Computational Modeling and Simulations

Computation Fluid Dynamics Model of Blast Eye Injury

The Warfighter Performance Group at the U.S. Army Aeromedical Research Lab (Fort Rucker, AL) developed a computational fluid dynamics model to investigate the response of ocular tissue to blast overpressure. Unlike related blast simulations that incorporate a detonation model to propagate a blast wave through the eye and orbit, this model applied a pressure directly to the corneal surface, eliminating the need to model the complex interaction of the blast wave with eye protection and the orbit. A human eye model was integrated into ANSYS AUTODYN using an explicit solver. Material properties for the cornea, sclera, choroid, retina, aqueous, and lens were defined. A Eulerian reference frame was used for the aqueous and lens while the rest of the tissue was assigned a Lagrangian reference frame. A patch independent tetrahedral mesh was then developed for the eye model. A distributed pressure was applied to the cornea and the front of the sclera and was allowed to behave as a Friedlander waveform.

Nine scenarios were analyzed for peak pressures between 0.207 and 1.03 MPa. Maximum displacements and stresses were shown to have a linear relationship with the applied pressure. The highest stresses were recorded on the sclera, and the highest displacements were recorded on the corneoscleral shell. Large displacement measurements for the retina were seen with greater than 0.621 MPa reflected pressures, which may indicate retinal tear or detachment. Results from this model are largely comparable to data from other simulations that employed a detonation model. Some differences were noted due to the absence of a bony orbit in this model, which manifested by faster decay times in tissue stress due to reductions in reflective pressures from the orbit. Overall these results (presented at the 2018 Military Health System Research Symposium) suggest that ocular tissue is susceptible to primary blast injury. Protective eyewear may be integrated into the model to evaluate the protection provided by different eyewear designs.

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