Potential technologies for rehabilitation of military traumatic brain injury

[Abstract]

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Identifying Technologies to assist Rehabilitation of Military Traumatic Brain Injury
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Synopsis: Traumatic brain injuries (TBI) are heterogeneous in terms of mechanisms, pathology, severity and treatment, with widely varying outcomes. Explosive blast injuries are the leading cause of TBI amongst deployed military personnel, over sixty percent of blast injuries result in TBI. TBI symptoms are broad-spectrum with long-term physical, cognitive, behavioural and emotional consequences. Military injuries result in unique, clinically challenging pathologies which complicate diagnosis, classification, treatment and rehabilitation. A pilot study was performed to identify improved interventions and use of novel technologies. Multidisciplinary teams have the potential to address concerns regarding rehabilitation of TBI military veterans for previously un-survivable conditions.

Target Audience: The aim is to communicate clinical requirements to an engineering audience who can develop technology to meet that need with an enhanced probability of uptake by clinicians and therapists. This work highlights the importance of the area and the need for a committed community prepared to address it in collaboration.

Purpose: To formulate a technology strategy to improve the rehabilitation of TBIs by determining the key science and technology challenges and opportunities. Specifically, to improve rehabilitation outcomes of both motor and cognitive impairments where the TBI has been sustained in a military setting.

Methods: A Loughborough University-led TBI pilot study was performed in collaboration with Royal Centre for Defence Medicine, UK to identify opportunities to improve and apply technologies from stroke rehabilitation and other areas to the rehabilitation of TBI, taking into account defence specific issues including blast induced neurotrauma (BINT). A broad literature study was conducted to identify and establish where technology, including imaging and biomarkers, bio-robotics and neuroprostheses, can assist in the diagnosis, treatment and rehabilitation strategies of military TBIs.

Results: Eight overlapping and interrelated areas/needs were identified for further investigation. These were: Definition and classification; Insult, mechanisms and TBI injury cascades; Intervention, protection and prevention; Integrated modelling strategies to develop meaningful models; Rapid diagnosis and detection of closed-head TBIs; Biomarkers and field-deployable closed head imaging systems; Polytrauma, co-morbidities and outcomes; Personalized evidence-based rehabilitation strategies.

Discussion: TBIs are the “signature wound” or of modern warfare [1]. Approximately 330,000 military personnel sustained combat-related TBI in the Iraq and Afghanistan conflicts [2], primarily due to increased frequencies of explosive blast attacks. Improvements to personal protective equipment [1]; tourniquet use [3]; better resuscitative techniques [4] and pre-hospital care [5]; coupled with highly efficient evacuation procedures have increased patient survivability of previously fatal wounds, in particular with regards to blast injuries. This has led to a new population of survivors with complex injuries including co-morbidities and/or polytrauma. Overlapping symptoms and delayed clinical manifestations confuse precise epidemiological description of TBI, delivery of appropriate clinical management, and development of rational research strategies [6]; highlighting the need for objective diagnostic tools, able to classify TBI by incorporating pathological, clinical and mechanistic factors, whilst providing insight into TBI phenotype. Multi-disciplinary teams guided by clinicians from multiple specialisms, need to be assembled, to design, develop and establish useful and human-relevant blast models. Repair interventions including regenerative medicine, neuronal and bionic devices must be accounted for in rehabilitation strategies and vice versa. Personalized therapeutic intervention which utilizes bio-robotics and neuroprostheses as biomarkers of TBI have potential for the improved assessment and diagnosis of TBI; whilst assisting rehabilitation strategies by providing accurate monitoring and quantification of neural gain and improved outcomes.

Conclusion: This work has the potential to evaluate and improve interventions and address the concerns regarding the rehabilitation of TBI military veterans for previously un-survivable conditions.