BLAST RESPONSE OF A FLUID-FILLED SPHERICAL SHELL

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Soldiers are exposed to weak air shock waves in the operation of firearms, artillery, and the firing of demolition or breeching charges, and may be exposed to severe blast levels when subjected to attack using explosive devices. There is evidence that shock waves may induce forms of mild traumatic brain injury (mTBI) even without overt damage to the skull. Since the mechanical structure and electro-chemical processes of the brain are intricate, cognitive or functional deficits may result from possibly subtle aspects of the induced transient stress.

An experimental study supported by computational simulations has been conducted to investigate the dynamics of air shock-wave interaction with an elastic spherical shell filled with viscous fluid. The fluid-filled shell is a highly simplified model of the human head and has been deliberately simplified in geometry and materials in order to assess the effects of basic variables of the shell/fluid system on the response dynamics. Measurements have been made of the incident blast-wave, internal pressure using miniaturized embedded gauges, and surface strain on the shell. Blast is shown to impart severe temporally and spatially variant stress conditions within the underlying fluid including rapid rates of loading and unloading (tension). This behaviour is dominated by the shell response dynamics although ‘damped’ by the underlying media. Most biological tissue is visco-elastic in nature and vulnerable to stress-rate as well as amplitude, in addition to exhibiting possible hysteresis behaviour. Therefore, results suggest that blast-induced elastic skull deflections are a credible cause for brain injury.

Despite the simplified nature of the skull model, results give some insights regarding conditions most likely to inflict blast-induced brain injury, and have important implications regarding the interpretation of results from animal models. Results will also be used to prescribe stress conditions simulating blast effects for in-vitro experiments. Further work is required using biofidelic models which more closely model the human skull geometry and materials.