Computational Investigation of Brain Neurotrauma Biomechanics under Blast

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The increasing use of improvised explosive devices (IED) in the battlefields has pointed the researchers' attention toward the problem of blast-induced traumatic brain injury. Due to moral and technical limitations for experimental studies, computational methods such as finite element (FE) analysis serve as the most common tools in the engineering sciences to study the biomechanics of brain neurotrauma. In the current research, a numerical study was carried out on the interaction of blast shockwaves with the head. The tissue level parameters such as shear stress, shear strain, and intracranial pressure (ICP) as well as the kinematic parameters such as linear acceleration of brain were recorded to provide an evaluation of injury related parameters. Due to the structural inhomogeneity of the human head as well as different tolerances and functions of head components, the head response to blast waves can differ with respect to the impact location of shockwaves t on the head. Accordingly, four different blast scenarios were performed based on the approaching blast waves from the front, back, top, and side of the head to highlight the effect of blast directionality on the head response. A detailed validated FE head model including most anatomical features of the human head was employed. Ls-Dyna, a nonlinear explicit FE solver was used to carry out all simulations. In order to comply with the lung injury threshold, a 520 kPa blast overpressure was generated around the head. The primary results showed the development of peak ICP and shear stress values inside the brain mainly at the coup site, the parietal lobe, and the brainstem. However, a comparison of brain biomechanics at different directions revealed that the side blast produced the highest peak values for both tissue and kinematic parameters, hence imposing higher risks of neurotrauma. However, while kinematical responses are addressed as main injury predictors in most studies, our correlational analysis did not indicate a direct relationship between tissue and kinematic parameters for all directions. Hence, the tissue level parameters were ascertained as a more reliable injury criterion. The observations from the present study may be considered in the design of protective headgears.