Imaging in traumatic brain injury

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Conventional imaging of the injured brain relies on X-ray CT, with the Marshall score commonly use to grade the severity of injury. CT is very useful at identifying skull and facial trauma, characterizing surgical lesions, and providing evidence of significant brain swelling that contributes to intracranial hypertension. However, there is increasing recognition that CT may be an inadequate means of detecting more subtle forms of TBI induced structural injury, and is particularly poor at characterizing posterior fossa injury – a critical deficiency, since brain stem lesions are key drivers of eventual outcome. In particular, in the early stages, CT is known to under-diagnose traumatic axonal injury, and provides no information on abnormal physiology in TBI at a stage that interventions may be stratified according to imaging findings, and provides incomplete prognostication, since TAI is a major driver of outcome. At later stages, CT correlates poorly with cognitive, psychiatric and behavioural deficits seen in TBI survivors. Finally, in most instances CT provides limited information about pathophysiology, and hence represents a poor biomarker for novel interventions that are targeted at key pathophysiological processes in TBI.

There is increasing evidence that magnetic resonance imaging (MRI) may provide greater sensitivity at detecting microstructural abnormalities, both in the acute phase, and also as an imaging correlate of the disabling deficits that are seen at follow up. This ability is of benefit across the entire spectrum of TBI, and recent publications have attested to the superiority of MR in predicting outcome in mild TBI, as well as predicting the likelihood of remaining vegetative in those patients who suffer a severe TBI and are slow to emerge from coma. While both CT and MR can be used to image blunt vascular injury following TBI, each has its own advantages and disadvantages. Perhaps most significantly, MR in general, and functional MRI in particular, provide important insights into the functional neuroanatomy that underlies cognitive and behavioural deficits after TBI, and may provide biomarkers to identify and test new therapies.

Physiological imaging of cerebrovascular adequacy using MR is technically challenging in acute TBI, and while ^{1}H and ^{31}P MR spectroscopy may provide information about metabolic abnormalities, these techniques have limited clinical utility in TBI, and have only been used sparingly as tools in clinical research. In this area, MR does not just compete with CT, but also (at least as an investigational tool) with positron emission tomography (PET). Recent interest has focused on imaging physiology in head injury. Increasingly, PET is being used to image key pathophysiological processes after TBI, and may in combination with MR (in PET-MR systems) provide the definitive investigational tool for understanding TBI.

Despite these many advantages, the uptake of MR as a modality for acute imaging of TBI remains limited. While price and access are clearly important factors, the major obstacles to wider use of MR in the acute phase relate to the need for prolonged imaging in ambulant (and often confused) patients, and the requirement for dedicated MR compatible physiological monitoring and life support systems for critically ill patients with severe TBI.