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How to read a Computed Tomography scan for traumatic brain injury in emergency room

Dr.Amit Agrawal*

*Professor of Neuro Surgery, Dept of Neuro Surgery Narayana Medical College & Hospital, Nellore-524002(AP) India Email :-dramitagrawal@gmail.com

Abstract

CT brain is the integral part of investigation in any case of cranio-cerebral trauma patient in emergency room. It is an extremely useful diagnostic tool that is used routinely in the care of trauma patients in emergency department. It has been suggested that even a brief educational effort of these persons can provide considerable proficiency to interpret cranial CT scans. With an increasing role of dental experts in the management of craniofacial trauma patients it is anticipated that it would be helpful to know how to read a CT scan of a suspected traumatic brain injury patient in an emergency department. It is important to recognize and familiarize with the normal appearance of different anatomical parts of the brain on CT scan (Cerebral, cerebellum, brain stem, ventricles and skull bones etc.). The present article discusses the basic s of CT scan and provides a pictorial presentation of commonly seen intracranial lesions in patient with traumatic brain injury.

Key words

CT scan, traumatic brain injury, skull fracture, head injury.

Introduction

Computed tomography (CT) of the brain is an extremely useful diagnostic tool that is used routinely in the care of trauma patients in emergency department. [1] It has been shown in many studies that the caregivers in the emergency department can have a deficiency to interpret brain CT scans.[2-7] However, at the same time it has been suggested that even a brief educational effort of these persons can provide considerable proficiency to interpret cranial CT scans.[3, 4] With an increasing role of dental experts in the management of craniofacial trauma patients it is anticipated that it would be helpful to know how to read a CT scan of a suspected traumatic brain injury patient in an emergency department. The present article discusses the basic s of CT scan and provides a pictorial presentation of commonly seen intracranial lesions in patient with traumatic brain injury.

Basic principles

It is important to recognize and familiarize with the normal appearance of different anatomical parts of the brain on CT scan (Cerebral, cerebellum, brain stem, ventricles and skull bones etc.). Based on their density different structures can appear as white (+1000 HU e.g. bone) or black (-1000 HU e.g. air). [8] The density of water is described as 0 HU. [8] Reviewing all the structures in a sequential manner will help to avoid or miss even subtle abnormalities on imaging. [8] Systemic collection also will help to identify abnormalities and deviations from the normal pattern. CT scan can be learned by following stepwise approach (Table-1). [3]

Table-1

Summary of systematic approach to read a CT scan

Parameter	**Significance**
Name	To correctly identify the person
Date	Will help to follow up the findings and also help to define the age of injury
Orientation	Right versus left
Approach	It may from inside-out It may be cranial-caudal It may be problem based
Slicing	Axial Coronal Sagittal
Windowing	• Bone window • Tissue window • Subdural window
Identify the contents and structures	Brain parenchyma (any hemorrhage or abnormal appearance) Bones (any fractures) • Skull and facial bones • Orbits • Orbital walls • Maxillary alveolus • Nasal septum Ventricles (symmetry or any presence of blood) Cisterns (any evidence of mass effect or presence of blood) Sinuses (any fluid or hemorrhage) • Frontal • Sphenoid • Ethmoid sinuses • Maxillary sinuses • Mastoid air cells Cerebrospinal fluid (any evidence of subarachnoid hemorrhage)
Blood	Acute hemorrhage appear hyperdense (50 to 100 HU) Location of the blood (please see epidural hematomas, subdural hematomas, intraparenchymal hemorrage, and subarachnoid hemorrhage)
Midline shift and mass effect	Position of the falx (midline or shift to any side) Symmetry or asymmetry of the ventricles Any loss of cisternal space Look for any effacement of sulci

Spectrum of pathologies

Extrdural hematoma (EDH)

An extradual hematoma often occurs when an impact fractures the skull and also usually associated with a skull fracture. The fractured bone fragment can lacerate the underlying dural artery or dural venous sinus leading to collection of the blood return skull and dura. [9, 10] On CT scan EDH appears as a uniformly hyperdense biconvex mass (Figure-1). The areas of hypodensity in EDH may be due to active bleeding.

Subdural hematoma

Subdural hematoma appears as a concavo-convex (sickle-or crescent-shaped) collection of blood, over the cerebral convexity (sometime in interhespheric fissure or along the tentorium).It can be an acute lesion, or a chronic collection and both can primarily occur from venous disruption of surface and/or bridging cortical vessels. [9]

Acute subdural hematoma

Acute subdural hematoma occurs due to deceleration, acceleration or rotational forces resulting in tear of bridging veins. In acute SDH the blood collects in space between the arachnoid and the dura. [9, 10] On CT scan it appears as concavo-convex (crescent or sickle shaped) hyperdense lesion (Figure-2). Because of the severity of the injury acute SDH can be associated with significant underlying brain injury contributing to the poor prognosis.

Chronic subdural hematoma

Chronic SDH is also crescent shaped collection over the cerebral convexity that usually follows a more benign course (Figure-3). It is caused by slow oozing after even a minor head injury. Depending on the age of the lesion, it can be hyperdense, isodense or hypodense in appearance. There may be associated septations and loculations. Chronic subdural hematoma, in contrast with acute subdural hematoma, usually follows a more benign course than acute subdural hematoma. [9, 10] Attributed to slow venous oozing after even a minor closed head injury, the clot accumulates gradually, allowing time for brain to compensate.

Cerebral contusion

These are the most common primary brain injuries. Cerebral contusions are caused by the impact of brain against bony ridge or a dural fold. On CT scan these lesions appear as ill-defined hypodense area mixed with foci of punctate hemorrhages or edema (Figure-4). The common locations for cerebral contusions are temporal lobe (anterior tip, inferior surface, sylvian region), frontal lobe, dorsolateral midbrain and inferior part of cerebellum.[9, 10]

Intracerebral hematoma

Traumatic intra cerebral hematomas appear as high-density areas on plain CT scan and produce much less mass effect than their size (Figure-5). These lesions can appear as early lesions and can develop in a delayed manner. [9]Based on the location and presentation it can be differentiated from non-traumatic hemorrhagic lesions.

Subarachnoid hemorrhage

Traumatic subarachnoid hemorrhage (SAH) occurs due to rupture of small cortical surface arteries or veins on the brain. The bleeding occurs into the space between the pia and arachnoid matter that occurs most commonly over the cerebral convexities. On CT, traumatic SAH appears as focal high density in sulci and fissures or linear hyperdensity in the region of cerebral sulci (Figure-6).

Skull fracture

Skull fractures can be classified as linear or depressed (whether the fracture fragments are depressed below the level of the skull) and closed or compound (communicating with environment) (Figure-.7-12). Fractures are better visualized with bone windows settings. Fractures lines needs to be differentiated with suture lines. Basilar skull fractures commonly involve the petrous ridge and maxillary/ethmoid or sphenoid sinuses.

Penetrating injury

Penetrating injury can lead to skull fracture and injury to the underlying brain parenchyma. Sharp objects or bullet fragments can get retained in the brain parenchyma (Figure-13 and 14).

Diffuse axonal injury

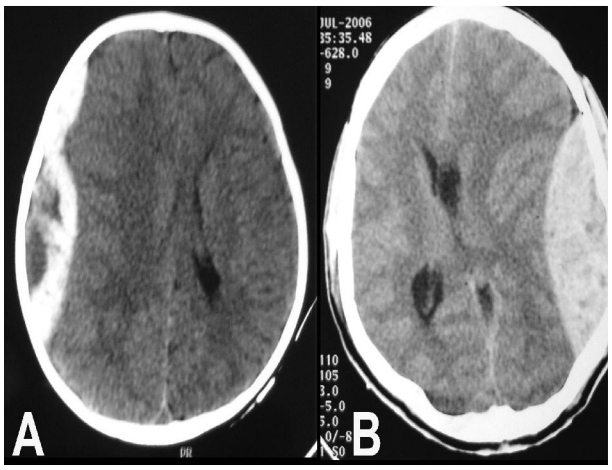
Diffuse axonal injury is caused by acceleration, deceleration and rotational forces causing shearing of the neuronal tissue and it the most common cause of significant morbidity and mortality. Hemorrhages usually involve subcortical white matter, internal capsule, corpus callosum and dorsolateral midbrain regions. [10] CT scan findings in a patient who sustained diffuse axonal injury can be normal. On CT scan there may be presence of ill-defined areas of high density or hemorrhages (Figure-16).

Conclusion

CT brain is the integral part of investigation in any case of cranio-cerebral trauma patient in emergency room. A basic knowledge of CT scan brain, familiarity with the normal anatomical structures and common pathological conditions without specialist assistance can help to make decision for those conditions that may require immediate

action. Brain CT interpretation is like other many skills that can be learned through continuous exposure, patience, practice, and repetition.

Figure-1



Typical appearance of EDH e.g. biconvex hyperdense lesion (A) right fronto-pareital region, (B) left parietal region (please note mass effect and midline shift

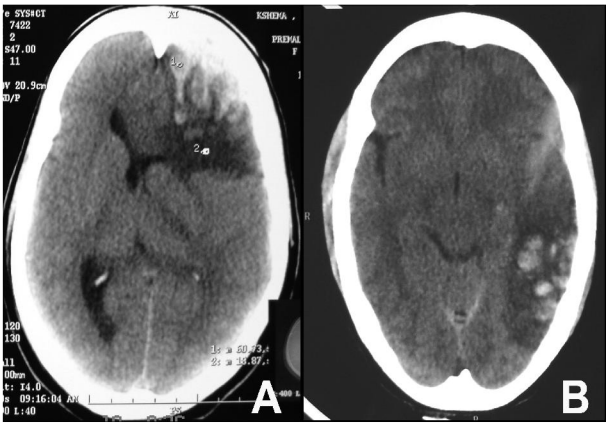
Figure-2

Left fronto-temporo-parietal acute subdural hematoma (concavo-convex shape and hyperdense appearance) with mass effect and midline shit

Figure-3

Left fronto-temporo-parietal chronic subdural hematoma (concavo-convex shape and isodense appearance) with mass effect and midline shift.

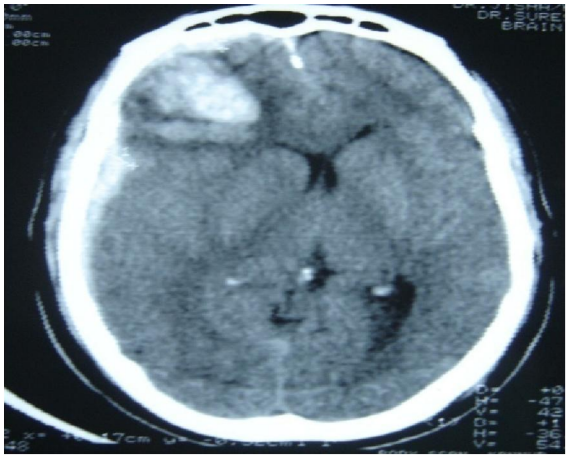
Figure-4



Mixed density lesions (A) left frontal and (B) left posterior temporal region with mass

effect and midline shift (Cerebral contusions)

Figure-5

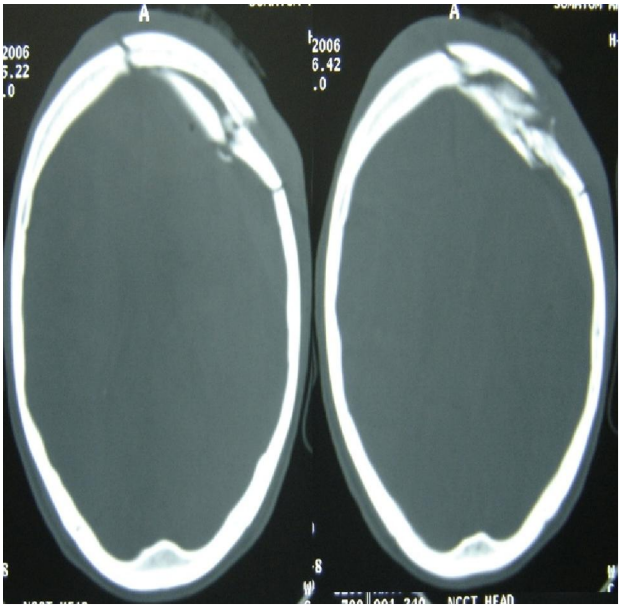


Hyperdense lesion right frontal region (intracerebral hematoma) with thin acute subdural hematoma right fronto-temporal region with mass effect and midline shift (compare appearance with cerebral contusions in figure-4)

Figure-6

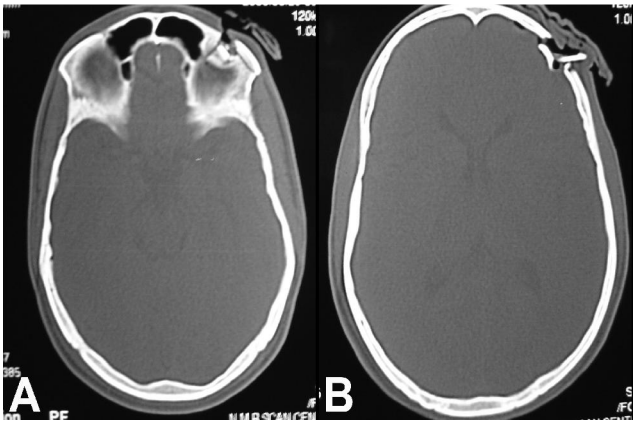
CT scan appearance of diffuse subarachnoid hemorrhage

Figure-7



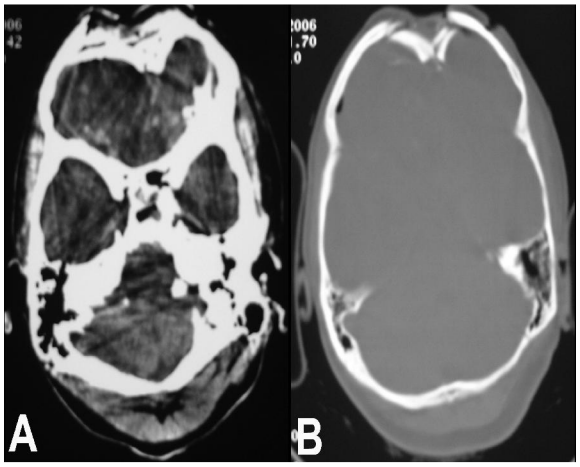
Left frontal skull bone fracture with minimal depression both inner and outer tables of calvaria

Figure-8



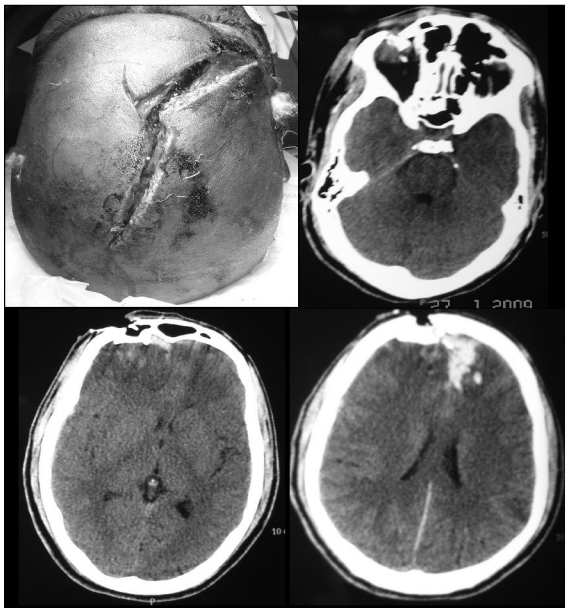
Fracture of left orbit rim and left frontal bone

Figure-9



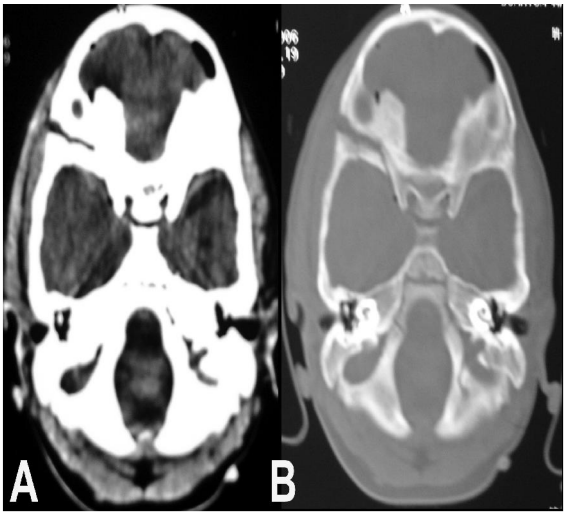
Significant depressed fracture of mid frontal bone

Figure-10



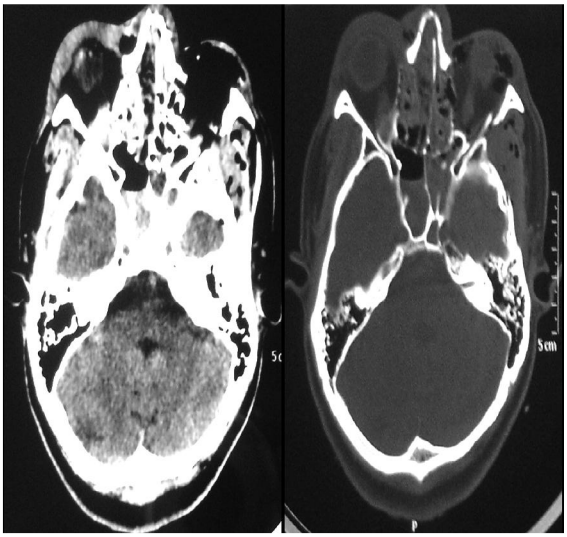
Compound fracture of frontal bone with a large scalp laceration

Figure-11



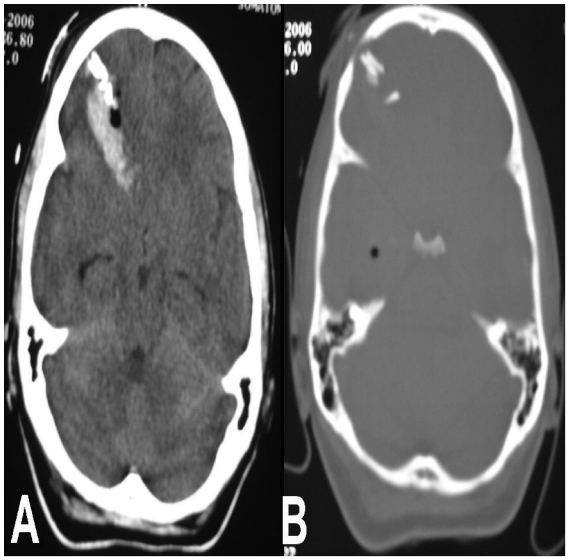
Skull base fracture (right sphenoid bone)

Figure-12



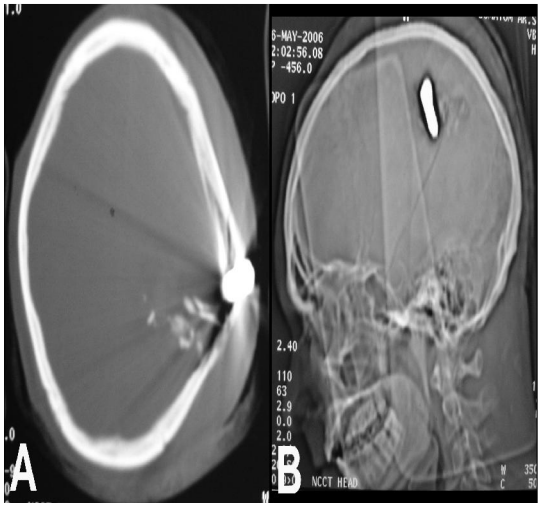
Skull base fracture involving anterior cranial fossa (note the blood in ethmoid sinuses)

Figure-13



Penetrating injuryinvolving right frontal bone, in bone window (B) note the bone fragment in brain parenchyma

Figure-14

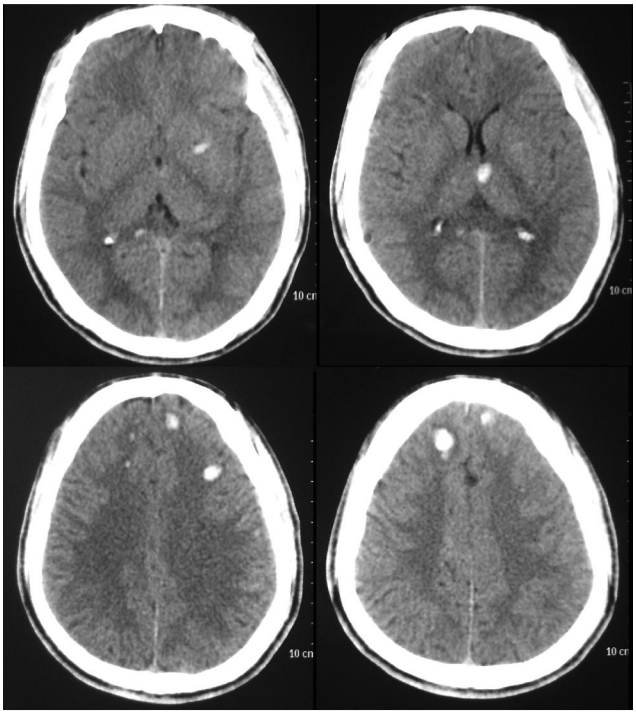


Gunshot injury causing depressed fracture of the skull

Figure-15

CT appearance of diffuse brain injury and diffuse cerebral edema

Figure-16



CT scan of a patient with diffuse axonal injury multiple small hemorrhages

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