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Review Article

Approach to Imaging in Mild Traumatic Brain Injury and Diffuse Axonal Injury

Sivakumar J *
Discipline of Surgery, University of Sydney, Australia

***Corresponding author:** Jonathan Sivakumar
Discipline of Surgery, University of Sydney, Camperdown, Australia

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Abstract

Traumatic brain injury is a commonly encountered condition in the emergency department. Mild traumatic brain injury and its squeal of diffuse axonal injury are difficult to diagnose with computed tomography scans as the preferred acute imaging modality. Our current decision on whether or not to scan a patient in the acute setting is best decided upon by the Canadian CT Head Rule. The role for MRI scans in diagnosing diffuse axonal injury is unclear, but current evidence suggests that they are preferred after the initial 48 hour period following head trauma.

Keywords: Surgical imaging; Diffuse axonal injury; Traumatic brain injury

Introduction

While the definition has varied depending on circumstances, Traumatic Brain Injury (TBI) is defined as the result of the application of either external physical force or rapid acceleration/deceleration forces that disrupts brain function as manifested by immediately apparent impairments in cognitive or physical function [1]. This is further classified as mild, moderate, and severe, depending on the patient's Glasgow Coma Scale Score (GCS) [2,3]. The majority of these cases present to hospital as minor TBI, and previous studies suggest that 40% of these cases are secondary to motor-vehicle-related events [4].

Discussion

In terms of neuroimaging following head injury, the decision on whether or not to scan tends to be guided by hospital-specific protocol, or is physician dependent. The general consensus, however, is that patients with new clinical symptoms or a change in GCS following head injury, should undergo a Computed Tomography (CT) scan of the brain. The specific clinical predictors for this are still very much debateable. The Canadian CT Head Rule study, as demonstrated in (Table 1), has developed a highly sensitive clinical decision rule for the use of CT in patients with minor head injuries [5]. These patients are classified into whether or not imaging is required based off five high-risk factors for neurosurgical intervention, and two medium-risk factors for clinically important lesions. The implementation of this guideline in other centres was associated with a modest reduction in CT use and an increased diagnostic yield of head CTs for trauma to the head [6,7].

CT scans are used in the assessment of head injury as they have widespread availability; rapid scanning times, and is compatible with medical devices. Furthermore, they are sensitive in demonstrating significant pathologies such as mass effect, abnormal ventricular size and configuration, bone injuries, as well as acute haemorrhage [8]. Despite its many advantages in the assessment of traumatic brain injury, CT imaging is limited in that lesions with smaller dimensions than that of its resolution remain undetected [9]. Consequently, a common diagnosis of after traumatic brain injury, Diffuse Axonal Injury (DAI), is likely to unnoticed on CT scans, and are better visualised with Magnetic Resonance Imaging (MRI) [10]. MRI scans, on the other hand, are provide superior soft tissue details, compared with CT scans, when evaluating complicated minor traumatic brain injury, including improved ability to detect DAI [11-13]. In spite of this, the drawbacks of MRI include its limited availability in the acute trauma setting, long scanning times, high sensitivity to patient motion, poor compatibility with various medical devices, and relative insensitivity to subarachnoid haemorrhage.

DAI is a complication of traumatic brain injury induced by sudden acceleration-deceleration or rotational forces and the subsequent tissue injury is characterized by axonal stretching, disruption and eventual separation of nerve fibers in the white matter [14]. Current imaging modalities in clinical use tend to under-estimate DAI, and while MRI does have better resolution than CT scans in detecting this pathology, there is still a high rate of false negative results for small lesions and milder forms of DAI [15]. Previous studies have quantitatively demonstrated that CT scans miss approximately 10-20% of abnormalities seen on MRI [13,16]. Although MRI scans

Table 1: Canadian CT Head injury/Trauma rule.

High risk criteria: Rules out need for neurosurgical intervention GCS <15 at 2 hours post-injury Suspected open or depressed skull fracture Signs of basilar skull fracture: Hemotympanum, raccoon eyes, Battle's Sign, CSF oto-/rhinorrhea ≥ 2 episodes of vomiting Age ≥ 65
Medium risk criteria: Rules out "clinically important" brain injury Retrograde amnesia to the event ≥ 30 minutes "Dangerous" mechanism?
The Canadian CT Head Rules have been validated in multiple settings and have consistently demonstrated that they are 100% sensitive for detecting injuries that will require neurosurgery.

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Table 2: Diffuse axonal injury (Grading).

Grade	Pathology
Grade I	Widespread axonal damage in white matter of cerebral hemispheres
Grade II	White matter axonal damage extending to the corpus callosum with tissue tear haemorrhages
Grade III	Pathology of Grade II diffuse axonal injury with tissue tear haemorrhages in brain stem

have greater sensitivity in detecting smaller lesions such as DAI, it is unclear whether the recognition of additional lesions on MRI would impact acute management of head trauma [9].

In light of the above information, and as CT scans are more convenient in the acute setting with an alibility to evaluate for the four types of cranial haemorrhages, the current preference is to initially CT scan a patient following head injury, rather than use MRI. There is a role, however, for MRI scan in patient following the initial 48 hour observation period whose symptoms continue to persist [17].

Conclusion

While current protocols guide us on when to image in the acute setting of head trauma, there is still difficulty in accurately diagnosing mild traumatic brain injury and its sequela, such as diffuse axonal injury (Table 2). The principal of CT head in the acute setting and either a CT or MRI after 48-72 hours, however, seems reasonable and the most evidence-based approach.

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