ORIGINAL ARTICLE

A REVIEW OF SERIAL BRAIN CT IN PATIENTS WITH TRAUMATIC BRAIN INJURY: A TERTIARY CARE EXPERIENCE

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ABSTRACT

BACKGROUND: Traumatic brain injury (TBI) remains a significant cause of neurological morbidity and mortality. The annual incidence of head injury in Pakistan has been estimated as 50/100,000 population based on data from public sector hospitals. Studies based on routine follow-up CT imaging have shown that approximately 20% to 50% of patients with TBI will develop progressive hemorrhagic injury (PHI). **OBJECTIVE:** To identify and study the importance of serial brain CT brain imaging in Traumatic Brain Injury (TBI) and analyze their evolution to redefine treatment strategies for trauma research in our region. **MATERIALS AND METHODS:** It is a retrospective study analyzing head trauma patients presenting to our emergency department over a period of six months between July and December 2016 in Liaquat National Medical College and Hospital, Karachi. Out of 468 patients, 202 patients were followed up and their data was recorded. **RESULTS:** Out of all the causes, road traffic accidents (RTA) was most common cause 125 patients (61.8%). The most frequent age group affected was between the age of 31-50 years. Intraparenchymal contusions (IPC) was the most frequent CT finding found in 78.7% of the patients and the least common finding was pneumocranium only 10.8%. On follow up studies, out of the 202 patients, 54 of them had significant increase since their last control CT and the remaining 148 had either stable or resolution in their findings. Patients with moderate GCS (≥9-12), intraparenchymal contusion (IPC) and subdural hematoma (SDH) were the common factors that were found to contribute to progressive hemorrhagic injury (PHI). **CONCLUSION:** The results of our study suggest that follow up imaging after TBI allows for more suitable patient care, like the facilitation in identifying this specific group of patients and warranting change in their treatment plan, either conservative or surgical. This will result in a potentially favorable outcome.

Keywords: Accident, Contusion, CT scan brain, Head trauma, Traumatic brain injury (TBI)

Introduction

Throughout the world, traumatic brain injury (TBI) remains a significant cause of neurological morbidity and mortality. It is also estimated that more than 1.7 million head injuries are encountered in the USA alone. The incidence of TBI has been estimated as more than 600 per 100,000 cases by WHO, leading to about 90 per 100,000 admissions in the US hospitals.[1] Such an impact is much worse in developing countries where illiteracy, negligence and frequent delays in acquisition of medical attention exacerbate the course and sequelae. Unfortunately, the data available on epidemiology of TBI in our region is scarce.[2] The annual incidence of head injury in Pakistan has been estimated as 50/100,000 population based on data from public sector hospitals.[3] These victims are frequently males in their most productive years of lives, and often the bread winners for their families. Additionally, the magnitude of problem is readily underestimated because of under reporting and poor record keeping.[2]

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The development of computed tomography (CT) in the 1970s revolutionized the management of severe brain injury by allowing rapid and accurate assessment. The value of CT scanning in patients with even minor head injury and trauma is well established. The use of CT scanning has become a standard part of the initial evaluation for most patients with head trauma. Our institution has always understood its importance and was the first in the region to have a dedicated EMI CT brain scanner. Currently we use a multi-slice CT scanner.

Although the use of CT imaging for the initial evaluation of head injury has been firmly established, the indications for follow-up imaging are not yet well defined. Studies based on routine follow-up CT imaging have shown that approximately 20% to 50% of patients with TBI will develop progressive hemorrhagic injury (PHI). Based on these findings, it has been suggested that routine follow-up CT should be obtained for all patients so early intervention can be facilitated and secondary brain injury can be minimized.[4] However, routine use of repeat CT imaging can expose patients to radiation risks, overtax limited resources and increase the cost of medical care. Transport of critically ill patients from the intensive care unit (ICU) in routine follow-up imaging is often with consequence.

The objective of the study is to identify and study the pattern of TBI and their evolution in serial CT scans in order to improve treatment strategies and enhance trauma research in our region.

Material and Method

This is a retrospective study analyzing trauma patients over a period of 6 months between July and December 2016 in Liaquat National Hospital and Medical College which is amongst a few tertiary care hospitals in Karachi, Pakistan. The study was approved by the ethical review board. A total of 468 patients presenting with head injury to our major trauma center and only those that were followed after 48 hours (n=202) were included in the study. In our hospital patients of all ages are first seen by emergency medicine have a head trauma protocol. We applied the Canadian CT head rules (Fig. 1)[20] for deciding whether take a CT scan for all head trauma patients. If there is no need for imaging, we sent the patients home with caution. If there is need for neuroimaging, then we sent patients for a head CT scan and referred the patient to a neurosurgeon.[5]

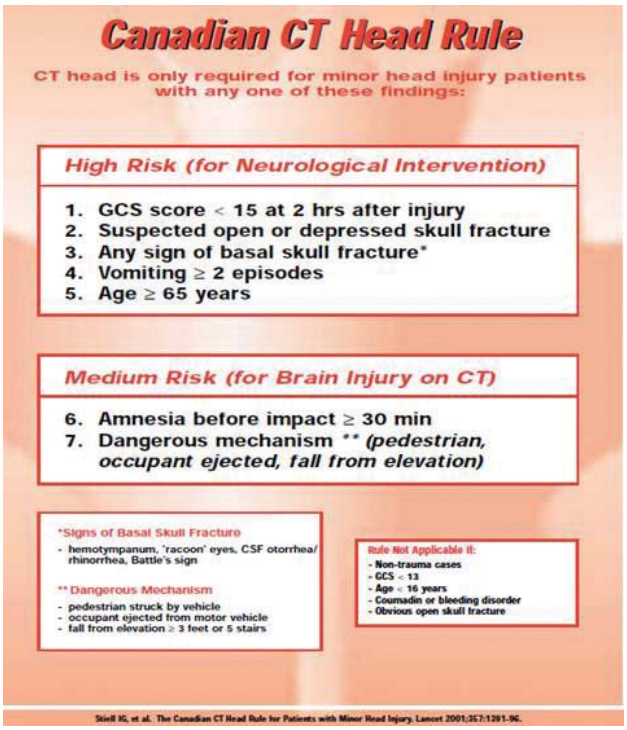


Figure 1:

The relevant findings were recorded on a self-designed questionnaire after informed consent from the patients or their attendants in cases where patient s Glasgow coma scale (GCS) was low. Results from the CT scan were categorized either as subarachnoid hemorrhage (SAH), intraparenchymal contusion, pneumocranium, extradural hematoma (EDH) or subdural hematoma (SDH).

Inclusion criteria

Patients of traumatic brain injury any year of age who were subjected to two or more CT scans of the brain. Patients were followed for 48 hours their initial and last scan was recorded. The decision of repeat scan was taken by the treating neurosurgeon.

Exclusion criteria

Patients who were taken up for surgery based upon the findings of the first CT scan

Patients who were discharged or who expired after

the first CT scan

Those on anti-coagulants or having a bleeding disorder[6]

Previous history of head trauma

The **indications** for repeating the CT scan were specified:[6]

1. First CT scan done less than 6 h after trauma.
2. Patient showing neurological deterioration during the course of management after the first CT scan. Neurologic deterioration was defined as a change in neurologic examination.[7]
3. A decrease in GCS score from admission for more than 1 hour, an acute change in pupillary examination, an increase in intracranial pressure (ICP) for more than 1 hour, or sudden appearance of symptoms attributable to head injury (headache, vomiting, dizziness, visual disturbance).

The neurosurgical team were then queried to analyze whether repeat CT scan was obtained on a routine basis or after a neurologic deterioration of the patient Patients who did not show any clinical deterioration- repeat CT was done within 48 hours regardless.

The outcome variables were

Type of brain injury

Presence or absence of intra / extra-axial pathology

The change was recorded for each scan

Observation and Results

A total of 202 consequent head injury patients with 2 or more CT scans were studied. 138 were male. The mean age at time of presentation was 38.66 years. Road traffic accidents (Fig. 4) was the most common cause of trauma (125, 61.8%) followed by fall from height (68, 33.6%) and assault (7, 3.5%).

Of all 202 patients, 33 were ≤16 years old (pediatric age group) in which 18 were males and 15 females. Rest were adults (n=169) where males were predominant 120 in number (Fig. 3) and there were 49 females.

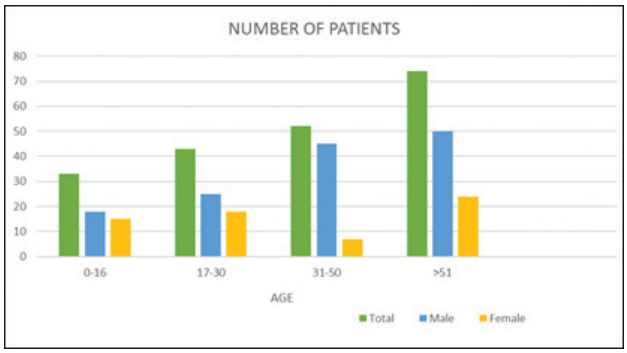
Most of the patients at the time of presentation had mild TBI (85, 42%) followed by moderate (64,31.6%) and severe (53,26.2%) according their GCS. (Fig. 7)

They were admitted in neurosurgery wards for observation of worsening neurological status and

Modality or Sequence	TBI Indication	Recommendation
Noncontrast head CT	First-line test for acute mid, moderate, and severe TBI	Class I
Noncontrast head CT	Repeat assessment in acute TBI with neurologic determination	Class I
Noncontrast head CT	Judicious use in pediatric mild TBI	Class I
Noncontrast head CT	Repeat assessment of mild TBI with negative initial NCCT results	Class III
CTA of the brain	Suspected vascular trauma	Class IIa
Brain MRI without contrast	Acute or subacute TBI when initial or follow-up NCCT is negative with unexplained neurologic findings	Class I
T2* and SWI MRI sequences	Acute early subacute and chronic stages of diffuse normal injury	Class IIa
Brain MRI with contrast	Can aid in visualizing subacute brain contusions	Class IIIb
Advanced neuroimaging*	Mild TBI with negative conventional CT and MRI	Class IIIb

Note: CTA = CT angiography; NCCT = noncontrast CT; SWI = susceptibility weighted imaging; TBI = traumatic brain injury
*Advanced neuroimaging: MRI diffusion tumor imaging, blood oxygen level-dependent functional MRI, MR spectroscopy, perfusion imaging, PET/single-photon emission CT, and magnetoencephalography (discussed in AMJR Am J Neuroradiol 2015-00-000-0000).

Figure 2:



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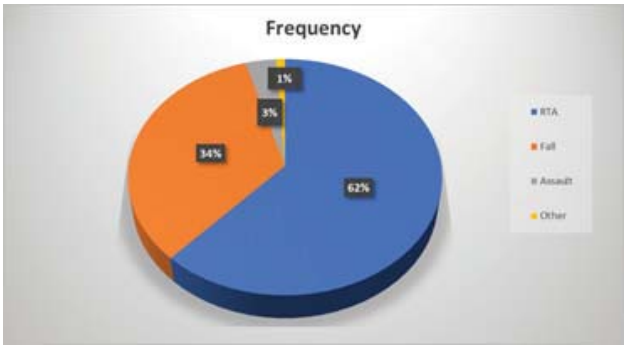


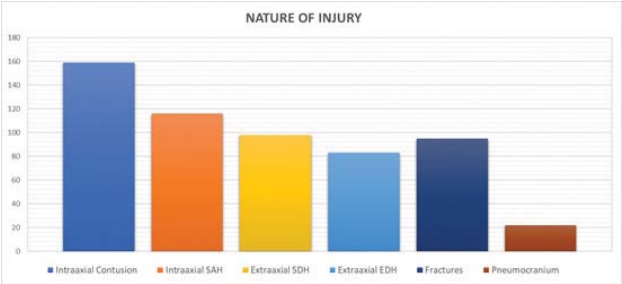
Figure 4:

were evaluated with a repeat CT scan after 24 hours from the time of injury.[8]

The most common CT scan finding seen was intraparenchymal contusion (159, 78.7%) and the least was pneumocranium (22, 10.8%). (Fig. 5)

On follow up, 54 patients (n=26.7%) had significant increase since their control CT, rest of the patients (n=148, 73.2%) had either stable or decrease / resolution on comparison. Intraparenchymal contusion (IPC) and subdural hematoma (SDH) were the common culprits in this increase as we can see in the table. (Fig. 6)

Among all patients with progressive head injury (PHI), 27.7% (n = 15) of those had mild traumatic brain injury (TBI), 57.4% (n = 31) had moderate TBI and severe TBI were found in 14.8% (n = 8)



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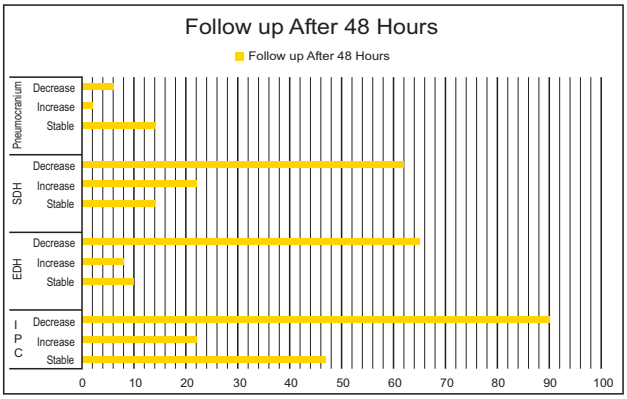

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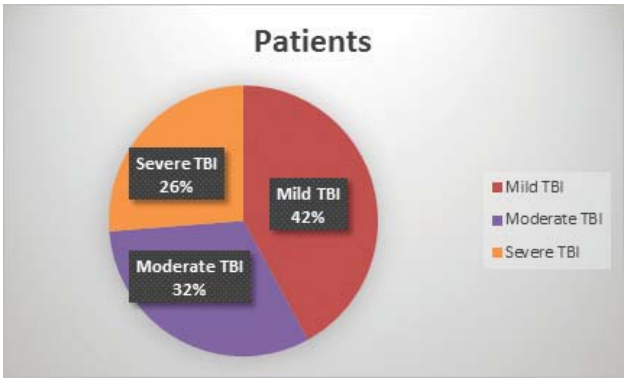

Figure 7:

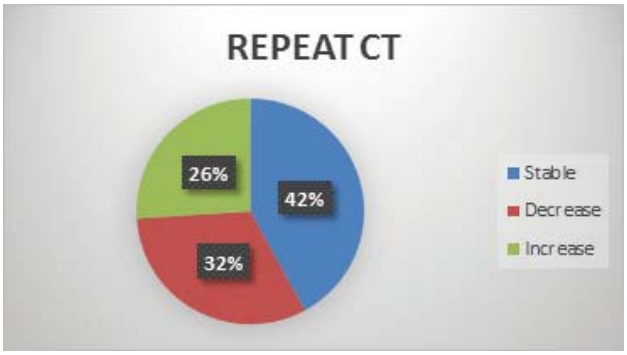

Figure 8:

Discussion

TBI has been a gradually increasing cause of long-term cause of morbidity and mortality particularly among all ages especially young adults. The leading causes of TBI differ according to the age of patients. TBI is classified into two main types: primary and secondary. Primary lesion is a result from the direct effect of trauma. These include contusions, epidural, subdural and subarachnoid hemorrhages and traumatic axonal injuries. TBI can has a steady worsening course and an early diagnosis and timely management are critical to its treatment and therefore CT scan is recognized as the investigation of choice.[8,19] (Fig. 2)

It helps in swift recognition of extra-axial hemorrhage (epidural, subdural and subarachnoid hemorrhage) as well as intra-axial hemorrhage (cortical contusion, intraparenchymal hematoma). Moreover, it also identifies the progression of hemorrhage and helps in identifying any secondary injury. Due to its rapid results, easy availability and sensitivity to hemorrhage, CT scan is now also being used to predict patient s outcome and mortality. Furthermore, all centers routinely perform CT scan in patients with moderate or severe head trauma, while argument continues for its utilization in mild injury.[8]

This study particularly investigated the importance of repeat CT scan and how it plays a role in early management.

We followed almost 202 patients with blunt trauma who had an initially abnormal head CT. Just less than half (43%) underwent a repeat head CT. Overall, 42% of the repeat scans were unchanged with 32% showing an improving radiological course and 26% had progression of injury.

38 % of all the patients with repeat imaging had prompted surgical intervention and out all those identified most of them (88%) had progressive hemorrhagic injury (PHI) Intervention taken up after repeat CT scan was solely based on the neurosurgical team assessment.

The results of our study reinforce what other studies have documented that routine CT scanning (in the absence of any clinical deterioration) after mild TBI had no therapeutic / interventional consequences.[9]

Our study included 85 patients with mild head injury and an injury progression was evident in 27% the

scans. However, this radiographic progression of injury alone did not lead to any surgical intervention.

A similar study published by Velmahos et al. who looked at routine repeat head CT for patients with mild head injury reported that 179 patients who underwent a routine repeat head CT, 21% of them showed injury progression. Overall, 4% of these patients with mild head injury required some type of intervention after repeat CT scan.[10,11]

It is striking to see from our study, that patients with moderate head injury (64%) underwent an intervention after a routine repeat head CT, these results should be viewed with caution. To our surprise more than half (57.4%) of them had Progressive hemorrhagic injury (PHI).

In a recent review, Wang et al. studied the utility of repeat head CT after blunt head trauma and found similar difficulties in drawing conclusions on patients with moderate head injuries. The only reasonable inference that can be drawn with regard to patients with moderate head injury is that they should undergo a repeat CT scan as it leads to an intervention about one-third of the time. Therefore, the severity of brain injury might be an important predictor of progression of injury on repeat CT.[13]

Patients with severe brain injury behaved much differently than did those with mild or moderate head injury. Patients with severe head injury presented with more subdural and intraparenchymal hemorrhages, and more often had multiple abnormalities on initial CT scan.[12]

When patients with severe head injury were taken for a repeat scan after a neurologic change, almost half (43%) of the patients underwent surgical intervention.

The phenomenon of the rise in volume of post-traumatic lesions has been cited in literature under several terms such as traumatic intracerebral hemorrhage, PHI or hemorrhagic progression of a contusion. We used the term PHI as it incorporates all types of traumatic hemorrhagic brain lesions.[8]

Our study has shown that PHI is evident in more than 26 % of the patients with TBI. In the follow up CT scan most frequent were IPC and SDH; 88% of them were consequently required decompressive Surgery. (Fig. 8)

In an earlier study on 37 comatose patients, servadei Et al. identified that 59.5% of their patients had demonstrated PHI on repeat CT scans and they required decompressive surgery. 31.8% of these patients had previously been operated upon and had developed a new hemorrhagic lesion.[14]

In a study involving 142 patients, oertel et al. studied evolution of hemorrhagic lesions after TBI. They concluded that PHI was found in 42.3% patients, most frequently occurring in those with IPC (51.0%). Only 6.6% patients with PHI underwent surgery after the second CT scan. However, their initial CT scan was performed Within (2.0 – 1.6) h and follow-up CT scans were obtained after (6.9 – 3.6) h.[15]

In a retrospective research, al ahmadi and his coworkers assessed patients with IPC who had been admitted in wards for observation and conservative management. They noticed significant progression in 45% subjects, defining them as 30% or more increase in contusion size on CT scan; subsequent decompressive surgery was performed in 19%.[16]

Sifri et al. concluded that hemorrhagic progression of contusion can take place after mild head injury as well with almost half the patients showing expansion in the initial lesion after follow-up CT scan.[17]

We found in our study that PHI can occur with both severe GCS ≤ 8 as well as mild/moderate (GCS > 8) head injury; the larger the initial lesion is, the greater risk of its progression is.[8]

Limitations

This study's findings regarding the changes in GCS score and neurological symptoms to have increased bleeding provides further evidence that this the population that would most benefit from repeat imaging and that those patients absent of such findings may be safe to manage without repeat imaging.

These findings should be viewed in light of some of our limitations in the study. Firstly, we are limited by the retrospective nature of our study. Although a prospective study can provide greater control of variables and a higher level of evidence, preliminary retrospective studies are vital for justifying the feasibility and need for future research.[18]

Second, the small size of our study sample limits our ability to say conclusively that routine reimaging of all patients is not warranted. Also, the size of our study limits our ability to look at other subgroups

including axonal injuries, patient with comorbidities that influence injury progression on CT scan e.g. coagulopathy, hypotension, elevated ICP etc. Significant findings in these subgroups might allow for more specific recommendations when a provider should or should not obtain a repeat head CT.

Third, we are limited by the data available in the hospital records. Ideally, we would like to know what happens to these patients in the long term to differentiate whether or not repeat imaging changes outcomes in long term with blunt TBIs. More research needs to be done to determine if a bleed of a specific type or size requiring repeat imaging.

Finally, increased time between initial & follow up and exclusion of later serial scans. Although timing of a routine repeat CT scan is an issue that has yet to be appropriately resolved. Obviously, a patient s neurologic deterioration will drive the timing of some repeat scans. However, waiting too long could allow patients to deteriorate while awaiting their repeat imaging. On the other hand, a scan obtained too early in the postinjury period might not allow progression of the injury to develop.

Conclusion

Head injury is considered as a Silent epidemic of the post industrialization era by some authors.[2] In our retrospective study of 202 TBI patients, we found the value of routine inpatient follow-up imaging. These results suggest that a selective approach to outpatient imaging after TBI should allow for appropriate patient care like the facilitation in identification for patients requiring change in treatment plan from conservative to surgical, ensuing a potentially better outcome of such patients.[8]

Patients with blunt trauma who sustain a head injury should be stratified by severity of injury to maximize the utility of serial CT scans of the head. Patients with mild head injury (GCS score ≥ 13-15) should not undergo routine repeat head CT, because it does not lead to subsequent surgical intervention. However, after clinical deterioration even those should promptly undergo a repeat CT scan, because an emergent intervention might be required.

The practice of routinely repeating a CT scan need not be individualized and majority have shown progression and will influence management or outcome for patients with moderate head injury. Patients with severe head injury merit a repeat CT scan of the head, either in a routine fashion or after neurologic deterioration. The timing of repeat imaging in patients with head injury of any severity is unclear at this point and should be based upon clinical judgment as well as identified risk factors for progression of injury.

Additional prospective studies are encouraged as they could further refine the appropriate criteria for imaging after TBI while also delivering significant financial and public health benefits.

Authorship

All authors contributed to the design of this study. A.A. conducted the literature search and collected data. A.M. performed data analysis. A.A, M.A.M and A.M. contributed to data interpretation.

All authors participated in preparing, critically revising, and approving the manuscript.

Disclosure

The authors have no conflicts of interest in the manuscript, including financial, consultant, institutional, and other relationships, which might lead to bias or conflict of interest. No funding was received for completion of this work.

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