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Evolving brain lesions in the follow-up CT scans 12 h after traumatic brain injury

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ABSTRACT

Objective: To establish the frequency of evolution in CT appearance from an initial scan to a subsequent scan within 12 h and the prognostic significance of such deterioration.
Methods: All patients who presented to Department of Neurosurgery, Liaquat National Hospital and Medical College with traumatic brain injury and received their CT scan within the first 4 h of injury were included in the study. Indications for repeat CT scan were: any deterioration in neurological status after the initial scan, potentially deteriorating lesion on initial scan with or without worsening neurology, worsening neurological status after the initial CT scan findings, or no neurological improvement after initial management in patients with normal CT scan with significant head injury. This compiled with the data of 107 patients.
Results: There were 67 males and 40 females. The cause of trauma of the 70% patients was road traffic accident. In 11 patients, the lesion evolved towards resorption while 32 patients had no significant changes in the subsequent CT scan. Sixty four patients showed an increase in the size of the lesion and 65.6% of them were required surgical intervention subsequently.
Conclusions: In case where the initial CT scan performed within 4 h of significant head injury was not correlated with the patient's neurology, it should be repeated within 12 h.

1. Introduction

Traumatic brain injury (TBI) often results in enduring mental, physical and behavioral morbidity and mortality, making it one of the most disabling and distressful traumatic injuries [1,2]. Around 10 million people fall prey to it every year around the globe[3]. TBI is classified into primary lesion which results from direct effect of trauma such as hematomas or axonal injuries and secondary lesion which is a consequence of multidimensional biochemical processes, which can lead to cerebral swelling and herniation. Thus, TBI can have a progressively worsening course, which demands best medical and surgical care of cerebral oxygenation, cerebral perfusion pressure and intracranial pressure to improve patients' recovery and prevent secondary injury[3].

The phrase “delayed intracranial haemorrhage” was coined by Doughty in 1938 and became quite well-known after the arrival of CT scan in the 1970s[4]. It is also known as progressive hemorrhagic injury (PHI) and it is now a well-recognized phenomenon with a reported occurrence ranging from 10% to 85% [5–10].

Initial quick assessment and management of acute head trauma requires a CT scan which is a standard investigation for head trauma patients and helps to take decision regarding performances of decompressive surgery or conservative monitoring [11]. There is a common practice to get a sequential CT scan done after a few hours of TBI. However, the literature is inconclusive regarding the timing of repeating the CT scan and some studies have reported against its need in the absence of neurological deterioration[12,13].

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The objectives of this study were to establish the frequency of deterioration in CT appearance from an initial scan to a subsequent scan within 12 h and the prognostic significance of such deterioration.

2. Materials and methods

This was a prospective, observational study during a period of two months (August–September 2012). It was conducted at the Neurosurgery Department of Liaquat National Hospital and Medical College which is amongst a few tertiary care hospitals in Karachi city, Pakistan. The study was also approved by Ethical Review Committee of Liaquat National Hospital and Medical College. All adult patients (aged over 15 years), presented at Accident and Emergency Department with TBI whose CT scan was done within the first 4 h of injury were included in the study. The relevant findings were recorded on a self-designed questionnaire after informed consents from the patients or their attendants in cases where patients' Glasgow coma scale (GCS) was low.

Results from the CT scan were categorized either as subarachnoid hematoma (SAH), intraparenchymal contusion (IPC), extradural hematoma (EDH) or subdural hematoma (SDH). After initial systemic evaluation and management in Accident and Emergency Department, patients were admitted for observation of any neurological deterioration.

Patients with GCS $\leq$ 8 were considered to have severe head injury, those with GCS of 9–12 were classified to have moderate head injury and those with GCS of 13–15 were considered to have mild head injury. A CT scan was repeated after 12 h of the initial CT scan. Indications for repeat CT scan were either deterioration in neurological status after the initial scan, potentially deteriorating lesion on initial scan with or without worsening neurology, much worse neurological status than the initial CT scan findings or no neurological improvement after initial management in patients with significant head injury. This compiled with the data of 107 patients and the CT scan outcome was categorized as a increase (PHI), a decrease (resolution) or no changes in the size of the lesion.

3. Results

Among the 107 patients in our study, 67 were males and 40 were females. The mean age of the patients was 34.88 years (Figure 1).

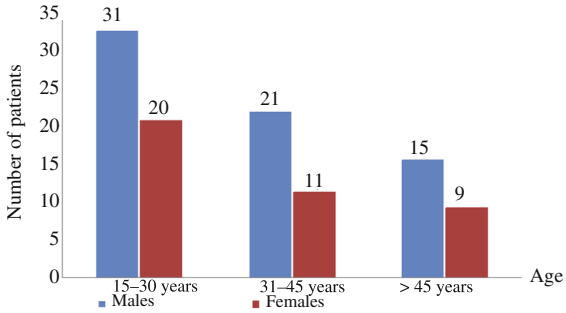

Figure 1. Age of patients with respect to gender.

Seventy percent patients sustained head injury caused by road traffic accident, 17.5% experienced assault, whereas falls were the cause of TBI in 12.5% subjects. The Accident and Emergency Department arrival GCS was 13–15 in 32 (30.0%), 9–12 in 52 (48.5%) and 3–8 in 23 (21.5%) patients. All these patients had their initial brain CT scan performed within 4 h after occurrence of the event (Figures 2 and 3).

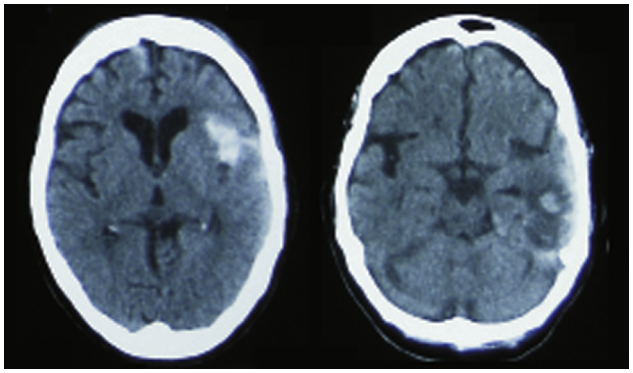

Figure 2. Brain plain CT scan of a middle aged male with road traffic accident showing left temporal contusion and SAH.

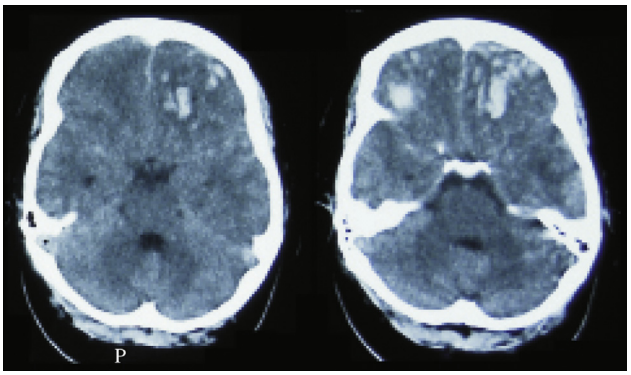

Figure 3. Brain plain CT scan of a young aged female with road traffic accident showing bilateral frontal contusion.

SAH was present in 31 patients, 40 patients had IPC, 22 had EDH and 14 had SDH on CT scan. They were admitted in neurosurgery wards for observation of worsening neurological status and were evaluated with a repeat CT scan after 12 h from the time of injury (Figures 4 and 5). PHI was found in 59.8% patients (n = 64), 10.3% patients showed resolution of their lesions (n = 11) and 29.9% patients showed no changes in lesion on repeat CT scan (n = 32).

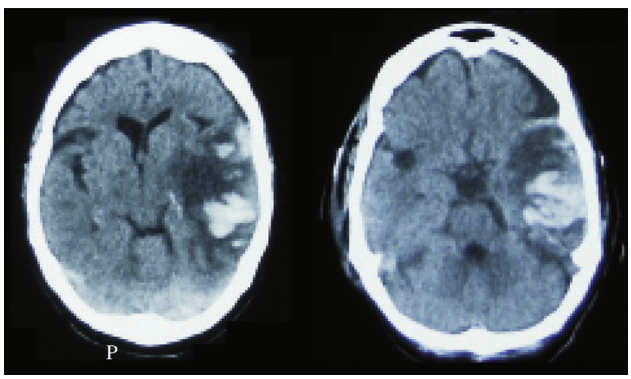

Figure 4. Repeated CT brain showing progression of temporal contusion with significant mass effect causing effacement of left lateral ventricle and midline shift.

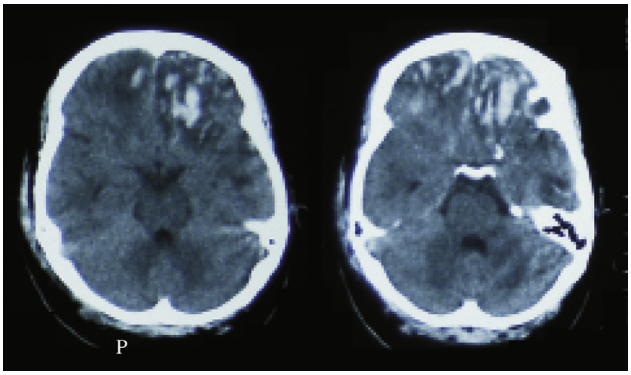

Figure 5. Repeated CT brain showing progression of bilateral frontal contusion.

Among the PHI patients, 22% (n = 14) experienced mild head injury, 59% (n = 38) moderate head injury and 19% (n = 12) severe head injury at arrival. Among those showing resolution of their lesions, 73% (n = 8) had a mild head injury, 18% (n = 2) had moderate head injury and 9% (n = 1) had severe head injury on arrival. Nearly 31% (n = 10) patients with mild head injury, 38% (n = 12) patients with moderate head injury and 31% (n = 10) patients with severe head injury at arrival showed no progression of lesion on repeat CT scan.

Forty five patients later on underwent surgery, and PHI was evident in 93% of them. Of these, 9 patients were those with SAH, 13 had IPC, 15 had EDH and 5 had SDH. Our study concluded that out of 107 cases, PHI was seen in 51.6% of SAH, 62.5% in IPC, 81.8% in EDH and 35.7% in SDH which showed that the increase in size of post-traumatic hemorrhagic lesions was observed most commonly in EDHs (Figure 6). The overall mortality rate was 4.6 (n = 5).

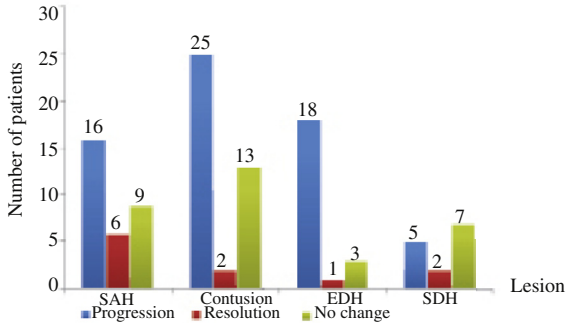

Figure 6. Evolution of lesion on repeat CT scan after 12 h.

4. Discussion

Over the years, TBI has been a progressively increasing cause of long-term disability and fatality particularly among adolescents and young adults[8,14–16]. With a global incidence of 106 per 100 000, it is set to exceed many other serious causes of casualty and disease[16]. The chief causes of TBI differ according to the age of patients. In children aged up to 4 years and adults over 75 years, falls are the foremost cause whereas motor vehicle accidents are the leading cause among teenagers. Other common causes include sports-related injuries, gun-shot and bomb explosion injuries and assaults[3].

TBI is classified into two broad types: primary and secondary. Primary lesion results from direct effect of trauma. These include hematomas (contusions, epidural, subdural and subarachnoid) and traumatic axonal injuries[3].

TBI can have a progressively worsening course and an early diagnosis and timely management are critical to its treatment[17]. In such cases, CT scan is acknowledged as the investigation of choice since it rapidly and precisely recognizes intracranial hemorrhage including extra-axial hemorrhage (epidural, subdural and subarachnoid hemorrhage) as well as intra-axial hemorrhage (cortical contusion, intraparenchymal hematoma and shear injury). It also identifies the evolution of hemorrhage and indicators of secondary injury. Due to its quick results, easy availability and sensitivity to hemorrhage, CT scan is now also being used to predict patients' outcome and mortality[3]. Most centers routinely perform CT scan in patients with moderate or severe head trauma, while debate continues for its utilization in mild head trauma[18–20].

The phenomenon of the increase in volume of post TBI lesions has been cited in literature under various terms such as traumatic intracerebral hemorrhage[7], PHI[8], or hemorrhagic progression of a contusion[21]. We used the term PHI as it encompasses all types of traumatic hemorrhagic brain lesions. Our study has shown that PHI is evident in more than 50% patients with TBI in subsequent CT scan performed 12 h after the initial incident, most often in EDH and IPC, and that 65.6% of them were consequently required decompressive surgery. In an earlier study on 37 comatose patients, Servadei *et al.* identified that 59.5% of their patients had demonstrated PHI on serial CT scans 12 h after admission that required surgical evacuation[22]; 31.8% of these patients had previously been operated upon and had developed a new hemorrhagic, non-contiguous lesion.

In a study involving 142 patients, Oertel *et al.* studied progressive hemorrhagic lesions after TBI[8]. They concluded that PHI was found in 42.3% patients, most frequently occurring in those with IPC, when the initial CT scan was performed within (2.0 ± 1.6) h and follow-up CT scans were obtained after (6.9 ± 3.6) h. Most frequent progression in lesions was evident in IPC (51.0%) while 6.6% patients with PHI underwent surgery after the second CT scan.

Narayan and his associates conducted a prospective study and reported that 50% of the patients who were presented with hemorrhagic lesions 2 mL or larger, suffered augmentation of their initial lesions on follow-up CT scan done 24 h of injury[7]. They also demonstrated that larger lesions were inclined to show more increase in size with time, together with a greater possibility of clinical impact.

Another study conducted on traumatic SAH reported PHI in 58.9% subjects, most often 12–24 h after initial CT scan, with the initial scan done within approximately 1.3 h of trauma[23]. Another study conducted by Servadei *et al.*[24], showed CT evolution after traumatic SAH and demonstrated PHI in 66% patients. In a retrospective research, Alahmadi and his co-workers assessed patients with IPC who had been admitted in wards for observation and conservative management[25]. 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%.

We found in our study that PHI can occur with both severe (GCS $\leq$ 8) as well as mild/moderate (GCS > 8) head injury; the larger the initial lesion is, the greater risk of its progression is. Sifri *et al.*[26], concluded that hemorrhagic progression of contusion can happen after mild head injury as well, with almost half patients showing augmentation in the initial lesion on follow-up CT scan.

Thus, we conclude that PHI is evident in more than 50% patients with TBI within the first 12 h after injury, occurring in all types of cerebral hemorrhages but most often in EDH and IPC. We propose that when the initial CT scan is performed within 4 h of injury, and patients show either deterioration of clinical condition, poor response to management or presence of large IPC or EDH on initial CT scan, then a follow-up CT scan should be performed 12 h after the initial CT scan. This will facilitate the identification for patients warranting change in treatment plan from conservative to surgical, resulting in a potentially better outcome of such patients.

Conflict of interest statement

The authors report no conflict of interest.

References

[1] Umerani MS, Abbas A, Sharif S. Traumatic brain injuries: experience from a tertiary care centre in Pakistan. *Turk Neurosurg* 2014; **24**(1): 19-24.

[2] Krishnamoorthy V, Vavilala MS, Mills B, Rowhani-Rahbar A. Demographic and clinical risk factors associated with hospital mortality after isolated severe traumatic brain injury: a cohort study. *J Intensive Care* 2015; **3**: 46.

[3] Kim JJ, Gean AD. Imaging for the diagnosis and management of traumatic brain injury. *Neurotherapeutics* 2011; **8**(1): 39-53.

[4] Doughty RG. Posttraumatic delayed intracerebral hemorrhage. *South Med J* 1938; **31**(3): 254-6.

[5] Yuan F, Ding J, Chen H, Guo Y, Wang G, Gao WW, et al. Predicting progressive hemorrhagic injury after traumatic brain injury: derivation and validation of a risk score based on admission characteristics. *J Neurotrauma* 2012; **29**(12): 2137-42.

[6] Dunham CM, Hoffman DA, Huang GS, Omert LA, Gemmel DJ, Merrell R. Traumatic intracranial hemorrhage correlates with preinjury brain atrophy, but not with antithrombotic agent use: a retrospective study. *PLoS One* 2014; **9**(10): e109473.

[7] Narayan RK, Maas AI, Servadei F, Skolnick BE, Tillinger MN, Marshall LF, et al. Progression of traumatic intracerebral hemorrhage: a prospective observational study. *J Neurotrauma* 2008; **25**(6): 629-39.

[8] Oertel M, Kelly DF, McArthur D, Boscardin WJ, Glenn TC, Lee JH, et al. Progressive hemorrhage after head trauma: predictors and consequences of the evolving injury. *J Neurosurg* 2002; **96**(1): 109-16.

[9] Kim WH, Lim DJ, Kim SH, Ha SK, Choi JI, Kim SD. Is routine repeated head CT necessary for all pediatric traumatic brain injury? *J Korean Neurosurg Soc* 2015; **58**(2): 125-30.

[10] Tong WS, Zheng P, Xu JF, Guo YJ, Zeng JS, Yang WJ, et al. Early CT signs of progressive hemorrhagic injury following acute traumatic brain injury. *Neuroradiology* 2011; **53**(5): 305-9.

[11] Yuh EL, Cooper SR, Ferguson AR, Manley GT. Quantitative CT improves outcome prediction in acute traumatic brain injury. *J Neurotrauma* 2012; **29**(5): 735-46.

[12] McCammack KC, Sadler C, Guo Y, Ramaswamy RS, Farid N. Routine repeat head CT may not be indicated in patients on anticoagulant/antiplatelet therapy following mild traumatic brain injury. *West J Emerg Med* 2015; **16**(1): 43-9.

[13] Sharifuddin A, Adnan J, Ghani AR, Abdullah JM. The role of repeat head computed tomography in the management of mild traumatic brain injury patients with a positive initial head CT. *Med J Malaysia* 2012; **67**(3): 305-8.

[14] Finnanger TG, Olsen A, Skandsen T, Lydersen S, Vik A, Evensen KA, et al. Life after adolescent and adult moderate and severe traumatic brain injury: self-reported executive, emotional, and behavioural function 2–5 years after injury. *Behav Neurol* 2015; **2015**: 329241.

[15] Bajracharya A, Agrawal A, Yam B, Agrawal C, Lewis O. Spectrum of surgical trauma and associated head injuries at a university hospital in eastern Nepal. *J Neurosci Rural Pract* 2010; **1**(1): 2-8.

[16] Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. *NeuroRehabilitation* 2007; **22**(5): 341-53.

[17] Reljic T, Mahony H, Djulbegovic B, Etchason J, Paxton H, Flores M, et al. Value of repeat head computed tomography after traumatic brain injury: systematic review and meta-analysis. *J Neurotrauma* 2014; **31**(1): 78-98.

[18] Stiell IG, Clement CM, Rowe BH, Schull MJ, Brison R, Cass D, et al. Comparison of the Canadian CT head rule and the New Orleans criteria in patients with minor head injury. *JAMA* 2005; **294**(12): 1511-8.

[19] Kavalci C, Aksel G, Salt O, Yilmaz MS, Demir A, Kavalci G, et al. Comparison of the Canadian CT head rule and the New Orleans criteria in patients with minor head injury. *World J Emerg Surg* 2014; **9**: 31.

[20] Jones LA, Morley EJ, Grant WD, Wojcik SM, Paolo WF. Adherence to head computed tomography guidelines for mild traumatic brain injury. *West J Emerg Med* 2014; **15**(4): 459-64.

[21] Kurland D, Hong C, Aarabi B, Gerzanich V, Simard JM. Hemorrhagic progression of a contusion after traumatic brain injury: a review. *J Neurotrauma* 2012; **29**(1): 19-31.

[22] Servadei F, Nanni A, Nasi MT, Zappi D, Vergoni G, Giuliani G, et al. Evolving brain lesions in the first 12 hours after head injury: analysis of 37 comatose patients. *Neurosurgery* 1995; **37**(5): 899-906.

[23] Fainardi E, Chieregato A, Antonelli V, Fagioli L, Servadei F. Time course of CT evolution in traumatic subarachnoid haemorrhage: a study of 141 patients. *Acta Neurochir (Wien)* 2004; **146**(3): 257-63.

[24] Servadei F, Antonelli V, Giuliani G, Fainardi E, Chieregato A, Targa L. Evolving lesions in traumatic subarachnoid hemorrhage: prospective study of 110 patients with emphasis on the role of ICP monitoring. *Acta Neurochir Suppl* 2002; **81**: 81-2.

[25] Alahmadi H, Vachhrajani S, Cusimano MD. The natural history of brain contusion: an analysis of radiological and clinical progression. *J Neurosurg* 2010; **112**(5): 1139-45.

[26] Sifri ZC, Livingston DH, Lavery RF, Homnick AT, Mosenthal AC, Mohr AM, et al. Value of repeat cranial computed axial tomography scanning in patients with minimal head injury. *Am J Surg* 2004; **187**(3): 338-42.