Standardized assessment of static neck strength capacity for representative in-flight head postures of CAF helicopter aircrew

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Military and Veteran Health Research Forum (RSMV 2014), pp. 70-71, 2014-11-26

Clinical Outcomes: As the operation of the DISS V3 during MAPLE ORZEL and the NATO Reassurance mission is a testing exercise, the primary outcome of interest is the identification and resolution of any outstanding program bugs that may compromise the system's usability. Secondary, and more long-term outcomes, include: (1) Improved data quality/diagnostic accuracy at point of medical contact, while on deployment (by using ICD-10 coding) to provide situational awareness to headquarters; (2) Improved ease of reporting to other entities (MedSitRep, EPINATO); (3) Early identification of any aberrant health patterns (including outbreaks) while on deployment; (4) Collecting complete clinical data that can be used to help in future operational health services planning.

Patient Population: This system is geared to serving CAF members, but is also used to record visit information, including diagnosis and disposition, for non-CAF military and foreign nationals receiving medical care from CAF Health Services personnel.

Conclusions: The CAF DISS V3 standalone will allow for improved health monitoring and response while on deployment in areas with low connectivity and will provide decision-makers with accurate and standardized medical intelligence with which to optimally plan future missions and deployments.

1B03: Near Term Solution to Address Aircrew Neck Pain

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Introduction: Aircrew neck pain poses a substantial challenge to the Canadian Armed Forces (CAF). Preliminary data from a recent study conducted by Defense Research and Development Canada indicates that nearly 60% of CAF Griffon aircrew report neck pain; where nearly 100 aircrew members have been grounded or benched as a result of neck pain. The purpose of this project was to develop and evaluate a near-term solution to help address aircrew neck pain.

Methods: The project is being completed in two stages; development (completed) and evaluation (underway). The objective of the development stage was to understand the root-cause of neck pain, and design and produce a prototype device to alleviate it in the near term. The design process was initiated by gathering information and feedback from aircrew to determine their general operations, requirements, and user needs. These data were combined with knowledge in the literature, and basic biomechanical analysis to synthesize functional design requirements. Using these requirements the team brainstormed design concepts, and then split into two groups to design specific elements. The team reintegrated solutions into a common prototype for evaluation. In the evaluation stage, twelve participants are completing vigilance and endurance tasks in two different postures (seated-pilot, and prone- flight engineer), while in each of three different head/helmet system configurations. Participants will be tested while wearing: a standard helmet and simulated NVGs; a standard helmet, simulated NVGs and applying the existing counter-measure; and standard helmet, simulated NVGs and the new prototype counter-measure. The vigilance test will require participants to complete a visual inspection of a wide area, requiring them to move through a typical range of neck postures. Speed and accuracy of gaze will be measured. The endurance test will require participants to sustain select postures until volitional fatigue, where time to fatigue will be measured. Participants will also be asked to provide feedback in the form of perceived exertion, measured using a Borg CR-10 scale.

Results: The research team has completed the design of a near term engineering based solution. Illustrations of the prototype will be provided during the presentation; however, the current patent filing process does not permits us to share images at this time.

Conclusions: This project has resulted in the development of a near term engineering based solution to help address aircrew neck strain. Results from the evaluation portion of the study will demonstrate the potential effectiveness of this new countermeasure approach.

1B04: Standardized Assessment of Static Neck Strength Capacity for Representative In-flight Head Postures of CAF Helicopter Aircrew

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Introduction: The capacity of the human neck to generate static moments of force is key in maintaining the stability of the cervical spine (c-spine) under various conditions of dynamic external load application. Compared to the lower c-spine (T_1), the upper c-spine (C_0-C_1) has a decreased capacity to generate moments, and is therefore more susceptible to injury, as forces that exceed this maximal capacity will be borne by passive tissues (ligaments and vertebrae). Deviations in head posture from neutral will modify the balance of muscle moments, increasing the risk of upper c-spine injury.

The aim of this study was to quantify the effects of seven postures, typically held by helicopter aircrew during in-flight, on the static strength capacity of the upper and lower c-spine of Canadian Armed Forces (CAF) helicopter aircrew.

Methods: Seven postures were identified by measuring head-neck-torso angles, relative to self-selected neutral, of a CAF helicopter pilot seated in a Bell-412 helicopter:

1) Left 20˚ rotation, 20˚ flexion, 2) 0˚ rotation, 0˚ flexion; 3 and 4) left and right 45˚ rotation, respectively, 0˚ flexion; 5) left 45˚ rotation, 20˚ flexion; 6) 0˚ rotation, 10˚ extension; 7) right 45˚ rotation, 10˚ extension.

Two male CAF CH-146 helicopter pilots (36 and 49 years old) performed one maximal voluntary isometric muscle effort (MVIE) in the seven head-on-neck postures. MVIEs were measured using a custom-modified Multi-Cervical Unit

(2048Hz; BTE Technologies). Absolute peak external force (N) was measured using a thin-beam strain gauge load cell. Anatomical landmarks were digitized to establish reference points at C_0-C_1 and T_1 (30Hz; Optotrak). Resultant peak moments ($M_{peak,}$ Nm) were calculated as the cross product of the external force and the distance from the load cell to the anatomical reference points.

Results: Normalized T_1 M_{peak} relative to neutral (posture 2) was 0.85, 1.00, 0.87, 0.92, 0.53, 0.63, and 0.40 (postures 1-7, respectively). Magnitude of M_{peak} generated at C_0-C_1 was 41% compared to T_1. Head postures 3 and 5 elicited differential C_0-C_1 vs. T_1 M_{peak} ratios of 47% vs. 34% and 44% vs. 26% (pilot 1 vs. 2, respectively).

Conclusions: Head postures that combine sagittal head flexion or extension with axial rotation decrease the moment-generating capacity and increase the vulnerability of the upper c-spine to injury. Static neck strength assessment in representative in-flight postures may help to identify pilots who may be at risk of developing flight-related neck pain, and identify postures that may increase the risk of injury.

1D03: Hair Follicle: A New Diagnostic Tool for Traumatic Brain Injury

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Introduction: Traumatic brain injury (TBI) is a generalized term that describes brain injuries caused by mechanical impact to the cranium. With the wide adoption of explosive-dependent weaponry, blast-induced neurotrauma (BINT)-induced TBI has become a significant medical issue for military personnel. Given the accessibility issues with the traditional biomarker systems such as blood and brain, a robust and more accessible one is in demand for effective TBI research and diagnosis. Here we hypothesize that the mammalian hair follicles house well-established molecular signatures for TBI. The present study thus explores the potential of mammalian hair follicle as a biomarker and pathology study system by investigating gene expression profile in rat hair follicle after exposure to traumatic conditions.

Methods: The prolonged effect post initial trauma often leads to damages on a cellular and/or subcellular level, triggering profound consequences (or secondary injury). Secondary injuries are driven by gene expressions that are involved in signal transduction and the corresponding downstream cellular events. Therefore, high throughput gene expression screening is a desirable approach of investigating such molecular complexity and the potential biomarker, as proven by previous studies. Thus present study utilized microarray and multiple bioinformatics analyses as the main methodology.

An Advanced Blast Simulator (ABS) was developed to generate shock waves simulating traumatic conditions on brains of rats (8 in total). Microarray analysis was performed on hair follicles to identify the gene expression profiles responsive shock waves. Gene ontology term enrichment, gene set enrichment analysis (GSEA) and sub-network enrichment analysis (SNEA) were used to investigate molecular complexity of simulated blast responses.

Results: A variety of TBI sensitive biological pathways were enriched in rat hair follicles when experiencing shock wave generated by a helium-driven advanced blast simulator. In fact, most of the blast pathways observed in rat hair follicles have been proposed in brain or blood upon TBI. Enrichment analyses showed that genes with altered expression levels were involved in signal transduction including Ca^{2+} transport-dependent signaling, toll-like receptor (TLR) signaling and mitogen activated protein kinase (MAPK) signaling cascades. Genes linked to inflammatory responses and synaptic central nervous system (CNS) responses were also differentially expressed.

Conclusions: Given that the pathways enriched in rat hair follicles during traumatic conditions have been proposed as TBI responses in brain and blood, our study demonstrated that hair follicle has similar TBI responsive molecular signatures. Therefore, we propose that hair follicle as a potentially viable system for TBI diagnosis.

2B01: Comparing the Effect of Normal Saline (NS) and Lactate Ringers (LR) with Erythropoietin (EPO) on Microcirculation Perfusion, Tissue Bioenergetics and Gut Integrity of the Small Intestine in a Rat Model of Hemorrhagic Shock and Resuscitation (HS/R)

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Introduction: EPO has acute hemodynamic and anti-inflammatory effects in addition to its erythropoietic action. We tested the hypothesis that EPO given at the time of resuscitation with NS or LR will improve capillary perfusion, oxygenation and gut integrity in a HS/R rat model.

Methods: The muscular layer of ileum of anesthetized rats was prepared for intravital microscopy. The rats were hemorrhaged 30ml/kg over 10 min via arterial catheter and uncontrolled mean arterial blood pressure for 50 minutes, then randomized to one of 4 resuscitation groups (n=6/group): NS, NS+EPO, LR, and LR+EPO. Intravenous EPO (1,000U/Kg) was given at the start of 3 times the volume of shed blood NS or RL. Baseline, end of shock and end of resuscitation images of capillary perfusion, RBC flow scores and NADH fluorescence were recorded for analysis. Gut integrity and bacteria translocation were measured at the end of HS/R.

Results: After shock, all groups had decreased perfused capillary density and increase NADH fluorescence. Post resuscitation all groups had a higher perfused capillary