Injury Models

Mechanisms of Shock Wave Propagation to the Brain after Exposure to Blast

The Defense Medical Research and Development Program (DMRDP) managed by the Congressionally Directed Medical Research Program (CDMRP) funded the research at the Naval Medical Research Center (NMRC) to study blast wave propagation through the body. The purpose of this study was to determine how a blast wave can transfer through the body and cause damage to the brain, despite helmet protection. This study used rats as the study population and tested against four hypotheses: (1) shock waves can enter the brain either directly via the skull or indirectly via the vascular system; (2) shock waves can enter the vascular system from any part of the body; (3) internal pressure can ameliorate propagation of the shock wave through tissues and blood vessels; and (4) pressure propagation through blood vessels results in cerebral hemorrhages. To accomplish this research, the rats were placed in a blast tube with either their head or tail towards the blast source to compare injuries to the brain. The rats are also provided with protection to their heads or bodies to simulate armor. The results of the study provided the following conclusions: (1) shock waves penetrate the skull and systemic circulation, and potentially they can interact and contribute to the resulting pressure in the brain; (2) whole body protection against blast does not protect against propagation of pressure in the brain, it changes but does not eliminate the presence of shock waves in systemic circulation; (3) contribution of indirect shock wave transmission to the brain depends on head and body shielding, shock waves can diffract and change direction; (4) head protection does not protect against shock wave entry into the brain; (5) wave propagation in vessels could have an impact on brain vasculature and could affect the blood-brain barrier (BBB) permeability by damaging endothelial cells. Understanding the mechanisms whereby blast waves reach the brain, will facilitate development of better personal protective equipment (PPE) to mitigate brain injury in the future.