Project Title: Ultrahigh Resolution Retinal Imaging with Adaptive Optics for Early Diagnosis of Traumatic Brain Injury
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Background: The ongoing wars in Iraq and Afghanistan have led to a sharp increase in the reported cases of blast induced traumatic brain injury (blast TBI). Surprisingly, blast TBI lacks an objective diagnosis tool with many mild cases going initially undetected, only for service personnel to later complain of delayed neurological symptoms.

Objective/Hypothesis: Common tools to diagnose TBI including blast induced are computed tomography (CT) and magnetic resonance imaging (MRI), both techniques have a resolution approaching 200 microns when used to image the brain. This coarse resolution coupled with their large size and long image acquisition times make them unsuitable to be frontline battlefield instruments. Investigators intend to use high resolution imaging of the human retina as a direct, non invasive biomarker for blast TBI. The eye provides a direct view of the central nervous system and with exciting advances in retinal imaging it is possible to see single cells with dimensions as small as 3 microns - a resolution increase of over 60 compared to CT and MRI. A technique called adaptive optics (AO) will allow us to image extremely small defects in the retina which may be a direct consequence of blast TBI: these include micro-hemorrhages, photoreceptor cells disruption, retinal pigment epithelium (RPE) detachment, pre-detachment microcysts, pre-detachment posterior vitreous detachments (PVD) and vitreous adhesions.

Hypothesis: High resolution imaging of retinal micro-structural changes can be used as early biomarker(s) for diagnosis of blast TBI.

Aim 1: Design and construction of a state-of-the-art AO-scanning laser ophthalmoscope (SLO)- optical coherence tomography (OCT) retinal imaging system. System resolution will be 3 microns in both the transverse and axial dimensions allowing individual cells and other extremely subtle retinal changes to be imaged in-vivo.

Aim 2: In-vivo cellular level imaging of the retina in patients with blast TBI and age-matched control subjects: Retinal measures such as photoreceptor packing and retinal thickness will be measured, analyzed and compared between the two populations.

Aim 3: Correlation of retinal micro-structural changes from Aim 2 with standard tests of visual function in patients with blast TBI and age-matched control subjects. Standard clinical tests will include visual field analysis and multifocal electroretinography (mfERG).

Study Design: 35 age-matched control subjects and 105 blast TBI patients of varying severity (mild, moderate and severe) will be imaged using the AO-SLO-OCT system and will be tested for visual function as outlined in Aims 2 and 3. The age-matched control subjects will be recruited from the New England College of Optometry (NECO) or surrounding institutions. Blast TBI patients will be recruited through our collaboration with the Veterans Affairs (VA) Boston Healthcare System.

Relevance: Investigation of retinal micro-structural changes will not only provide further insights into the degenerative mechanisms of TBI but also identify potential biomarker(s) for diagnosing blast TBI in frontline military personnel. The ultimate aim is to deploy a compact, portable, retinal imaging system that can screen for the first signs of blast TBI enabling treatment to commence at the earliest possible stage. Further, such a device has great applicability away from the battlefield, in situations such as vehicular accidents, shaken baby syndrome (SBS) and general ophthalmologic practice.