk for sudden incapacitation for pilots during flight. Relevant data regarding the implications of COVID-19 towards heart tissue, circulating cells, and endothelium were comprehensively reviewed to describe the role of pre-existing cardiovascular disease, cardiac-specific mortality risk, mechanisms underlying pathologic alterations, pharmacologic interactions, and aviation environmental considerations for managing pilots resuming flight duty. Existing literature on high-performance athletes as a correlate for experiencing high G forces, scuba divers as an environmental work analog, occupational medicine, and established medical aviation benchmarks towards this target population were additionally examined. Conditions of primary concern included hypertension, subclinical myocardial injury as potential pro-arrhythmic substrate, increased risk of sudden death, myopericarditis, impaired flow reserve from microvascular damage, pulse and blood pressure lability in response to vigorous activity, cardiovagal and orthostatic dysfunction, and thromboembolic disease. **APPLICATION:** Aviation medical professionals should remain cognizant of the clinically apparent and occult manifestations of cardiovascular dysfunction associated with COVID-19 to ensure the highest standards of flight safety during the ongoing pandemic. Review and implications in the aviation environment are applied towards aviation pilots who may be assessed in a clinic-based setting.

Learning Objectives

1. Describe the cardiovascular effects of Covid-19 during and after infection.
2. Understand the implications for cardiovascular Covid-19 changes in the aviation environment.

[420] POST-COVID-19 TO THE EXTREME

Anshika Singh³, Dana Herrigel¹, Leigh Speicher¹, Jan Stepanek², Michael Harrison¹, Wiaam Elkhatab¹, Kamal Shair¹
¹Mayo Clinic Florida, Jacksonville, FL, USA; ²Mayo Clinic Arizona, Scottsdale, Arizona, USA; ³Naples Community Hospital, Naples, FL

(Education - Tutorial/Review)

INTRODUCTION: Over 220 million people worldwide have recovered from COVID-19, and many individuals without overt sequelae have resumed normal activities, including travel. **TOPIC:** As worldwide travel increases with the widespread availability of vaccines, recovered individuals will be exposed to stressors in the form of hypoxia during air travel or destination at altitude. Most of these individuals will not have symptoms at their altitude of residence; however, some of these individuals may develop symptoms at altitude. After acute infection, there are a number of potential chronic effects of COVID-19, including hematologic, pulmonary, cardiovascular, and neuropsychiatric impacts. Venous thromboembolism, pulmonary fibrosis, myocardial injury, and "long covid" are examples of chronic sequelae. The true incidence of these complications is unknown. One meta-analysis noted up to 16.5% of hospitalized patients developed venous thromboembolism (VTE) during hospitalization. In addition, long term pulmonary structural changes in the form of reticulation or ground glass opacities have been noted in survivors of severe acute COVID-19, particularly in those requiring intensive care. Chronic thromboembolic pulmonary hypertension (CTEPH) following acute PE is found in less than 5% of patients; however, minor changes to ventilation and perfusion may impact an individual's ability to compensate in the setting of extreme stressors. The careful assessment of individuals with a history of persistent functional deficits in cardiac and pulmonary function as well as subjective residual symptoms is important for safe travel to altitude. Here we will discuss the pathophysiology of the problem, an approach to prevention, assessment, and mitigation of symptoms, and impacts on responsible organizations. **APPLICATION:** This is a unique opportunity to observe, assess, and determine the need for screening and response to long term effects of COVID-19. This unique problem may impact travel to altitude destinations.

Learning Objectives

1. Identify patients with a history of COVID-19 that are at increased risk in extreme environments.
2. Employ strategies to mitigate risk for adverse events at altitude after recovery from COVID-19.

[421] SPACE: THE FINAL FRONTIER IN THE COVID-19 PANDEMIC

Michael F. Harrison¹, Rebecca Blue², Jan Stepanek³, Leigh Speicher¹

¹Mayo Clinic, Jacksonville, FL, USA; ²University of Texas Medical Branch, Galveston, TX, USA; ³Mayo Clinic, Scottsdale, AZ, USA

(Education - Tutorial/Review)

INTRODUCTION: The first infectious cases of the COVID-19 pandemic were reported in late 2019; shortly thereafter, the launch of the SpaceX Demonstration 2 mission marked a return of spaceflight operations launched from American soil. During the pandemic, at least 8 spaceflights of varying duration have launched with 4 of these representing long-duration missions to the International Space Station (ISS). While every continent including Antarctica has reported cases of COVID-19, the ISS represents the sole remaining civilized site of permanent human habitation that, as of the time of this publication, has not reported an acute COVID-19 infection. **TOPIC:** Infectious disease prevention and quarantine in U.S. human spaceflight dates back to NASA's Mercury Program. High-profile examples of spaceflight infectious disease concerns with mission impact are publicly available for review; simultaneously, a rigorous quarantine and monitoring program continues to exist for NASA's human spaceflight missions. The COVID-19 pandemic has overlapped the arrival of commercial spaceflight and space tourism. While NASA astronauts represent an exceptionally healthy population with minimal chronic medical conditions, the health and age profile of current spaceflight participants differs from NASA's selection criteria. **APPLICATION:** This presentation will summarize concerns specific to COVID-19 as it pertains to human spaceflight for long- and short duration missions with professional astronauts and commercial spaceflight participants. A brief summary of risk mitigation strategies as well as specific theoretical concerns related to medical management of an acute case in the microgravity environment will be presented.

Learning Objectives

1. The participant will gain an understanding of the risks and mitigation strategies associated with infectious disease and human spaceflight, presented in the context of the COVID-19 pandemic.
2. The participant will learn the differences in infectious disease risk mitigation for long-duration and short duration spaceflight and for professional and private astronaut missions.

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3:30 PM

[S-82]: SLIDE: EXTREME ENVIRONMENT EMERGENCIES: PREPARATION & RESPONSE

Chair: Paul Young

Co-Chair: Cathy DiBiase

[422] PANDEMIC RATIO TRACKING: PREDICTING PANDEMIC TRAJECTORIES

Walter Dalitsch

Naval Medical Research Unit - Dayton, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Many decisions on risk mitigation during the COVID-19 pandemic have been made using raw numbers such as new cases per day and hospitalization rates, to include daily or weekly percentage changes. However, these raw numbers do little to predict

future trajectory of pandemic growth or decline. Predicting whether a pandemic is worsening or improving can be of great benefit in formulating policies and trigger points for mitigation intensity. **METHODS:** The author served as Public Health Emergency Officer (PHEO) for 37 commands at an overseas U.S. military base during the COVID-19 pandemic. In that capacity, he recorded and tracked numbers reported by government public health entities at provincial, regional and national levels, as well as county and state numbers after transferring back to the U.S. Utilizing these numbers, largely through trial and error of various equations and long-term observation of trends, he developed several useful ratios and their displays in graphical form. **RESULTS:** Amongst many other products, the two most useful ratio tools became the pandemic "Growth Ratio" (two-week average of daily new cases: two-week average of daily recoveries) and the 60-day "Incidence versus Prevalence Trajectory" (change in active cases over previous week: current active cases per 100k). The development and application of these tools will be presented in numerical and graphical forms with real examples of their utility as lead indicators of pandemic trajectory. **DISCUSSION:** While raw numbers offer only a current snapshot, they are not reliable predictors of pandemic trajectory. Instead, key ratios may be useful lead indicators to inform decision-making based on projections. These projections may be used to predict both worsening, as well as improvement, of pandemic spread, which may guide informed decision-making and policies, thereby ultimately improving quality of life, social interaction, and local, regional and national economies.

Learning Objectives

1. The audience will learn about the development of growth ratios as predictive tools that were formulated during the COVID-19 pandemic.
2. The audience will learn about ratios that may be useful in predicting the trajectory of pandemic growth or decline.
3. The audience will learn how to use pandemic predictive ratios that can assist in decision-making and mitigation strategies.

[423] MASS CASUALTIES, PANDEMICS, GLOBAL SURGERY: HOW TO ACHIEVE THE UN HEALTHCARE-RELATED SUSTAINABLE DEVELOPMENT GOALS FOR 2030

Russell Andrews

NASA Ames Research Center, Los Gatos, CA, USA

(Education - Program/Process Review)

BACKGROUND: Lack of surgery results in 1/3 of all deaths worldwide; the annual Gross Domestic Product (GDP) loss by 2030 will exceed US\$1.5 trillion. The trauma suffered by hundreds of thousands annually from both natural and man-made mass casualty disasters requires immediate surgery – not the current delay of days to a week or more. The United Nations (UN) Sustainable Development Goal (SDG) 3 and the World Health Organization (WHO) National Surgical, Obstetric, and Anesthesia Plan (NSOAP) establish global healthcare and surgical goals, respectively, for 2030. The need is great for programs to achieve the UN/WHO goals. **METHODS:** The trauma/stroke center model (24/7/365 availability of emergency/intensive care, radiology, laboratory, blood bank – and programs for prevention, emergency transport, rehabilitation, research, and education/training) has improved morbidity/mortality for surgical conditions (in addition to injuries and cerebrovascular accidents) from difficult childbirth to acute abdomen to cancer and cardiac emergencies. Additional methods include integrating resources from the civilian and military sectors nationally, collaboration among national and international healthcare organizations (UN, WHO, NGOs), and technological advances that improve efficiency and resilience as well as ameliorate morbidity/mortality for day-to-day care, mass casualty events, and pandemics. **RESULTS:** The Mass Casualty Center (MCC) project integrates both healthcare systems (civilian and military, national and international) and technologies to improve both day-to-day care and mass casualty events. Examples: nationwide telemedicine programs improve outcomes while reducing costs (e.g. Albania, Cabo Verde); drones fly lab samples, blood products, antibiotics, and vaccines to remote regions (e.g. Rwanda, Ghana); integration of civilian and military

emergency response resources (e.g. Chile); integrated full-service healthcare systems – from prevention programs to ambulances to hospitals to medical and nursing schools to rehabilitation (e.g. Peshawar, Pakistan). Articles describing the MCC project have been published recently in *BMJ Global Health* and *JAMA Health Forum*. **DISCUSSION:** Through integration (civilian and military), collaboration (national and international – UN/WHO/NGOs), and innovation (technological and organizational), projects like the MCC can reduce the 1/3 of global deaths due to lack of surgery.

Learning Objectives

1. The audience will understand the healthcare impact of lack of surgical resources worldwide and its effect on both day-to-day healthcare and mass casualty disasters.
2. The audience will learn about the benefits of expanding the trauma/stroke center model for both day-to-day healthcare and mass casualty disaster response.
3. The audience will learn about the aeromedical and other resources available for immediate care in mass casualty disasters, pandemics, and daily healthcare delivery.

[424] TWO WEEKS OF AIR EVACUATION DURING OPERATION ALLIES REFUGE

Paul Marian¹, Jianzhong Zhang², Caitlin Gaudet³

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(Education - Case Study)

INTRODUCTION: Large scale air evacuation is an unimaginable task. The world watched in wonder as one of the largest human airlifts in modern history was carried out over a period of two weeks.

BACKGROUND: Troops deployed to Southwest Asia in summer of 2021 faced an unexpected humanitarian crisis. The change of government in Afghanistan forced many people chose to leave the country abruptly. On short notice, many people needed to be evacuated, including U.S. and allied Afghan nationals. Historically, Berlin airlift was significant for the tonnages of materials delivered to post World War II Germany. India airlifted 170,000 passengers in two months during 1990 from Iraq and Kuwait. Operation Allies Refuge transferred 123,000 by air to safety in less than two months with the help from other nations as well as the International Federation of Red Cross and Red Crescent Societies. **CASE PRESENTATION:** Approximately 58,000 of the 123,000 were moved through an undisclosed airbase in Southwest Asia from Kabul during 15-31 Aug 21. On Aug 15, the first C-17 brought back 823 evacuees to the airbase. With the influx of population, came the influx of diseases such as E. coli, cholera, measles, and chickenpox outbreak among the evacuated population. Other medical issues such as pregnancy and chronic medical conditions were also challenging the local medical response capacity. The crisis was compounded by the ongoing COVID-19 pandemic, which added to the logistical challenges.

DISCUSSION: Natural and manmade disasters occur throughout history. There are four humanitarian principles that were endorsed by the UN General Assembly resolutions, known as "humanitarian response resolution". One can never be fully prepared to respond to a crisis, and therefore crisis responses are mainly pragmatic. In assisting those affected with a different culture background, then language as well as custom barriers should also be considered. During the acute phase of a crisis, the basic needs such as food, water, and shelters are first priorities. After that, the diseases that most commonly occur when there are large human gatherings with less-than-ideal sanitation standard become the focus. Public health teams play an important role in the latter to balance the basic human needs and suppression of specific transmission of diseases.

Learning Objectives

1. The audience should understand the huge task involved in human crisis response, and have a realistic expectation of the process

- No matter how big the task is, the basic training principle applies: to meet the basic human need and following the WHO's four humanitarian principles: humanity, neutrality, impartiality and independence.
- From public health point of view, addressing the most common disease threats during the crisis, and postpone any secondary and tertiary measures to a later stage.

[425] TOURNIQUET APPLICATION AND CONVERSION IN EXTREMITY HEMORRHAGE CONTROL

Matt Paulson

University of Colorado School of Medicine, Aurora, CO, USA

(Education - Tutorial/Review)

INTRODUCTION: Appropriate tourniquet application is a vital pillar of prehospital medicine. Tourniquet use has soared over the past 20 years due to the advent of Tactical Combat Casualty Care in the US military and has been credited with saving countless lives on the battlefield. Given the increased use of tourniquets in both military and civilian trauma, it's important to review proper tourniquet application and understand the indications and recommended processes for converting prehospital tourniquets. **TOPIC:** Proper tourniquet use centers on 3 main principles: apply the tourniquet 2-3 inches above the wound, tighten the tourniquet until the bleeding stops, and apply a second tourniquet as necessary. Converting tourniquets, however, is slightly more complicated.¹ Though much has been published regarding the success of prehospital tourniquet use, little information exists to identify appropriate protocols for tourniquet conversion. In early 2021, a group of medical professionals—ranging from trauma surgeons to emergency medicine physicians—sought to rectify this and introduced an algorithm for addressing prehospital tourniquet conversion in the emergency department.² This process changes in a prolonged field care setting, and is outlined in an article published by the Journal of Special Operations Medicine in 2015.³ Both scenarios find commonality in contraindications to tourniquet conversion.^{2,3} **APPLICATION:** Tourniquet use has proven to save countless lives over the past 20 years. While proper use and application is important, it is also important for medical providers to understand the indications for conversion. Appropriate use of these protocols could help to not only save lives, but save limbs as well. **RESOURCES:** 1.) System JT. TCCC Guidelines. <https://www.deployedmedicine.com/market/11/content/40>. Updated 01 August 2019. Accessed 18 September 2021. 2.) Levy MJ, Pasley J, Remick KN, Eastman AL, Margolis AM, Tang N, Goolsby CA. Removal of the Prehospital Tourniquet in the Emergency Department. *J Emerg Med.* 2021 Jan;60(1):98-102. doi: 10.1016/j.jemermed.2020.10.018. Epub 2020 Dec 7. PMID: 33303278. 3.) Drew B, Bird D, Matteucci M, Keenan S. Tourniquet Conversion: A Recommended Approach in the Prolonged Field Care Setting. *J Spec Oper Med.* 2015 Fall;15(3):81-5. PMID: 26360360.

Learning Objectives

- The audience will learn about the recent history of tourniquet use and its increase in popularity over the past 20 years.
- The audience will learn about indications for tourniquet conversion in an emergency department and in a prolonged field care setting.
- The audience will learn about contraindications for tourniquet conversion in an emergency department and in a prolonged field care setting.

[426] MIXED REALITY GUIDANCE FOR SURGERY AND COMPLEX MEDICAL PROCEDURES ON DEEP SPACE MISSIONS

David Warmflash¹, Attila Medl², Victoria Medl², Mackenzie Cook³

¹Mgenuity Corporation, Portland, OR, USA; ²Mgenuity Corporation, Princeton, NJ, USA; ³Oregon Health Sciences University, Portland, OR, USA

(Education - Tutorial/Review)

INTRODUCTION: Upcoming human lunar and interplanetary missions will require that astronauts operate with unprecedented

independence from Earth-bound medical and surgical support. This presentation will describe augmented/mixed reality (AR/MR) technologies that we are adapting to guide and train astronauts of varying medical and surgical experience in medical and surgical procedures.

TOPIC: Upcoming *Artemis* lunar missions and subsequent interplanetary missions will include crewmembers with at least minimal training roughly at the paramedic level, but may not include surgeons or physicians experienced in specialized, invasive procedures. Therefore, utilizing Microsoft *HoloLens* with a combination of holographic visual effects, audio instructions, and a rich multimedia knowledge base, we have devised sample AR/MR as a proof-of-concept for systems that will be able to guide operators who are practiced in basic techniques, such as suturing, making incisions, clamping and ligation, diathermy, and eventually the use of laparoscopic instruments. To illustrate the application of this technology, this talk will demonstrate sample *HoloLens* apps that we have created to guide an inexperienced operator through three sample procedures: creation of a surgical airway, placement of a pigtail chest tube, and open appendectomy.

APPLICATION: While AR/MR technology currently beckons to assist trained surgeons with highly specialized procedures on Earth, the same technology could guide more routine procedures that minimally trained personnel, including non-surgeon physician astronauts and non-physician crew medical officers, could not perform on their own. Designed specifically for the space exploration environment, the system that we are developing will be preloaded with anatomic and medical data for each crew member, will hold an expandable library of medical and surgical procedures, will know, and adapt to, the surgical skills of each crew member, and will function either with remote assistance from Earthbound specialists, or independently, depending on mission circumstances.

Learning Objectives

- To understand how augmented reality and mixed reality systems can be utilized to be utilized to train operators possessing basic skills, such as suturing, incision making, and ligation to perform surgical procedures and complex medical procedures in space environments.
- Understanding how augmented/mixed reality systems can guide operators possessing basic skills, such as suturing, incision making, and ligation through actual performance of surgical procedures and complex medical procedures in space environments, with appendectomy, chest tube insertion, and surgical airway as example procedures.
- To gain an appreciation of how holography and audio instructions can combine in an augmented reality and mixed reality system to enable surgery and complex medical procedures by nonspecialists, not only in space environments, but also in remote environments on Earth.

Thursday, 05/26/2022

3:30 PM

Tuscany 5/6

[S-85]: POSTER: COOL CASES & INTERESTING POPULATIONS

(This is out of numerical session order. Apologies for any inconvenience this may cause.)

Chair: Ernest Prochazka

Co-Chair: TBD

[457] GUT CHECK-THE IMPORTANCE OF BEING HANDS-ON IN A WORLD FULL OF MACHINES- A CASE STUDY

Courtney Beaver

U.S. Air Force, Fairchild AFB, WA, USA

(Education - Case Study)

INTRODUCTION: This case study describes a military pilot who presented to sick call for non-specific symptoms, underwent imaging due to a concerning physical exam, and was diagnosed with and treated for a desmoid tumor. **BACKGROUND:** Desmoid tumors, though

rare, can sporadically occur in our patient population and can present with non-specific abdominal complaints. While not metastatic, timely diagnosis is critical due to the locally aggressive nature of these tumors. The initial exam on our patient lead to rapid diagnosis and treatment of his tumor and return to flying status. **CASE PRESENTATION:** A 33 year-old male pilot with a past medical history remarkable only for a previous laparoscopic appendectomy presented to sick call with three days' history of non-specific abdominal pain and intermittent nausea. He denied changes to his stooling patterns and denied sick contacts, though a viral GI illness was occurring in the local base populace at the time of presentation. His physical exam was notable for a solid mass in his right abdomen. After exam, imaging was ordered, and a 14 cm mass was discovered. Further imaging and an urgent referral to general surgery occurred. Ultimately, he underwent a right hemicolectomy and tumor resection and was diagnosed with a desmoid tumor with no need for adjuvant therapy. **DISCUSSION:** This case emphasizes the importance of a physical exam when presented with "benign" sick call symptom complaints. While many GI symptoms may be attributed to a viral illness, completing a thorough physical examination can detect abnormalities and lead to further diagnostic exploration and possibly surgery, as emphasized in both medical education and surgical literature. Additionally, obtaining multiple views when ordering radiographs is key to obtaining the full picture. The combination of these two may result in a diagnosis that can impact both short-term and long-term readiness and flying status outcomes in our patient population.

Learning Objectives

1. Participants will learn about desmoid tumors, to include the presentation and treatment course.
2. The audience will learn about monitoring after surgical resection as it applies to flying waivers.

[458] A CASE OF SILENT SINUS SYNDROME IN A GERMAN EUROFIGHTER PILOT

Susanne Barthelmann¹, Diana Hering², Manuela Andrea Hoffmann³, Sven Erik Sönksen², Frank M. Jakobs²

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(Original Research)

INTRODUCTION: Silent Sinus Syndrome (SSS) is a rare disease presenting with unilateral enophthalmos, facial asymmetry and diplopia due to orbital floor collapse caused by negative pressure from preexisting maxillary sinus atelectasis. So far, about 150 cases have been reported in the world literature. This case, to our knowledge, is the first report of a SSS in a military fighter pilot. **CASE REPORT:** A 32-year-old Eurofighter pilot presented with a self-reported, painless enophthalmos of his right eye. Apart from a low-grade facial asymmetry, no further symptoms or functional deficiencies were complained. Subspecialty examinations revealed a mucocele of his right maxillary sinus which was surgically removed, and a superimposed erosion of the orbital floor which was not surgically addressed in order to not further interfere with the topography of the eye. Yet, following surgery, a slight esotropia persisted in extreme supero-lateral eye position, indicating tractive inhibition of an extraocular muscle and causing inconstant microstrabism. Operational performance testing with helmet on revealed no diplopia within the relevant binocular visual field. After six months free of complaints, a waiver was granted and the pilot readmitted to flight duties. **DISCUSSION:** It is well known that SSS may cause diplopia due to affection of the orbital bone and successive dislocation of the globe and/or incarceration of one or more ocular muscle(s). In a military pilot, this may impose a relevant flight safety problem up to in-flight incapacitation when primarily vertical diplopia is present and affects the visual field in forward or oblique direction. In the case reported here, the underlying motor deficiency was inconstant, minimal in extent, and present in extreme position only which has to be

considered a lucky happenstance for the referring pilot. **CONCLUSION:** Our case documents the importance of taking individual self-observations of pilots seriously, as well as the impact of a collaborative check-up including MRI and consideration of different reasons of acquired enophthalmos. We conclude that clinical apparent silent sinus syndrome does not necessarily require permanent grounding of a military fighter pilot.

Learning Objectives

1. Understand the pathomechanism and differential diagnosis of silent sinus syndrome.
2. Understand the waiver criteria of silent sinus syndrome with special regard to military fighter pilots.

[459] ENTEROBACTER OSTEOMYELITIS AND SEPTIC NON-UNION. THINKING BEYOND STAPH.

Bruce Waterman

US Navy, Pensacola, FL, USA

(Education - Case Study)

INTRODUCTION: A 50-year-old male, in flight status, sustains an open left both bone forearm fracture in a recreational cycling accident. The patient self reduced the severely angulated fractured arm and was transported to a nearby trauma center. Injured on a Sunday afternoon, operative fixation was completed the next morning after overnight analgesia and IV antibiotic prophylaxis. Two-and-a-half months later, the patient presented to MTF with increasing pain and gross instability of fracture site. CT Scan confirmed non-union, inflammatory markers were all normal, no systemic symptoms or fevers noted. Operative debridement and hardware performed the following day confirmed non-union, septic as per bone and wound cultures. Three operations later, six weeks of IV antibiotics, continued oral antibiotics, and a planned delayed hardware removal, the patient was returned to flight duties eight months following the initial injury. **BACKGROUND:** Open fractures and delayed repair within 24 hours are not uncommon. However, usual prophylaxis in civilian centers focus on gram positive coverage. Emerging, emerged rather, gram negative infections are of increasing concern. Gram negative wound infections are covered from the moment of injury for combat casualties--Moxifloxacin from combat pill packs, or broad spectrum IV antibiotics started during CASEVAC, per Joint Trauma System clinical guidelines. Less so is gram negative contamination and risk of surgical site infection considered for non-combat, in-garrison, and shipboard injuries. **CASE PRESENTATION:** This case of a septic non-union was secondary to gram negative organisms. Debrided bone returned 4+ Enterobacter cloacae complex and wound cultures returned the same, plus, 1+ E. coli. Antibiotic prophylaxis to that point was with Cefazolin to which the organism was resistant. In addition, the organism is an inducible Beta-Lactamase producer which may induce resistance and/or clinical failure is likely if treated with monotherapy. **DISCUSSION:** This case provides opportunity to discuss common rates of non-union with open and closed fractures. Associated and contributing factors to this case of septic non-union can be discussed in a panel forum. Lastly, the author will use this case to provide education on emerging gram negative nosocomial and surgical site infections, the importance of emerging multi-drug resistance, inducible resistance, and clinical considerations in a shipboard environment.

Learning Objectives

1. Review emerging gram-negative infections, multi drug resistance, and inducible resistance.
2. Review skin and soft tissue infection management aboard US Navy warships, aircraft carriers for example, which need be considered much different than MTF's at sea. Further, use this case of gram-negative infection as a primer of thought about antibiotic coverage when open fractures occur shipboard.

[460] MEASURING COVID-19 INCIDENCE IN USAF AIRCREW- ARE FLYERS AT HIGHER RISK?

Jeffrey Harris, Victoria FH Bylsma, Michael Lang
USAFSAM, Wright-Patterson AFB, OH, USA

(Education - Tutorial/Review)

The views expressed are those of the authors and do not reflect the official guidance or position of the United States Government, the Department of Defense or of the United States Air Force. **INTRODUCTION:** In response to the COVID pandemic, and in order to “social distance”, many US workers stayed out of their usual workplace. Those persons employed in “essential” jobs continued to go to work presumably at a higher risk of contracting the virus. While the defense industry is included in the “essential industry” list, most US Air Force (USAF) bases scaled back operations starting in March 2020 and encouraged workers, when able, to work from home. Frontline workers, like healthcare and security forces, were anticipated to have higher risks of exposure and so had early implementation of protective measures. Many USAF aviators, including remotely piloted aircraft (RPA) crews and air traffic controllers (ATC), also continued working throughout the pandemic, likely without as aggressive of protective procedures. The differences in occupational exposure risks have not been previously quantified. This project proposes a method to utilize existing data to better understand differing risks of infectious disease exposures in USAF aircrew and other occupations. **TOPIC:** The USAF requires the reporting of all cases of COVID-19 infection in the active duty population using the Air Force Disease Reporting System (AFDRS). These reports include basic demographic data about the patient including their Air Force Specialty Code (AFSC) which identifies their occupation within the Air Force. This data can be compared against numbers of personnel with each AFSC to determine the incidence of disease by AFSC. Specifically looking at AFSCs of aircrew, RPA crews, and ATCs compared against the general USAF rates will show if these occupations carry a higher risk of disease exposure. **APPLICATION:** Similar data collections exist in other US military branches and the same process could be used to look at all military aviators. An equivalent process using data from FAA medical exams could be accomplished to compare commercial pilots with non-commercial pilots, providing a method of quantifying occupational risk. This method could be used to identify which aviators, if any, would benefit from increased protection measures, or to validate the protections already in place which may help alleviate fears among workers who must continue to work through infectious disease outbreaks.

Learning Objectives

1. The audience will learn about available methods to quantify occupational risk in pandemic epidemiology.
2. The audience will understand how the incidence of COVID-19 compares between USAF aviators and the rest of the service.

[461] DISCLOSURE RATES OF SARS-COVID19 INFECTION DURING AEROMEDICAL SCREENING AND VACCINATION HESITANCY IN A SAMPLE OF US AVIATORS

William Hoffman

Brooke Army Medical Center, Ft Sam Houston, TX, USA

(Original Research)

WITHDRAWN

[462] PHARMACOGENETICS IN THE AEROSPACE ENVIRONMENT: TAILORED RISK ASSESSMENTS FOR DIABETES, HYPERTENSION AND ASTHMA

Jeffrey Kinard, Richard Chapleau

¹USAFSAM, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Diabetes, hypertension and asthma are three medical conditions for which the United States Air Force's Aeromedical Consult Service provides aeromedical readiness waiver recommendations. While the conditions themselves impact flight readiness, the side effects associated with medications used to control these conditions also

carry risk to flight operations. Pharmacogenetics is the science of applying an individual's genetic make-up to select medications with the greatest therapeutic efficacy and lowest risk of side effects. **METHODS:** Known side effects and frequencies for medications approved for use in the US were collated. After combining the side effects and removing the drug names from the list, three US Air Force flight surgeons categorized the impact of each side effect on flight operations. A five-point Likert scale was used to create a side effect severity score ranging from no impact (0) to catastrophic (4). Severity scores were averaged and then used to generate a medication risk score, calculated as the sum of all side effect frequencies multiplied by the respective side effect severity score. A control group of medications from two published risk assessment studies was used to establish control lines for acceptable risk levels. We also surveyed the PharmGKB database for pharmacogenetic information related to these medications. **RESULTS:** Of the 83 medications approved for these three conditions, 66 (64%) were within the acceptable control limit. There were 34 medications which also had pharmacogenetic recommendations in the Clinical Pharmacogenetics Implementation Consortium guidelines. Each of the six medications within 10% of the control limits have pharmacogenetic recommendations. **DISCUSSION:** Those medications for which pharmacogenetic testing may be considered when treating diabetes, hypertension and asthma in an aeromedical context were identified. These findings can reduce costs by avoiding high-risk medications and improve aircrew safety by optimally selecting the right drug for the right aviator at the right time.

Learning Objectives

1. Understand the use of systematic risk scores for side effects.
2. Identify the utility of pharmacogenetics to aid treatment decision support.
3. Determine pathways for integrating genomic medicine within aeromedical practices.

[463] INCIDENCE AND PREVALENCE OF CORNEAL REFRACTIVE SURGERY PROCEDURES IN GERMAN AIR FORCE FIRST TIME APPLICANTS: A RETROSPECTIVE ANALYSIS

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(Original Research)

INTRODUCTION: Refractive corneal surgery (CRS) has become a safe and effective procedure for vision correction in all types of professions including military and aviation-related environments. However, in contrast to the United States Air Force, there is no supported CRS program in the German Air Force. Such program would need precise data for reasons of election, validation, and cost-effectiveness considerations. In this study, we analyzed the prevalence of refractive surgery procedures in military first-time applicants seen at the GAF Centre of Aerospace Medicine during the past 15 years.

METHODS: A central query was performed assessing the pre-occupational data of all pilot, additional crewmember and ground personnel applicants during the time of 2007 to 2021. Data were extracted and retrospectively analysed with regard to common CRS procedures. Substratification included known variations of corrective procedures as LASEK, PRK and transepithelial approaches as LASIK or ReLex. For a complete point of view, the 2021 preliminary results will be provided as a forecast trend analysis. **RESULTS:** A total of 14,658 individuals were scanned, including 61% (n=8,914) pilot applicants, 16% (n=2,390) additional crew members, and 23% (n=3,354) non-pilot/non-ACM applicants. The overall prevalence of preexisting refractive surgery was 1.7%, relating to 247 cases identified. Subgroup prevalences revealed 1.55% pilot, 2.85% ACM, and 1.22% non-pilot/non-ACM applicants. Incidence analysis showed stable rates of 0.8 to 1.8% until the year of 2016, followed by a rapid increase up to 4.09% until present. The most common procedure was Laser in situ keratomileusis (LASIK; 60.3%),

followed by classical surface treatments (e.g., PRK, trans-PRK, and LASEK; 34.8%). The least frequent procedure was Refractive Lenticule Extraction (ReLEx) with 4.9%. **DISCUSSION:** Our results indicate an increasing impact of refractive surgery in the context of military aviation. Given the substantial enhancement, the spare of spectacles and contact lenses will have on human performance in military duties and environments, this could pave the way for a successful implementation of CRS in the German military health system. Further research focussing on long-term visual outcomes, refractive error prevalences, complications and recurrence rates will be necessary to define the details of this approach.

Learning Objectives

1. Increased prevalence of refractive surgery with military aviation first-time applicants within the last few years.
2. The most common refractive surgery procedures and their frequencies among first-time applicants in military aviation.

[464] REVIEW OF THE LITERATURE: AEROMEDICAL RISK CONSIDERATIONS IN THE EVALUATION OF MIGRAINE HEADACHES

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(Education - Tutorial/Review)

INTRODUCTION: Due to the prevalence and significance of migraine in aircrew, a literature review was performed to consolidate relevant background information to enable evidence-based aeromedical risk assessments of prospective and current aircrew with migraine. Scopus, Embase, PubMed, and the Cochrane Library were searched to identify relevant studies about migraine from all years, in general and aircrew populations. International and national headache and neurology guidelines were also reviewed, as well as headache policies from various militaries. Finally, the reference lists of included studies were also analysed for relevant citations. **TOPIC:** This literature review generated up-to-date background information for use in a risk-matrix approach to the aeromedical assessment of migraine in aircrew. The review includes the information on topics deemed to be relevant for evidence-based assessment of migraine: classification of headache disorders; migraine prevalence by sex, population, and age; migraine incidence; natural course of migraine, including persistence, progression, and remission; frequency and duration of migraine attacks; clinical presentation of migraine, including prodromal symptoms and aura; aeromedically relevant migraine triggers; comorbidities of migraine; implications of family history; and pharmacologic and non-pharmacologic management. **APPLICATION:** This poster will present findings relevant to evaluating the risk of migraine in safety-sensitive aeromedical duties, including: 1) up to 45% of migraineurs in the general population experience aura, with visual disturbance being the most common type (>90% of aura); 2) up to 88% of migraineurs in the general population experience prodromal symptoms, such as fatigue, cognitive change, sleep disturbance, phonophobia, and photophobia; 3) headache-free periods can represent true migraine remission or simply headache-free episodes before migraine recurrence, as a minority (estimated 10% to 42%) of migraineurs in the general population experience true remission; and 4) though family history is associated with increased risk of developing migraine and younger age of migraine onset, the prognostic impact of family history on migraine course and severity is controversial.

Learning Objectives

1. The audience will be able to identify relevant clinical features of migraine headaches required to evaluate the risk of migraine to safety-sensitive aeromedical duties.
2. The audience will learn about the natural course of migraine headaches, and the relevance of this to conducting aeromedical risk assessments of prospective and current aircrew with migraine.

[465] GENETIC VARIATIONS LEADING TO ATOPIC DERMATITIS: DEVELOPING A SCREENING PROTOCOL FOR THE DISEASE AMONGST US AIR FORCE AIRCREW APPLICANTS

Ian Gregory

¹USAFSAM, Wright-Patterson AFB, USA

(Original Research)

INTRODUCTION: The human genome is being better outlined to identify specific markers that produce an increased risk for various disease. Atopic dermatitis is a skin condition with many different genetic variants that have already been identified. This project looked to summarize the different genetic variants for AD so that they can be utilized for screening purposes within the US Air Force aviation community. **METHODS:** 13 papers containing information on genetic variants potentially leading to atopic dermatitis were reviewed. Specific variants were identified, observing odds ratios for the variants leading to atopic dermatitis with the information compiled together. **RESULTS:** The studies included populations from North America, Europe, Asia and Africa. 98 genetic variants were found to be associated with atopic dermatitis in the literature. Four of these variants had a greater than 2-fold increased odds of developing the condition when present. The variant rs145809981 in the gene MICB was reported in two studies with conflicting results. This variant was associated with atopic dermatitis in one while not significantly associated in another study (P=0.94). 45 associated genes were also found, including LRRC32, OVOL1 and IL13 which were each replicated in three studies; as well as RTEL1 and ZNF365 which were each replicated in two studies.

DISCUSSION: There are numerous genetic markers associated with AD from diverse populations. A polygenic risk model was created using the relatively small effect sizes of most of the identified variants to develop a military screening protocol for aviation candidates. The screening protocol could potentially be utilized to determine which candidates may be at high risk for atopic dermatitis or other atopic diseases (e.g. asthma, allergic rhinitis). For those found to have the genetic variants, efforts can be made to minimize the risk for disease development.

Learning Objectives

1. To understand the likelihood of developing atopic dermatitis based off of the odds ratios associated with specific genetic variations.
2. To understand how identifying genetic variations can lead to disease prevention through risk modifying efforts.

[466] EVALUATING UROGENITAL CANCERS IN AIR FORCE PILOTS

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711 HPW/USAFSAM, Wright-Patterson AFB, OH, USA

(Original Research)

INTRODUCTION: Between 2002 thru 2004, five F-15 aircrew stationed at Seymour Johnson, Air Force Base, North Carolina were diagnosed with a urogenital cancer. The incidence of cases spurred concern of potential poor health effects secondary to radio frequency radiation (RFR) exposure. This study evaluated the potential exposures which lead to these types of urogenital cancers. **METHODS:** A retrospective review was conducted using the United States Air Force Aeromedical Information Management Waiver Tracking System (AIMWITS). The database was queried to obtain specific diagnoses of kidney and renal pelvis, urinary bladder, prostate and testicular cancers in active duty Air Force pilots only. These cancers were compared to gender, age at diagnosis, aircraft type, and number of flight hours. IBM SPSS[®] Software Statistical software was utilized for calculations. **RESULTS:** Ninety-eight pilots had one of four urogenital cancers, 64.3%, 24.5%, 7.1% and 4.1% for testicular, prostate, renal and bladder cancer. These findings are consistent with age distribution of the general population in comparison to the study population. Urogenital cancer was 4.84 times more likely to occur in fighter aircraft pilots versus non-fighter aircraft pilots. The diagnosis of cancer correlated with the number of flying hours and pilot

age which showed a negative/inverse small ($r=-.272$) and ($r=-.356$) medium relationships. The given conclusion, pilots with more hours of flying and older corresponded to a decrease in cancer prevalence among Air Force pilots. **DISCUSSION:** The demographics most susceptible to urogenital cancer were males 20-39 for testicular cancer, and 40-49 for prostate cancer. These findings correlate with the general population. The higher rate for fighter-pilots versus non-fighter pilots is a concern and the "why" is not fully addressed. Cancer is a multifactorial disease, a combination of genetics and environmental insult. RFR exposure could be the potential environmental link, but only three of ninety-eight pilots had source of family history reported in their charts. Further study is warranted to define levels of concern for RFR in aircraft, further record review of a familial pattern, and potential need for genetic mapping for the purpose of risk mitigation.

Learning Objectives

1. Understand the incidence and prevalence of urogenital cancer in Air Force active duty pilots versus United States general population.
2. Understand potential correlations of risks associated with urogenital cancer in Air Force active duty pilots.
3. Identify if radio frequency exposure as an occupational hazard warrants greater review.

[467] ASSESSING MORTALITY BETWEEN THE BASICMED POPULATION AND THIRD-CLASS MEDICALLY CERTIFICATED PILOTS

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(Original Research)

INTRODUCTION: Because airmen seeking third-class medical certification and those declaring intention to fly under BasicMed differ in degree of medical observation and review, mortality and incapacitation differences are relevant to assess safety. In support of the Congressional requirement to review efficacy and safety of BasicMed, we investigated differences in mortality between BasicMed and third-class medical certificate pilots. **METHODS:** We conducted a retrospective cohort study among pilot populations from May 2017 through December 2019. All BasicMed pilots within the first year of implementation were included in the study, and a random sample of third-class medical certificate holders were observed as a comparison group. Both groups were followed forward through December 2019. Mortality data obtained from the U.S. Centers for Disease Control and Prevention (CDC) for these groups of airmen were collected and analyzed using Cox proportional hazards regression, adjusting for age and Special Issuance (SI). **RESULTS:** A total of 29,248 BasicMed pilots were included in the study, and the same number of third-class airmen were randomly selected from the active third-class airmen population. Generally, BasicMed pilots had a lower risk of dying in non-medically related deaths than the third-class group. When restricting the outcome to medically-related deaths, BasicMed pilots had an overall age- and SI-adjusted 53% higher mortality risk compared with the third-class group (HR=1.53, 95% CI 1.18, 1.98). After adjustment for age and SI status, the mortality risk from suddenly incapacitating causes was three times higher among BasicMed airmen than third-class airmen (HR=3.03, 95% CI 1.17-7.84). Further, risk of cancer-related deaths was two times higher among BasicMed airmen (HR=2.05, 95% CI 1.35-3.10).

DISCUSSION: The mortality data are generally unfavorable to BasicMed, likely because the BasicMed population is significantly older and much more likely to have required an SI. But the risk remains elevated even when controlling for both age and SI. Absent FAA oversight, mitigation of elevated risk of incapacitation and death is dependent upon the airman seeking regular medical care for their conditions.

Learning Objectives

1. Report that the percentage of BasicMed pilots who held a special issuance waiver on their last FAA medical exam was approximately 4 times higher than non-BasicMed pilots who held a third-class medical.

2. Understand that the mortality data are generally unfavorable to BasicMed pilots as compared to non-BasicMed pilots who held a third-class medical.

[468] INFLUENCE OF REPEATED EXPOSURES TO VARIATIONS OF G ACCELERATIONS IN THE CEREBRAL AUTOREGULATORY MECHANISMS IN HIGH PERFORMANCE PILOTS

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(Education - Tutorial/Review)

The evolution of high-performance aircraft systems has been resulting in a crescent exposure of pilots to physiological stressors. In this set, +Gz accelerations are especially important once they can induce blood flow redistribution in a cephalad-to-foot direction, with consequent impairment of cerebral perfusion, and possibly resulting in loss of consciousness (G-LOC). A rupture between cognition and the ability to act, marked by periods of absolute and relative incapacitation, has already been reported in conditions of decreased intracranial pressure (ICP). Transitory ischemia in the retina can be noticed in the pilots as peripheral vision loss, greyout, and blackout. These events arise as a result of ICP variations and may or may not precede a G-LOC episode. New lines of research have been suggesting the existence of adaptative cardiovascular mechanisms that are able to modulate the physiological resistance of pilots to G accelerations. Regular training in +Gz environments has shown a protective role by modulating blood pressure and the downstream parameters influenced by this variable. On the other hand, long periods of lack of training seem to result in the reduction of a +Gz resistance. However, there are no studies focusing on how G accelerations influence ICP and the capacity of autoregulation induced by training. A major problem in data collection comes from the difficulty in performing accurate ICP measures in an aeronautic environment, which has been overcome with the development of non-invasive techniques. Among these, some of the most promising ones are the transcranial doppler and the optic nerve sheath diameter measurement, which are already used in the clinical context. In future projects, we aim to evaluate ICP variations in high-performance pilots using non-invasive approaches and to explore eventually adapting cerebral mechanisms that may arise from training.

Learning Objectives

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

[469] THE IMPACT OF MRI IN IDENTIFICATION OF RADICULAR ODONTOGENIC CYSTS

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(Education - Case Study)

INTRODUCTION: Radicular cysts are the most common odontogenic cystic lesions arising from inflammatory pulp. Developing at the root apices of involved teeth, they tend to enlarge and infect not only bone and neighboring teeth, but also the maxillary cavity. They are usually detected or verified by radiological assessment. **BACKGROUND:** In rare cases, symptoms can be so serious that those affected endanger flight safety due to pain. For example, in a survey of 1,184 military and civilian aviators in France, 10 out of 74 reported cases of barodontalgia were considered to be so severe that

they impaired flight safety (Stoetzer M et al. Pathophysiology of barodontalgia. Case Rep Dent. 2012; 2012:453415) **CASE DESCRIPTION:** We report a well- documented case of a radicular odontogenic cyst affecting an upper molar in a 41-year-old flight surgeon. Symptoms with presence of intermittent dull pain were first determined two years after root filling. In spite of dental X-ray, the issue had not been clarified for ten years until the use of a pressure chamber leading into throbbing pain. Diagnosis was then made by magnetic resonance imaging (MRI) and confirmed by digital volume tomography. The attempt of root filling's revision resulted in flaring up of the cyst, causing massive pain, visual impairment alongside a swollen face as well as the urge of immediate surgery. Following extraction of infected tooth and cleaning of maxillary cavity, the patient had no longer complaints and continued to fly as a flight surgeon. **DISCUSSION:** Our case documents that in the aviation dentistry environment, radicular odontogenic cysts may cause unfit assessment, which can be detected by MRI and be resolved by surgical means. Furthermore, it points out the value of MRI versus X-ray imaging.

Learning Objectives

1. Participants will be able to respond to patients facing toothache.
2. The audience will be able to understand the necessity of MRI.

[470] HUMAN FACTORS ANALYSIS AND CODING SYSTEM VERSION 8.0.

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(Education - Program/Process Review)

BACKGROUND: The Joint Service Safety Council directed the Human Factors Analysis and Coding System (HFACS) Working Group to review, revise and update HFACS version 7.0 to improve the implementation of HFACS coding by the end user, resulting in HFACS version 8.0. This presentation will inform users of changes which have been made, and enable them to better utilize HFACS 8.0 as it is implemented across the DoD. **OVERVIEW:** The DoD Human Factors Analysis and Coding System (HFACS) version 7.0, has been in use since 2014 and is in need of an update to accommodate current and future need for a broader application. Key factors demanding the update include: 1.) Application of the taxonomy throughout the services has evolved from use by human factor experts to application in the field by uniformed and civilian safety personnel, requiring revisions to make HFACS application more standardized and easier to understand for end users; 2.) Numerous nanocode definitions are ambiguous or have overlap between several definitions resulting in critical nanocodes being overlooked or used ineffectively across all communities; 3.) The HFACS 7.0 nanocodes are often aviation-centric indicating a need for more inclusive language in the definitions to ensure accurate employment; 4.) Verbiage used throughout the HFACS taxonomy (e.g., violation, inadequate) is an artifact of engineering language and contributes to the misnomer that safety investigations find culpability rather than seeking to improve mishap prevention strategies. This leads to incorrect usage and a reluctance to use supervisory and organizational level codes. **DISCUSSION:** The HFACS Working Group examined, revised, and updated HFACS version 7.0 to improve functionality at the end user level, producing HFACS 8.0, which represents a major revision to this important tool. Application rules and guidance were refined to increase clarity, and standardization. Definitions were revised to reduce ambiguity, make language more inclusive outside of aviation, and removed language that may imply culpability. Similar nanocodes were either folded into a single, more broadly defined nanocode, recategorized to improve distinction between them, or archived. New codes were added to address gaps in

HFACS coverage. Version 8.0 will improve the efficacy of HFACS coding, and better focus mishap prevention efforts.

Learning Objectives

1. To provide an update to HFACS users on the reasons an update is required and highlight changes being implemented to address those requirements with HFACS version 8.0. This will provide HFACS users with information to update themselves on changes to definitions and language.
2. To provide information to HFACS users regarding how to actually employ the revised rules of application. This will help to better standardize the use of the updated rules of application in version 8.0 as it is implemented across the DoD.

[471] INNOVSPACE AEROSPACE MEDICINE HUB (IAMH) - A REMOTE TEACHING EXPERIENCE DURING THE COVID-19 PANDEMIC

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(Education - Tutorial/Review)

InnovaSpace is a British Think Tank company operating in the fields of Space Life Sciences, Aviation Medicine, Aerospace Physiology, Extreme Environments, Telemedicine and Digital Health, having a global, inclusive and disruptive vision. Through its work, InnovaSpace conducts innovative activities in teaching and research, provides technical and scientific consultancy and has established a network of professionals, researchers, entrepreneurs and students, linked by the common theme of the human presence in extreme environments, such as astronauts on orbital/interplanetary missions and aviators/ crewmembers in aeronautical activities. The IAMH is the InnovaSpace Hub that organizes and promotes educational and research activities in the Aerospace Physiology/Aviation Medicine areas. Restrictions on in-person activities imposed by the COVID-19 pandemic have led the IAMH to develop a series of webinars for Portuguese speaking countries, including Angola, Brazil and Portugal. Webinars have addressed several topics related to Human Physiology in the Aerospace Environment, Aerospace Medicine, Interface between Medicine and Commercial Aviation, and Space Physiology. Digital platforms, such as Teams, Google Meet, Zoom and Webex were utilized, with each open-event webinar plus Q&A session lasting approximately 180 min. The IAMH webinars had the participation of 2 or 3 experts in a defined area, who presented a 40-60 min lecture. The open-access webinars were attended by students, professors, researchers and professionals from multiple fields, including medicine, nursing, pharmacy, physiotherapy, speech therapy, physical education, information technology, artificial intelligence and engineering. A total of 10 IAMH webinars have taken place since June 2020 during courses and scientific events in partnership with universities, aviation and space associations and research centers, with an average attendance of 50 people per webinar. Physical distance did not preclude the establishment of interdisciplinary and multiprofessional interaction, suggesting that these meetings may contribute to knowledge dissemination and provide opportunities for interaction between apparently different areas. This interaction provided access to concepts and knowledge exchange, which, we believe, contributes to lifelong learning, professional qualification and the safety of flight operations as a whole. Considering the good response to these virtual webinars, we are continuing this activity.

Learning Objectives

1. To promote an interdisciplinary and multiprofessional discussion of topics related to the effects of the aerospace environment on human physiology.
2. To provide an open access virtual platform for the debate of aspects linked to aviation medicine, focusing on passenger health and wellbeing, professional qualification and flight safety.