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The role of CT scan in comprehensive and early diagnosis of strokes and severe head injuries

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Abstract

Strokes represent a major health problem that threatens many people at different stages of their lives. They are one of the most common diseases, as they are considered the second cause of death and the main cause of neurological dysfunction that may lead to permanent neurological impairments. CT scanning is useful in evaluating the cerebral blood supply, distinguishing treatable tissues, and determining the true size of cerebral clots in their early stages. CT scan of the head is an important diagnostic method for developing a three-dimensional image of the skull, brain, and other related areas of the head. A CT scan of the head can provide more details than traditional X-rays, which is especially useful when the doctor wants to examine the blood vessels and soft tissues of the body. Using modern CT imaging, a comprehensive view of the total cerebral circulation and microcirculation can be obtained within minutes for strokes and severe head injuries. The aim of this research was to evaluate the role of CT scan in the comprehensive and early diagnosis of strokes and severe head injuries. The general principles of multi-segment CT scanning, the possibility of their application, and the extent of their importance in cases of strokes were also clarified.

From what has been studied, it is clear that multi-section CT scanning gives highly accurate and sensitive diagnostic results in the comprehensive diagnosis of cases of strokes and severe head injuries in their early stages, which positively affects the treatment strategy. Comprehensive CT scanning is a fast and safe method that allows accurate diagnosis and opens the way for individualized treatment in acute stroke.

Keywords: Computed tomography scan (CT); strokes; severe head injuries; traumatic brain injury (TBI)

1. Introduction

Cerebrovascular diseases are serious health conditions that can affect quality of life by causing disabling consequences, such as dysarthria, paralysis, and memory loss (Chiaramonte et al., 2020). A stroke occurs when the blood vessels that supply the brain with blood are torn or obstructed, frequently with thrombus development, displacement embolism, stenosis in the cerebral arteries, and bleeding in the brain parenchyma (Campbell et al., 2019). These occurrences may cause a severe reduction in the amount of blood and oxygen reaching the brain, which may result in a stroke (Akbarzadeh et al., 2021).

Head injuries are also one of the most important public health problems, and are frequently seen in emergency departments (ED). A Glasgow Coma Scale (GCS) of 13 to 15 on the initial ED examination and a history of contact or acceleration/deceleration forces to the head are common indicators that it is mild (Mack et al., 2003). Brain computed tomography (CT) is a recognized method for the diagnosis of intracranial lesions (Geisler et al., 2019). In patients with MHI, the justifications for a CT scan are a topic of discussion. Although the use of CT scans was originally widely recommended for all patients with MHI, there are now concerns about its high cost, radiation-related problems, and limited accessibility in some places. There have been several attempts to create complete criteria. In the numerous MHI instances, there are significant differences regarding these criteria (Feigin et al., 2017).

In hospitals, the therapy of moderate or severe head injuries has a clearly defined care route. However, only 1% of MHI will require neurosurgical intervention, and only 8% of MHI will result in intracranial damage (Yang et al., 2017). In order to effectively manage this significant percentage of patients, it is important to strike a balance between underinvestigation, which puts patients at risk of missing early treatment for cerebral damage, and overinvestigation, which increases the likelihood of radiation exposure and wastes money from the healthcare system (Jafarabad & Hashemian, 2014).

An important global public health issue, traumatic brain damage following head trauma can cause severe long-term morbidity and mortality in adults and children. An estimated 1.7 million Americans suffer traumatic brain injuries each year, according to estimates. Even though the majority of the injuries are minor, 50,000 people die and 70,000 become permanently disabled as a result. For those who have had traumatic brain injury, emergency brain imaging is required to identify curable disorders as early as possible (Carney et al., 2017). Early neurosurgical treatment of problems that may be managed can stop more harm and consequent neurological impairments. In turn, this will enhance the result and lessen long-term impairment (Harburg et al., 2017). The study of choice for evaluating individuals with head injuries is computed tomography (CT) of the brain due to its accessibility, benefits, and sensitivity for several neurological problems following head trauma (Alfageeh et al., 2018).

The most crucial tools in the treatment of an acute ischemic stroke are still clinical assessment and NECT testing. With the use of CT angiography (CTA) and CT perfusion, contemporary brain CT-imaging may quickly provide a comprehensive picture of the cerebral macro- and microcirculation, giving important information before to or during the start of therapy (Löve et al., 2011). Against this background, the aim of this study was to evaluate the role of CT scan in the comprehensive and early diagnosis of strokes and severe head injuries, and discuss the importance of CT imaging in evaluating patients with traumatic brain injury, its advantages, limitations, and prognostic values.

2. Stroke, pathophysiology and Etiology

Stroke is the leading cause of death that is avoidable, accounting for more than 10% of fatalities globally (Feigin et al., 2017), with one in five stroke patients dying each year. Although their incidence may fluctuate between nations, the risk factors for stroke are mostly those that are also prevalent in other non-communicable illnesses, such as diabetes, high blood pressure, obesity, smoking, and alcohol use (Almobarak et al., 2020). The most frequent indications of a stroke include weakness or numbness, blurred or lost vision, sensory disturbance, decreased awareness, dizziness and loss of balance, dysphagia, headaches, and speech difficulties (Di Stefano et al., 2021).

A correct and speedy diagnosis is essential, just like in other life-threatening situations. Since brain tissue is destroyed for every minute of delay in diagnosis, irreparable harm may occur. In an effort to speed up the diagnosis of stroke, a number of severity grading scales and stroke assessment scales have been developed, including the Face Arm Speech Time (FAST), Cincinnati Prehospital Stroke Scale (CPSS), Los Angeles

Prehospital Stroke Scale (LAPSS), and Melbourne Ambulance Stroke Scale (MASS). It has been demonstrated that simpler scales like CPSS and FAST have sufficient sensitivity for clinical applications, but more complicated scales may have lower sensitivity and, as a result, overlook more instances (Purrucker et al., 2015). The conclusive diagnosis is mostly reliant on imaging, even if several significant clinical signs, such as facial drooping, arm weakness, and speech problems, may imply stroke in the first examination (Brunser et al., 2013). A wise choice of imaging method might therefore lead to an early, life-saving diagnosis of an acute stroke. This article examines the use of several imaging techniques in the diagnosis of acute ischemic stroke and weighs their benefits and drawbacks (Akbarzadeh et al., 2021).

The primary pathophysiology of an ischemic stroke is the loss or interruption of blood flow to certain regions of the brain, which may be caused by thrombotic or embolic blockage. According to the size of the affected arteries, thrombotic ischemic strokes are frequently linked to atherosclerotic accidents (Alqahtani et al., 2017), regardless of the cause, when blood flow abruptly stops, a series of ischemia-related processes start to occur both at the cellular and macroscopic levels (Zhao et al., 2017).

First of all, even in the absence of total blood occlusion, the energy supply by mitochondria is disrupted, which causes membranous proteins to lose their function and the gradient between the intracellular and extracellular space to become impaired. This, in turn, leads to enlarged neurons and glial cells, also known as cytotoxic edema (Wang et al., 2018). Additionally, the release of excitatory neurotransmitters places additional strain on the cells' ability to supply energy, as well as causes the ectopic activation of harmful enzymes like lipases and proteases, the destruction of essential organelles in neurons, and the production of oxygen free radicals, which ultimately results in the necrotic death of the neurons in the core of the ischemic region and starts a cascade of apoptotic events in the peripheral neurons (Rodrigo et al., 2013).

3. The role of CT scan in comprehensive and early diagnosis of strokes and TBI

Traumatic brain injury (TBI), often known as brain damage is a leading cause of morbidity and mortality globally and has considerable financial implications for the healthcare system. The Centers for Disease Control and Prevention in the USA estimates that 1.7 million individuals experience TBI each year, and it is predicted that 10 million people globally experience TBI every year. The yearly cost of TBI in the USA is projected to be over $60 billion, including direct medical expenses and indirect costs from lost productivity (Centers for Disease Control and Prevention, 2010). Long-term functional and cognitive deficits as well as the emergence of disorders like epilepsy in TBI patients need supportive care for the rest of their lives. The main causes of TBI change depending on the patient's age. The most common cause of traumatic brain injury (TBI) in those over 75 and children under the age of four is falls. Motor vehicle collisions are the main cause of TBI among teens. Other frequent causes of TBI include assaults, the use of firearms, and explosion injuries for active-duty military personnel (Kim et al., 2011).

Imaging is essential for both TBI diagnosis and treatment. Noncontrast CT is the method of choice for diagnosing TBI in the acute situation because it may immediately and precisely identify cerebral bleeding that necessitates neurosurgical evacuation. Both intra-axial bleeding (cortical contusion, intraparenchymal hematoma, and TAI or shear damage) and extra-axial hemorrhage (epidural, subdural, and subarachnoid/intraventricular hemorrhage) are easily recognized by CT. Magnetic resonance imaging (MRI) provides superior diagnostic sensitivity for certain injuries that are not always hemorrhagic, such as cerebral contusions and nonhemorrhagic traumatic axonal injuries, but computed tomography (CT) remains the standard of care for TBI imaging in the acute situation. Noncontrast CT makes it simple to track the course of bleeding and symptoms of secondary damage important to neurocritical care, such as cerebral edema, herniation, and hydrocephalus, in TBI patients (Kim et al., 2011).

3.1 Primary injuries in TBI patients

Epidural hematoma

An epidural hematoma (EDH) nearly often coexists with an adjacent skull fracture and typically develops at the site of traumatic impact, sometimes known as the "coup" site. A characteristic lentiform-shaped blood collection caused by damage to a meningeal artery/vein, a diploic vein, or a dural venous sinus peels the dura away from the inner table of the skull. The middle meningeal artery or one of its branches is frequently torn, which causes EDHs, which are most frequent in the temporal or temporoparietal regions (Bullock et al., 2006). A venous EDH may develop in the middle cranial fossa from damage to the sphenoparietal sinus or the posterior fossa from rupture of the transverse/sigmoid sinus (Gean et al., 2010).

Due to the periosteal layer of the dura's strong adhesion to the cranial sutures, EDHs generally appear lentiform or biconvex on imaging. However, unlike subdural hematomas, EDHs can cross the midline when the superior sagittal sinus—which may be displaced from the inner table of the skull—is formed by the periosteal layer of the dura. EDHs can also extend above and below the tentorium cerebelli, a dural reflection that divides the cerebellum from the occipital lobes, in contrast to subdural hematomas. The patient's GCS score; pupil exam, comorbidities, age, and CT findings all have a role in the decision to surgically evacuate an acute EDH (Kim et al., 2011).

Significant hematoma thickness (>15 mm), large hematoma volume (>30 cm3), significant midline shift (>5 mm), compression of the basilar

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cisterns, and mixed density of the hematoma, which frequently indicates active bleeding, are imaging findings that indicate a poorer prognosis and necessitate early surgical evacuation . The ABC/2 approach outlined by Kothari et al. [21] can be used to determine the hematoma volume, where A represents the diameter of the bleeding on the chosen CT slice, B represents the measurement obtained perpendicular to A, and C represents the approximate number of 10-mm slices having hemorrhage (Mathur et al., 2010).

Subdural hematoma

Although the contrecoup site is more frequent, a subdural hematoma (SDH) can develop either at the coup or contrecoup site. Blood may continue to build up in this region when bridging veins are gradually stretched and ruptured. Injury to superficial bridging veins causes bleeding between the meningeal layer of the dura and arachnoid. In descending order of frequency, SDHs usually develop across the cerebral convexities, over the tentorium cerebelli, and along the falx cerebri (De Leciñana et al., 2014).

SDHs are shown as crescent-shaped on imaging; do not cross the midline, but can cross the cranial suture lines (unlike EDHs). The falx cerebri and tentorium cerebelli should be carefully examined for any mild asymmetric high density lesions since small SDHs can be very inconspicuous. On noncontrast CT scans, the majority of SDHs in the presence of acute TBI are homogeneously hyperintense. Isodense hematomas, however, can develop if the patient has significant anemia or if bleeding and CSF from an arachnoid rip mix. Acute-on-chronic hemorrhage, coagulopathy, and active bleeding can all be associated with heterogeneous SDHs (Chrzan et al., 2017).

Subarachnoid hemorrhage

A subarachnoid hemorrhage (SAH) is a form of intracranial hemorrhage that affects around 40% of those who have moderate to severe head injuries. The tiny cortical arteries that cross the subarachnoid space may be directly torn, intraventricular hemorrhage may be redistributed and leave the fourth ventricular outflow foramen, or cortical contusion or hematoma may directly extend into the brain. According to the findings of a sizable study carried out by the European Brain Injury Consortium (Servadei et al., 2002), patients with traumatic SAH have a significantly worse prognosis than those without SAH: 41% of patients without traumatic SAH achieved a level of good recovery compared with only 15% of patients with SAH.

On noncontrast CT images, linear regions of high attenuation in the cerebral sulci at the convexities, Sylvian fissures, or basilar cisterns are easily recognized as acute SAH. Examining regions like the interpeduncular cistern is crucial since it may contain minor SAH that is often overlooked without conscious attention to this region. SAH may be the lone aberrant finding on a noncontrast CT scan in 5% of individuals with TBI. A frequent side effect of traumatic SAH is hydrocephalus, which can manifest suddenly or gradually. Acute hydrocephalus may be caused by intraventricular hemorrhage or inflammatory arachnoiditis, whereas chronic hydrocephalus is caused by arachnoid villi's impaired ability to reabsorb CSF (Zhang et al., 2019).

Cortical contusion/hematoma

When a closed head injury occurs, the brain is bruised by the uneven interior surfaces of the skull at the time of impact. This is known as a cortical contusion. When the underlying cortex is grazed by a blow to the immobile head, they may develop at the coup location as a result of a transitory calvarial deformity or a depressed skull fracture. However, they happen more frequently when the moving head bumps against a stationary item at the contrecoup position. The contusions sustained during the contrecoup are usually more severe than those sustained during the coup. There is much discussion over the exact process of contrecoup contusions and the reason why they are more severe (Drew et al., 2004). A new theory states that the buoyant brain is pushed by CSF in the opposite direction from impact, resulting in damage opposite the blow, when a moving skull collides against a stationary object, such as when a person falls and smacks the back of his head against the ground. When the blow strikes the occiput, the rough, irregular surfaces of the anterior and central skull base can bruise the underside of the brain, causing the recognizable hemorrhagic contusions seen in the inferior frontal and temporal lobes. This makes contrecoup injuries particularly severe. On first noncontrast CT scans, contusions may present as small, localized

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foci of petechial hemorrhage peripherally positioned in the brain, although they may be extremely mild with little hemorrhage and/or edema (Almandoz et al., 2011). However, almost half of contusions develop and enlarge in size with time. Serial CT imaging and thorough clinical monitoring of TBI patients are crucial for this reason. Gradient-echo (GRE) sequences on MRI, which are far more sensitive than CT to minor hemorrhagic contusions, are particularly sensitive to inhomogeneities in the magnetic field generated by paramagnetic bleeding (Beaumont et al., 2006).

Microhemorrhages related to a contusion may combine into an intracerebral hematoma (ICH) with more severe head trauma, illustrating the fact that both contusions and ICH are a spectrum of damage rather than distinct, separate entities. The condition termed as a "delayed traumatic intracerebral hematoma" occurs when an ICH develops in a brain region that was previously thought to be radiographically normal. ICHs indicate a dynamic process of damage, much like contusions do. Only 84% of ICH attained their maximum size by 12 h after damage, according to one research, highlighting once more the significance of rigorous clinical monitoring and serial imaging (Liebeskind & Alexandrov, 2012).

In patients with contusion or ICH, the precise indications for craniotomies and surgical evacuation are yet unknown. It is generally believed that a combination of clinical and radiologic parameters, such as

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bleeding site and volume, amount of mass effect on CT (cisternal effacement or midline shift), GCS score, ICP, and neurological deterioration, are significant. Although precise surgical criteria have not been defined, patients with contusions/ICH and progressive neurological impairment, medically resistant elevated ICP, or radiographic indications of mass effect likely to have poor outcomes without surgical treatment (Lövblad et al., 2015).

Traumatic axonal injury

Diffuse axonal damage or shear injury are other popular names for traumatic axonal injury (TAI). The term TAI is favored by the authors of this review because injuries do not affect the whole brain uniformly but rather manifest in distinct, recognizable regions, such as the corpus callosum, brainstem, and parasagittal white matter. Severe (grade III) TAI involves the dorsolateral midbrain in addition to the subcortical white matter and corpus callosum, as well as the gray-white junction of the lobar white matter and particularly the parasagittal frontal lobes in mild (grade I) and moderate (grade II) TAI. The axonal cytoskeleton is injured by cytoplasmic shear-strain as a result of persistent acceleration and deceleration, such as during a high-speed car collision or protracted shaking (Bullock et al., 2006). A detrimental cascade of biochemical reactions, Wallerian-type degeneration, and gradual neuronal loss cause damage to the neurons not only at the time of mechanical injury but also in the hours, days, weeks, and even years that follow the traumatic event. The bulk of overall cognitive deficits observed after TBI are believed to be caused by changes related to TAI, specifically with relation to issues with memory and information processing.

TAI is regrettably famously challenging to identify on CT. In just 10% of TAI patients, petechial hemorrhages at the gray-white junction of the cerebral hemispheres, the corpus callosum, or the brainstem are seen on a CT scan. Because >80% of TAIs are nonhemorrhagic, the findings of the majority of admission CT tests are normal (Bullock et al., 2006; Meythaler et al., 2001). Because it may find both hemorrhagic and nonhemorrhagic lesions, MRI is far more sensitive than CT. Due to the paramagnetic effects of deoxyhemoglobin on gradient-recalled echo (GRE) and susceptibility-weighted imaging (SWI), acute hemorrhagic lesions exhibit localised susceptibility and signal loss. With almost twice as many hemorrhagic lesions observable at 3 Tesla (3T) compared to 1.5T, these susceptibility effects are further amplified. When compared to traditional T2-weighted imaging, fluid attenuation inversion recovery imaging allows for the greatest understanding of nonhemorrhagic lesions and makes subcortical and periventricular lesions more obvious. Additionally sensitive to TAI, diffusion-weighted imaging (DWI) can identify lesions that are not visible on fluid attenuation inversion recovery or GRE sequences (Scheid et al., 2007). In the acute context, TAI lesions often have hyperintense appearances with decreased apparent diffusion coefficient values, which presumably indicate cytotoxic edema (Huisman et al., 2003). Sadly, there are now no effective treatments available for TAI patients; hence the advantage of increasing imaging diagnostic accuracy resides mostly in being able to predict clinical outcomes more accurately (Kim et al., 2011).

3.2 Importance of imaging in approach to stroke

Suspicion of ischemic stroke should be followed by early neuroimaging for the following reasons:

Exclude the presence of hemorrhage

The first therapy of a stroke patient, in addition to patient stabilization, relies on the kind and etiology of the stroke [27]. Thrombolytic treatment is beneficial for ischemic strokes but not for hemorrhagic ones [28]. This procedure needs to be completed quickly since there is a window of safety for using Tissue Plasminogen Activators (tPA), such Alteplase, of 4.5 hours from the beginning of symptoms [29, 30.[

Confirmation of the stroke

The presence of a hyperdense area in a vessel, particularly in the middle cerebral artery, which is a common sign of an intravascular thrombus or embolus, should be detected by imaging in order to confirm the diagnosis of a stroke, even though clinical signs and symptoms of a stroke typically include facial drooping on one side, arm weakness, and difficulty speaking [31, 32]. Even while the collateral flow usually makes up for the absence of blood flow in the damaged area, early symptoms like hypoattenuation and a loss of the ability to distinguish between grey and white matter would still be present [33].

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Determining the status of brain-supplying arteries

In order to identify potential causes, show the degree of the damage, and in certain situations, determine the likelihood of recurrence, the condition of the brain-supplying arteries should be evaluated during the work-up (Weimar et al., 2016).

Rule out the stroke mimics

Tumors imitate strokes and have to be ruled out. Other conditions that might mimic a stroke include migraines and seizures, which call for imaging to rule out a stroke. Early ischemic stroke symptoms on a CT scan include hypoattenuation, loss of grey-white matter differentiation, parenchymal swelling and edema, hyperattenuation of the middle cerebral artery, infarction in the region of the brain-supplying arteries, and cortical sulcal effacement on the affected side (Lövblad et al., 2015). Based on the topographic involvement of the MCA-supplying areas of the brain, the Alberta Stroke Program Early CT Score (ASPECTS) is a quantitative scoring system that assesses early alterations of MCA stroke. One point is subtracted from the total of 10 points for each region affected. ASPECTS have also undergone several clinical modifications, such as the pc-ASPECTS, which assesses the stroke of the posterior circulation (Akbarzadeh et al., 2021).

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4. The role of imaging in predicting outcomes following traumatic brain injury

Imaging modalities can be utilized to forecast the clinical and functional outcome following a head injury in addition to identifying the condition and providing therapeutic guidance. Given its speed, accessibility, and sensitivity to bleeding, noncontrast CT has traditionally considered the gold standard for imaging acute TBI; hence, research has typically been directed toward discovering CT predictors of clinical prognosis. The commonly used Rotterdam score and Marshall Classification (described below) link imaging results on noncontrast CT scans to patient outcome and death. However, there is a lot of interest in researching these modalities to better diagnose and treat TBI patients as a result of the introduction of innovative CT methods, such CT perfusion (Campbell et al., 2019).

Susceptibility-weighted and diffusion tensor imaging are two advancements in MRI that, like CT, may aid to improve prognostication for patients with traumatic brain injuries. The presence of subarachnoid hemorrhage, midline shift, compressed or missing basilar cisterns, subdural or epidural hematomas, shear damage, and contusions are all individual indicators of poor prognosis on conventional CT. A two- to three-fold increase in mortality is linked to compress or missing basilar cisterns, which also imply a threefold greater risk of elevated ICP [48]. Traumatic subarachnoid hemorrhage has a 70% positive predictive value for a bad result, and basilar cistern hemorrhage has a two-fold increase in mortality (Zhang et al., 2019).

Although this link is slightly complicated by the fact that midline shift is brought on by cerebral bleeding, which also has a detrimental effect on prognosis, midline shift signals elevated ICP and is similarly associated with a bad clinical result. Finally, cerebral bleeding has a prognosis that deteriorates as the hematoma volume grows, with a positive predictive value for poor functional result of about 80% [48]. It is noteworthy that patients with acute subdural hematomas had greater fatality rates than those with epidural hematomas (Akbarzadeh et al., 2021).

A categorization system for head injuries based on imaging that predicts death was developed by Marshall et al. [49] in their article on the Trauma Coma Data Bank. This method includes the existence of a mass lesion and indicators of elevated ICP (status of the basilar cisterns, presence of midline shift) when defining the four different categories of diffuse head injuries. Although the Marshall Classification is well known and frequently used, a more recent research from Rotterdam by Maas et al. modified imaging characteristics to provide a CT score that more accurately predicts clinical outcome (Marshall et al., 1991). To determine a score that correlates with 6-month mortality, the Rotterdam Score assesses the condition of the basilar cisterns, the existence of midline shift, the presence of epidural hematoma, and the presence of intraventricular or subarachnoid hemorrhage (Wintermark et al., 2004).

Noncontrast CT can only show anatomical data, while being useful for diagnosing, treating, and predicting the prognosis of individuals with TBI. Conventional noncontrast CT scans cannot detect the physiological abnormalities in cerebral perfusion, blood flow, and oxygenation associated to the harmful cascade of secondary traumatic brain injuries that have a substantial influence on functional outcome. A recent imaging technique called perfusion CT makes use of dynamic scanning while an intravenous contrast agent is injected to show the physiologic parameters of cerebral blood volume (CBV), cerebral blood flow (CBF), and mean transit time (the amount of time it takes for blood to perfuse a particular area of tissue (Maas et al., 2005).

A positive clinical result has been linked to evidence of normal brain perfusion, or hyperemia (high CBV and CBF), on perfusion CT scans in TBI patients, whereas oligemia (low CBV and CBF), has been linked to a negative clinical outcome. Patients with relatively minor head trauma and intact autoregulation maintain or even slightly increase cerebral perfusion, whereas patients with severe head injury have impaired autoregulation and pressure-passive flow, which frequently results in oligemia and decreased perfusion. These findings on perfusion CT scans have been hypothesized to reflect the status of cerebrovascular autoregulation. Concerns about higher radiation exposure, especially in young patients who are frequently the victims of head injuries, temper the enthusiasm of employing perfusion CT to better understand the physiology of TBI patients (Kim et al., 2011).

4.1 Role of initial imaging

The non-contrast computed tomography (CT) scan is indispensable when assessing the trauma patient. Epidural hematomas (EDH), subdural hematomas (SDH), subarachnoid hemorrhage, intraventricular hemorrhage, contusions, and severe deep white matter shear injuries can all be readily detected with a CT scan of the head (CTH). Neurosurgical intervention can be quickly considered, and clinical judgments can be taken quickly. However, not every patient with a history of trauma should have a CTH, and specific clinical correlations must be used. The risk factors that are now present may be used to guide recommendations for getting scans (Fong et al., 2017).

Low risk patients exhibit no symptoms, headaches, vertigo, or superficial soft tissue damage to the scalp. The CTH may not be necessary for these low-risk individuals (18-20). There are established criteria for which patients ought to receive a CTH (Fong et al., 2008). The following symptoms are taken into consideration: vomiting, headaches, altered mental status, loss of consciousness, drunkenness, PTSs, post-traumatic amnesia, signs of a basal skull fracture, facial damage, and numerous traumatic injuries. These kinds of standards have the power to enhance valuable treatment and lessen radiation exposure to patients (Schmidt al., 2012).

Another crucial factor is the CTH's timing. The CTH only offers a moment in time when evaluating a trauma patient. Depending on the sort of damage, there can be a concern about the insult progressing. According to a UCLA research, 50% of patients who have a CTH within two hours of their injury experience progressive hemorrhagic injury (PHI); this suggests that TBI patients who appear with imaging taken during the first two hours of presentation may not have fully recovered from their damage. A CTH taken at this time period may become much worse, necessitating a management adjustment. The study's findings, which support the practice of a routine repeat scan to assess progression, showed that intraparenchymal contusions were more likely to exhibit PHI (Oertel et al., 2002).

Although other studies have reported varied timing intervals, this study's advice was to do repeat CT 4 hours after the initial CT (23). No repeat CTH is advised for patients with moderate TBI and/or patients on anticoagulation without neurological abnormalities, according to several research(Bauman et al., 2017). According to a comprehensive analysis, up to 67% of TBI patients show deterioration on subsequent CT scans (26). In cases with severe TBI, the value of repeat imaging is obvious, but the time and volume of CTH still need to be determined. It has also been investigated if repeat CTH was performed because of hospital transfers within trauma systems (Holmes et al., 2017). Even as bleeding develops with worsening radiographic findings, specific recommendations for surgical intervention are difficult to make, and must be individualized, because of the heterogeneous populations studied and outcomes reported (Hill et al., 2017).

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5. CT Scan importance in the first eight hours of head injury

5.1 CT scan of the head and brain

A CT scan of the head, also known as a computed tomography scan, is a non-invasive diagnostic imaging procedure that uses special x-rays to produce axial images of the brain. This type of imaging gives more detailed information about brain tissue and structure compared to traditional X-ray images of the head, such as information related to brain diseases and injuries that include bleeding, strokes, and brain tumors. In emergency cases, a CT scan of the brain helps detect internal injuries and bleeding quickly enough to help save a life. The CT scanner takes a group of images and then merges them together to create a detailed image of the brain, which helps the doctor accurately diagnose the patient’s condition. CT scans can be performed with or without contrast dye. Contrast dye is defined here as a substance that is taken by injection or orally to show a specific organ or tissue more clearly. It is worth noting that medical procedures that require the use of dye X-rays require the person to fast for a certain period before taking it (Bauman et al., 2017).

5.2 Grades of traumatic brain injury

One of the primary causes of illness and mortality in the world is traumatic brain injury. Multiple internal parts of the skull can be impacted, and different brain regions may be involved following a head injury either directly or indirectly through secondary effects. The severity of traumatic brain injuries is assessed using a variety of categories. According to the initial Glasgow Coma Scale, the length of the loss of consciousness, and the length of posttraumatic amnesia, traumatic brain injuries are essentially divided into mild, moderate, and severe injuries (Raj et al., 2015).

Patients with a mild traumatic brain injury have a Glasgow Coma Scale of 13 or above, a loss of consciousness lasting less than 30 minutes, and posttraumatic amnesia lasting less than an hour. Patients who have had a mild traumatic brain injury often have an initial Glasgow Coma Scale between 8 and 12, a loss of consciousness between 30 minutes and 6 hours, and posttraumatic amnesia lasting between 1 and 24 hours. Severe instances of traumatic brain injury include those with an initial Glasgow Coma scale below 8, loss of consciousness for six hours or more or posttraumatic amnesia lasting longer than twenty-four hours. Although this categorization reflects the degree of brain damage and the severity of the accident, modest instances are not exempt from long-term problems (Slovarp al., 2012).

Even though they are not taken into account by the severity ratings, many additional factors play a part in determining how traumatic brain injury will turn out. Age of patients at the time of the head injury and alcohol use are two of the most frequent ones. Older patients have a worse

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prognosis; according to some research, even with modest traumatic brain injuries, only 6% of individuals over the age of 60 may recover functionally Harvey & Close, 2012). Additionally, there is a very low likelihood that patients 65 years of age or older who maintain a Glasgow Coma Scale below 8 for more (than a few days would have a positive functional result. Chronic alcohol consumption occurs in at least 50% of patients with traumatic brain injury and it has a poor prognostic value (Stippler al., 2012).

5.3 Brain CT in traumatic brain injury

For the purpose of assessing potentially therapeutic cerebral lesions that may have developed following traumatic brain injury, early brain imaging is crucial. To see acute lesions, early imaging should be done within 8 hours after the start of head trauma, as will be explained in the next section. When cerebral bleeding is initially identified or when there is a subsequent decline in the level of consciousness, follow-up brain imaging may also be advised at 24 to 48 hours15. The primary and preferred imaging method for evaluating traumatic brain damage is CT of the brain (Lolli et al., 2016).

5.4 Advantages and Limitations

In the emergency setting of traumatic brain injury, brain CT represents a rapid, available, safe and invasive imaging modality for early assessment of the cerebral status after head trauma. The majority of monitoring devices and life-support systems may be accommodated and do not prevent access into the CT scanning suite. The remarkable sensitivity of CT brain in these circumstances to show intracranial or extracranial bleeding is one of its key benefits. Additionally, it can depict ventricular size, mass effect, and bone fractures. Bone fractures and radiopaque foreign substances can be seen more clearly on a CT scan than they can on an MRI scan (Zhang et al., 2019).

In less than 10 minutes, serial sections from the vertex to the base of the skull may be reliably acquired using CT imaging, which is a quick modality. Modern CT scanners offer narrower slices (1–2.5 mm) for examination of suspected orbital, skull base, or maxillofacial fractures. The diagnostic yield is increased by the high-quality three-dimensional pictures that multi-slice CT scans also offer. When traumatic brain damage is present, CT scans are evaluated on various levels and in different windows, and the interpretation is done at workstations. In these acute circumstances, intravenous contrast injection is not utilized to simulate or conceal underlying bleeding. The CT results can be performed and interpreted quickly and accurately thanks to these procedures (Akbarzadeh et al., 2021).

However, there are a number of drawbacks when doctors utilize the CT brain as the only imaging technique to assess patients with traumatic brain injury. The biggest drawback is the low sensitivity of CT scans in detecting several lesions associated with head injuries, including minor cortical contusions, hypoxic insults, and diffuses axonal damage. These non-hemorrhagic lesions are not sensitively detectable by CT scans. Plain X-rays and MRI scans are two more imaging methods that have been or are still used to diagnose traumatic brain injury. Adults with head injuries were once evaluated with simple skull X-rays. Plain films, on the other hand, have been shown to be poor indicators of intracranial diseases. On rare circumstances, it can depict serious disorders (Coles et al., 2007).

Only when neurological abnormalities cannot be explained by the CT findings is an MRI scan carried out. While MRI is recommended in situations of subacute or chronic traumatic brain damage, CT scan is the modality of choice for individuals with acute traumatic brain injury. With regard to non-hemorrhagic lesions, tiny extra-axial collections, subarachnoid hemorrhage, and brainstem lesions, MRI has the benefit of being more sensitive than CT23. Additionally, it improves the visibility of white matter lesions, diffuse axonal stress or damage, and cortical contusions27. Normal MRI scans and CT imaging, on the other hand, are not sensitive to tiny micro-hemorrhagic foci (Alfageeh et al., 2018).

6. Conclusion

Imaging plays an essential role in the management of patients with stroke and severe head injury. In the case of acute head trauma, CT is the imaging method of choice because it allows for the precise diagnosis and subsequent treatment of vascular injuries, hydrocephalus, mass effect, and extra- and intra-axial hemorrhage. CT is effective in identifying secondary injuries as well, making it crucial for follow-up. Despite the absence of structural brain damage on CT, individuals with significant neurological impairment are only allowed to have MRI in the acute situation . Almost all head injuries require immediate brain imaging, with the exception of those considered low risk (normal neurological evaluation, no concussion, and no sign of a skull fracture). The imaging technique of choice for evaluating head injuries immediately is CT. It benefits from being rapid, safe, readily available, practical in emergency situations, and sensitive to the majority of acute post-traumatic lesions. CT scans are able to identify a wide range of skull fractures, including compound and depressed fractures, as well as epidural, subdural, subarachnoid, parenchymatous, and intraventricular hemorrhages as well as a number of subsequent problems, including brain edema and herniation. The primary drawbacks of CT scans are their axonal damage, hypoxia insults, and insensitivity to non-hemorrhagic lesions. However, it remains the diagnostic investigation of choice in patients with acute head injury.

Imaging is critical to the survival of the patients in light of the clinical significance of stroke and the benefits of early intervention. Although MRI provides superior diagnostic sensitivity for nonhemorrhagic contusions and shear-strain injuries, CT is still the standard for TBI imaging in the acute situation. Both CT and MRI may be used to predict clinical outcomes, and sophisticated applications of both methods are of special interest since they may significantly increase the sensitivity of traditional CT and MRI for both the diagnosis and prognosis of TBI. In excluding cerebral bleeding, MRI is more reliable, while MRI with DWI is more accurate in identifying acute ischemic stroke. However, CT is favoured in the majority of healthcare settings because to its accessibility and quicker acquisition time. Understanding the early symptoms of a stroke and creating quick, easy, and practical imaging tools might help us improve the results and lessen the impact of stroke. The CT Head Rule appears to be accurate and dependable in the minor head trauma recommendations currently available. Clinicians can thus be sure that patients with modest head injuries would benefit from CT imaging. When CT imaging is unavailable or a choice about moving patients to a facility with better equipment needs to be made, it is very helpful. This rule has several implementation challenges, and subsequent research should pinpoint solutions for these as well as more potent ways to translate information.

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