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TRAUMATIC BRAIN INJURY

Simulations of TBI highlight the importance of impact direction

A team based at the University of Ottawa in Canada has staged laboratory recreations of traumatic brain injuries (TBIs) to model the forces and strains that the brain undergoes after impact. The results reveal that the consequences of TBI are not only dependent on the severity of impact, but on impact direction as well.

Andrew Post and colleagues reviewed over 700 cases of TBI across two hospitals in Canada and one in Ireland. From these, the team identified 20 patients who sustained TBI after a fall, the circumstances of which could be verified by detailed and reliable first-hand accounts. "Once we had a good description of what happened, we recreated the injuries using a combination of computer simulations and physical models," reports Post.

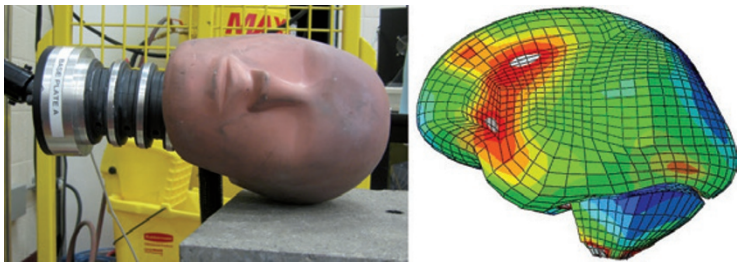
The focus of each impact was determined by reviewing patients' brain scans, but to determine impact force, the investigators turned to software originally developed for modelling vehicle–pedestrian collisions. Recreating the circumstances of each fall helped corroborate the reported versions of events, and also revealed a window of potential impact velocities.

Post's team then used the location and velocity parameters to model each fall using the head and neck of a crash-test dummy fitted with multiple accelerometers. These data were analysed with finite element modelling to estimate the pressure, shear, and other forces and strains caused by each impact.

Medical records indicated that patients with frontal TBI experienced subdural haematomas and subarachnoid haemorrhages, and the computer model revealed that a haematoma could occur after much lower forces than those required to produce haemorrhages. Low-force impacts to the side of the head produced parenchymal contusions, and significantly higher force was needed to produce subdural haematomas. The opposite effect was seen after occipital trauma, with subdural haematomas manifesting after much less forceful trauma than was necessary to produce parenchymal contusions.

"The work demonstrated that there is likely a continuum of injury based on severity, where one type of TBI generally occurs at a lower level of response, followed by the other types," concludes Post. "This finding is relevant to clinicians as it can give some information as to what might be expected when a patient with a head injury comes to an emergency department." The investigators also hope that their detailed characterization of the types of force produced by head trauma might lead to improved designs for helmets, cars and children's play equipment.

Alex Chase



The head and neck of a Hybrid III anthropometric dummy, fitted with multiple accelerometers, were attached to a monorail and dropped onto an anvil (left). Data from the impact were used to produce detailed representations of the forces and strains inflicted on the brain (right). Images courtesy of A. Post.

Original article Post, A. *et al.* Traumatic brain injuries: the influence of the direction of impact. *Neurosurgery* doi:10.1227/NEU.0000000000000554