REVIEW ARTICLE

Role of Imaging in Craniocerebral Trauma: A Narrative Review

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Abstract

Traumatic brain injuries (TBI) are common and cost heavily to both society and the individual. The diagnosis of TBI is a clinical decision; however, imaging, particularly CT, plays an important role in diagnostic work-up, classification, prognosis, and follow-up. The goal of this study was to contrast and compare the roles of different imaging modalities in craniocerebral trauma. Radiologists are critical in the detection of craniocerebral trauma, and they must look for injury patterns, methods of injury, and subsequent injuries such as herniation and mass effect. CT has a much greater sensitivity for fracture detection when compared to MRI and no risk for safety, which is vital in penetrating or blast injuries. MRI holds higher sensitivity in diagnosing intra- and extra-axial hemorrhages, white matter axonal injuries, and brainstem abnormalities.

Keywords: Computed tomography, Craniocerebral trauma, Fracture, Hematoma, Magnetic resonance imaging.

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Introduction

Traumatic brain injuries are common and cost heavily to both society and the individual. The diagnosis of TBI is a clinical decision; however, imaging, particularly CT, plays an important role in diagnostic work-up, classification, prognosis, and follow-up. In the event of a traumatic head injury, a CT scan can quickly identify skull fractures, traumatic hemorrhages, and edema, allowing for prompt treatment. Computed tomography can be used to detect infarction and subarachnoid hematoma. The goal of this research was to contrast and compare the roles of different imaging modalities in craniocerebral trauma.

Primary Injury[1,2]

Mechanical forces cause this to happen during the injury. Primary injury is caused by two mechanisms:

- Contact, which occurs when an object collides with the head or when the brain collides with the inside of the skull.
- Acceleration and deceleration.

Unstopped head movement induces shear, tensile, and compressive strains in the acceleration-deceleration primary injury.

Intracranial hemorrhage, widespread vascular injury, and damage to cranial nerves and the pituitary stalk are all possible outcomes of these stresses.

Secondary Injury[1,2]

A secondary injury occurs after the initial hit and may add harm to a brain that has already been damaged by a mechanical injury. A cascade of mechanisms affecting "cerebral blood flow (hyper or hypoperfusion), reduced cerebrovascular autoregulation, cerebral metabolic dysfunction, and impaired cerebral oxygenation" results in the secondary insult. Secondary injuries include ischemia and edema.

Imaging in Craniocerebral Trauma

The history of imaging started on November 8, 1895, when a German physicist WC Roentgen discovered X-rays. The concept of X-ray is based on the principle of ionizing radiation passing through the body and projecting images on a photosensitive plate placed behind it.

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In the 1970s, computed tomography scan was developed. AM Cormack, a physicist, and G Hounsfield, an electrical engineer, created the machine. A CT scan is an X-ray procedure in which a sequence of X-rays are rotated around a bodily part to obtain cross-sectional images. When compared to traditional X-rays, these images have the advantage of containing comprehensive information in cross section, which eliminates image superimposition and gives them a significant advantage over plain films.[3–9]

Through a gantry, the CT scanner equipment moves the X-ray tube around the patient's body. Computerized data are collected every time the machine rotates. Different cross-sections are created as the subject is moved up and down in the table. A 2D picture slice is created with each rotation. The operator determines the thickness of each subsequent image slice. The thickness of each subsequent imaging slice is determined by the operator and the radiologist, and typically ranges from 1 to 10 mm. A scan is copied into a computer image and simply stored once the required number of slices is obtained.

The image is made up of pixels that correspond to the radiosensitivity of the image and is presented in Hounsfield scale units. Water has a density of 0, air has a density of 1,000, and bone has a density of 400–2,000. Intravenous iodine can be injected into the bloodstream to evaluate blood arteries, tumors, and infectious diseases.[10]

The digestive tract is depicted using intravenous iodine or oral barium contrast. The photographs can be digitally stitched together to provide a three-dimensional image of a target location. The CT scans are procured from feet to head direction.

CT has more sensitivity for detecting fractures, CSF leaks, and vascular injuries than MRI, and there is no need to screen for MRI safety (particularly in the case of penetrating injury).[11]

CT scans provide information that is as close to real-time as possible, assisting in the effective management of a variety of disorders. CT scan can show traumatic hematomas, skull fractures, and edema in a quick way to obtain rapid management in case of traumatic head injury. Computed tomography could be used to diagnose strokes and sudden subarachnoid hematoma.

When fractures extend into the carotid canal, there is a risk of posttraumatic vasospasm, or there is an abnormal cerebral bleeding pattern, computed tomography or magnetic resonance angiography is recommended.[12]

Lee and Newberg[13] ascertained that the neuroimaging can detect the presence and extent of injury and support surgical planning and minimally invasive interventions and also vital in chronic therapy of TBI, recognizing chronic sequelae, defining prognosis and rehabilitation.

Prashanth et al.[14] found that with the introduction of CT imaging, assessment has changed dramatically since it can accurately describe the nature and location of the causative pathology(s). Among 382 patients, CT showed skull fractures (62.04%), epidural hematoma (30.36%), intracerebral hematoma (46.33%), subdural hemorrhage (19.37%), subarachnoid hemorrhage (28.79%), diffuse axonal damage, brain edema (63.35%), midline displacement (24.34%), pneumocranium (12.04%), and intraventricular hemorrhage (10.73%). The parenchymal injury to the brain was detected and correctly regionalized using a CT scan, and the functional prognosis was accurately predicted.

Doddamani et al.[15] conducted a study to determine the significance of serial CT scans in detecting changes in intracranial diseases and their impact on therapy. Patients with complex lesions were the most likely to progress (21.8%). At CT-2, 5.5% of patients had newer lesions, and at CT-3, 5.8% had newer lesions. They discovered that patients who had their first CT scan within 6 hours of acute trauma had a higher rate of intervention. They concluded that repeat CT scans is of value in diagnosing changes at early stages.

Bhaskar et al.[16] did a study to look for features on the admission CT scan adding significantly to other baseline clinical information for predicting mortality in patients with head injury. In this study of 211 patients, 55 succumbed accounting for 26.06%. Marshall's CT grading mortality prediction in moderate and severe head injury patients holds good. Status of midline shift and basal cisterns serves as independent factors for in-hospital mortality.

Mutch et al.[17] reviewed the current state of TBI imaging was examined, including its uses, benefits and drawbacks, imaging techniques, and imaging findings. They also analyzed recent imaging techniques and found out the importance of CT imaging in early detection and timely intervention to prevent long-standing morbidity and disability.

Lolli et al.[18] identified that CT plays a vital role in the acute event of head trauma, precise recognition of pathologies necessitating instant neurosurgical treatment. CT also helps in identifying secondary injuries and is important in follow-up.

Khadka et al.[19] did a study to evaluate the CT findings in patients suffering from head injury and to establish the importance of CT scan in head injury. Linear skull fracture was the commonest skull fracture. They came to the conclusion that early and prompt CT identification of correct pathology had a significant impact on therapy initiation, intervention, and outcome.

Heit et al.[20] reviewed that imaging is very important for the treating doctor to establish the cause of hemorrhage, the location and severity of hemorrhage, and the risk of impending brain injury and to assist in immediate treatment. CT and MRI were reviewed extensively for intracranial hemorrhage with the aim of providing an overview of the different causes and varied appearances of intracranial hemorrhage.

Prasad et al.[21] did a prospective study among patients with clinically suspected head injury. CT was slightly better at detecting linear fractures than skull radiography, which was more specific for depressed fractures. In this investigation, CT has a diagnostic accuracy of 99%. Contusion was the most prevalent pathology (39%) followed by edema (34%) and subdural bleeding (16%).

Alfageeh et al.[22] reviewed that acute brain imaging is essential for individuals sustaining traumatic brain injury to detect treatable conditions. They discussed the vital role of CT imaging in assessing patients with TBI, its advantages, disadvantages, and prognostic values. For the assessment of patients with head injuries, CT scanning of the brain is the preferred method.

Nagesh et al.[23] did a study to see whether patients with mild-to-moderate head trauma need routine follow-up head CT scans following an initial aberrant CT scan. Lower Glasgow Coma Scale (GCS) score at arrival, presence of midline displacement, abnormal INR, multiple lesions, and effaced basal cisterns on initial CT were all found to be strongly linked to neurological and imaging worsening, and/or the requirement for intervention, according to the authors.

Rao et al.[24] did a study in patients with craniofacial trauma. Numerous cerebral traumatic lesions were the most prevalent. They found that the typical age-group for head injuries was 21–40 years, common in males.

Schweitzer et al.[12] in their study concluded that CT is especially important in the case of acute TBI because of its quick assessment, accessibility, and greater sensitivity for finding diseases that require care. Although MRI has a higher sensitivity for detecting intracranial injuries, its use in TBI is still under investigation. MRI is currently used when the CT scan is normal or unable to detect any pathology, and there are persisting neurological symptoms.

Conclusion

In craniocerebral trauma, radiologists play an important role in assessing injury patterns, injury mechanisms, and subsequent injuries that can occur due to mass effect and herniation. When compared to MRI, CT offers a considerably higher sensitivity for detecting fractures and does not require any safety concerns, which is essential in piercing or explosion injuries. For intra- and extra-axial hemorrhages, brainstem injuries, and white matter axonal damage, MRI has a better sensitivity. With safety problems, availability, longer scanning duration, patient movements, and greater costs, the function of MRI in TBI remains uncertain.

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