ORIGINAL ARTICLE

Assessment of Prognosis in Cranio Cerebral Trauma Based on Findings on First CT Scan

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Abstract:

Background: Traumatic Brain Injuries (TBIs) are a leading cause of morbidity, mortality, disability and socioeconomic losses in India and other developing countries. The first Computed Tomography (CT) scan of TBI patient is vital in diagnosing underlying neuroparenchymal injury and also plays a predictive role. *Aim and Objectives:* We intended to correlate features on the admission CT scan of brain that might help in predicting prognosis and survival in patients with head injury. *Material and Methods:* All patients with head injury referred for CT scan of brain were included in the study and evaluated for craniocerebral injury. Patient outcome was measured with Glasgow outcome score at the time of discharge. Results were statistically analyzed to assess feasibility of predicting the prognosis. *Results:* Of the 327 patients who presented exclusively with head trauma, 206 (67.1%) had abnormal CT scans. Patients who had a midline shift had statistically significantly higher mortality. Patients with diffuse axonal injury and burst lobe had a higher mortality rate. The mortality among the patients that had contusions was lower compared to those who did not have contusions. Subdural hematoma, extradural hematoma, intraventricular or subarachnoid hemorrhage did not statistically significantly alter the mortality rate .There was marked increase in the morality rate as the magnitude of midline shift increased. *Conclusion:* Basal cistern effacement, midline shift > 15mm, burst lobe, diffuse axonal injury and herniation are associated with increased mortality. Predicting percentage mortality is especially important as it will help patients' family to have a better insight about the patient's condition and the likely outcome.

Keywords: Traumatic Brain Injuries, Head Injury, Computed Tomography Brain, Prognosis

Introduction:

Traumatic Brain Injuries (TBIs) are a leading cause of morbidity, mortality, disability and socioeconomic losses in India and other developing countries. Road traffic injuries are the leading cause (60%) of TBIs followed by falls (20%-25%) and violence (10%) [1]. In India, more than a million are injured annually and about a lakh are killed in road traffic accidents. It causes the country to lose around 55,000 crores annually which is 2-3% of Gross Domestic Production (GDP) [2]. The spectrum of outcome of TBIs varies from complete recovery to death. The first Computed Tomography (CT) scan of TBI patient is vital not only in diagnosing underlying neuroparenchymal and bony injury but also plays a predictive role. Various classifications systems like the one given by Marshall to the recent 'Rotterdam scoring system' have been applied to assess the prognosis of these patients. In this study, we intended to evaluate features on the admission CT scan of brain that might help in predicting prognosis and survival in patients with head injury. Characteristics of primary injuries to the brain parenchyma in head injury patients on the first CT scan and secondary effects of these injuries on brain parenchyma and their ability to affect the prognosis of such patients were assessed.

Material and Methods:

This prospective study was conducted at our hospital from August 2012 to July 2014. All patients with head injury referred for CT scan of brain were included in the study. Plain CT scan of brain was done on the same day of injury with a slice thickness of 5 mm from C-2 level to vertex, using Hitachi Eclos (Hitachi Corporation, US). Patients with normal and abnormal CT brain were assessed for following features - Primary extracerebral lesions like epidural hematoma (Fig. 1a), subdural hematoma (Fig.1b), subarachnoid hemorrhage (Fig. 1b) and primary intra axial lesions like diffuse axonal injury (Fig. 2 a) and cortical contusions (Fig. 2b) and secondary lesions like cerebral herniation (Fig. 1b), traumatic ischemia, infarction and diffuse cerebral edema. Patients with poly trauma were excluded from the study as mortality and morbidity of these patients were affected by other factors due to multi-system involvement. Patient outcome was measured with Glasgow Outcome Score (GOS) at the time of discharge. Results were statistically analyzed to assess the possibility of prognosticating patients with TBIs, purely on the basis of CT findings. Midline shifts were graded into 3 groups (1-5 mm, 5 - 10 mm and > 10 mm). Basal cisterns were assessed for effacement (Fig.3). Location of extra axial bleeds as well as contusions was assessed, as well as for mass effect. CT was assessed for subarachnoid bleed and diffuse axonal injury. CT was assessed for herniation (subfalcine, transtentorial, and tonsillar). Bone window of the CT scans were assessed for fracture. Outcome at discharge was graded as good / vegetative / death. Appropriate tests of significance were employed and p value (< 0.05) was considered statistically significant. Association between categorical variables was performed using Pearson's Chi Square test (Fisher's Exact in case of 2 x 2 tables). Multivariate analyses and logistic regression were performed to see the effect of a CT finding in presence of the other findings with mortality as the dependent variable.

Results:

Out of the three hundred and seven patients who presented during the period of August 2012 and July 2014 exclusively with head trauma, 206 (67.1%) had abnormal CT. Age of the patients were aged ranged from 17 to 86 years with mean of 40.2+1.5 year. The study sample was predominantly male (87.9%) and females constituted only 12.1%. The duration taken from the time of accident and presenting at the emergency room was twenty minutes to six hours. The mean GCS at presentation ranged from 1 to 15 (9.6+3.1). A patient was considered to have severe head injury if GCS was 8 or less which was observed in 64 patients (20.8 %). Figure 4 shows the major findings on CT along with the number and percentage, with Subdural Hematoma (SDH) (65%), contusions (60.2%) and Subarachnoid Haemorrhage (SAH) (59.7%) being the commonest findings.

Midline shift was observed in 76 (36.9%) cases. This was divided in six categories as in Table 1. Those who had a midline shift had statistically significantly higher mortality ($p < 0.001$) when compared to those who did not (Fig. 5). 57 patients (27%) had effaced basal cisterns and 149 patients (72.3%) had normal cisterns. Mortality rate among the patients who had normal basal cisterns was 8.9% whereas it was 56.4% (n – 31) among those that had effaced basal cisterns.

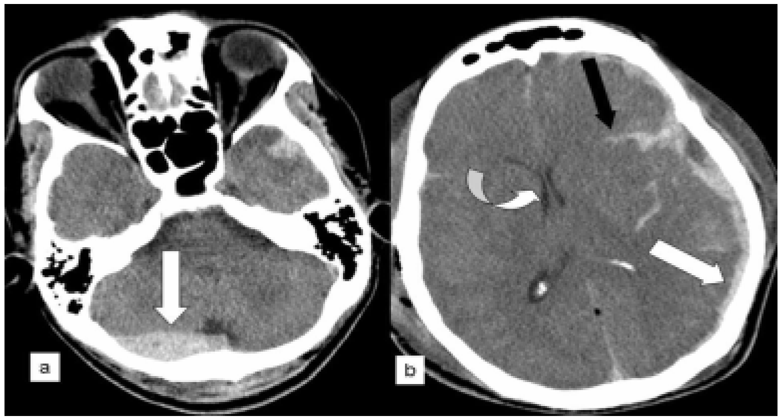

Fig. 1: (A) White Arrow in Axial CT Brain shows Epidural Hematoma in Posterior Fossa

Fig. 1: (B) White Arrow in Axial CT Brain Shows Subdural Hematoma in Left Temporal Region. Black Arrow Shows Subarachnoid Hemorrhage; Curved Arrow Shows Mild Subfalcine Herniation and Midline Shift.

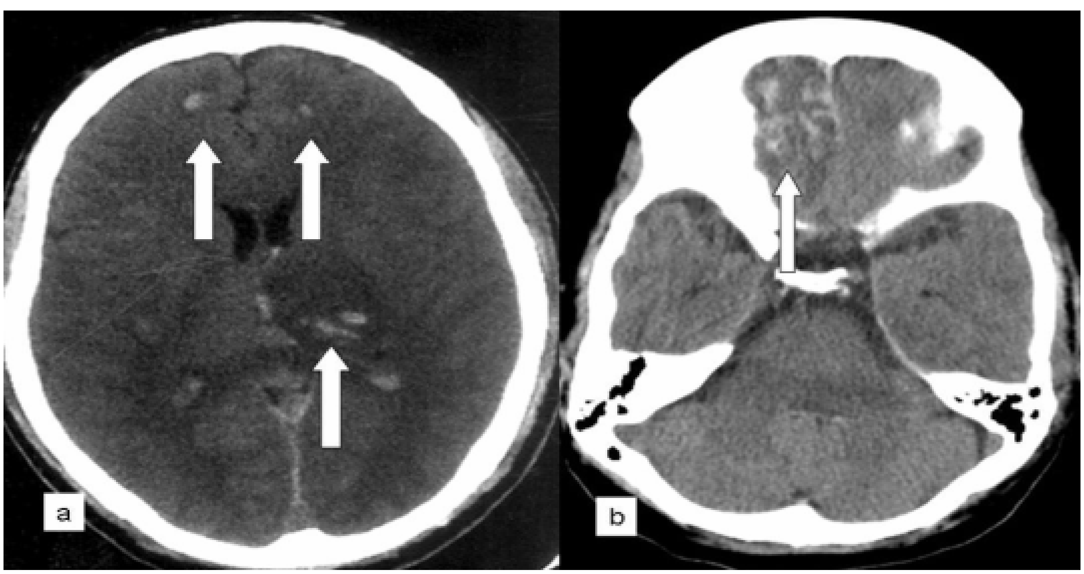

Fig. 2: (A) White Arrows in Axial CT Brain shows Diffuse Axonal Injury

Fig. 2: (B) White Arrow in Axial CT Brain shows Hemorrhagic Contusion In Right Basifrontal Region

Fig. 3: White Arrow in Axial CT Brain Shows Effacement of Basal Cisterns

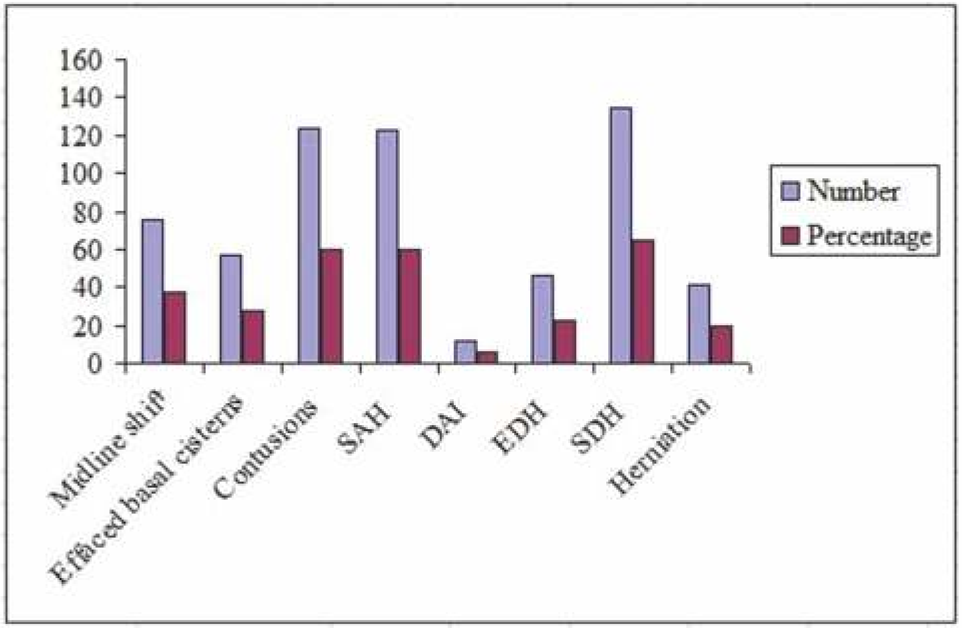

Fig.4: Major Findings on CT Following Head Injury

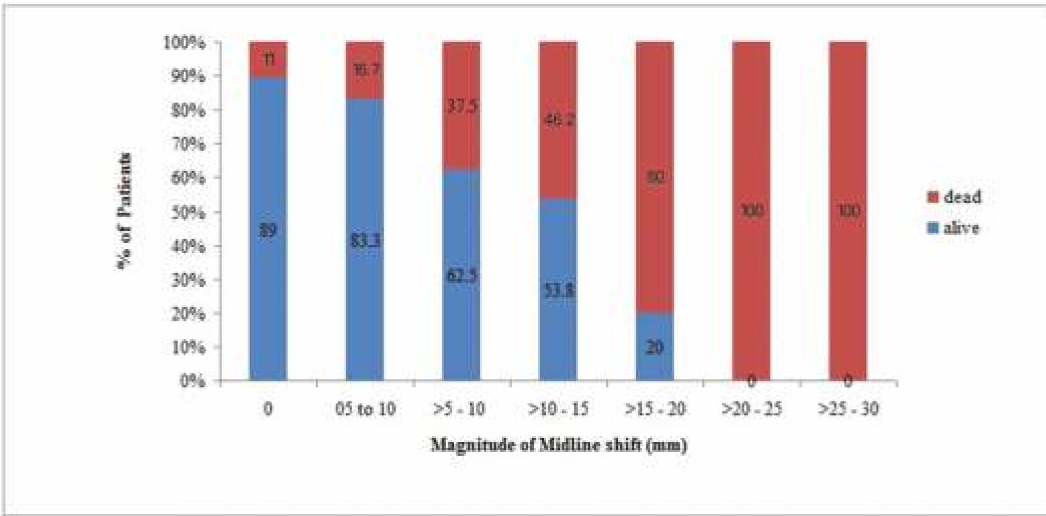

Fig. 5: Correlation between Midline Shift and Mortality

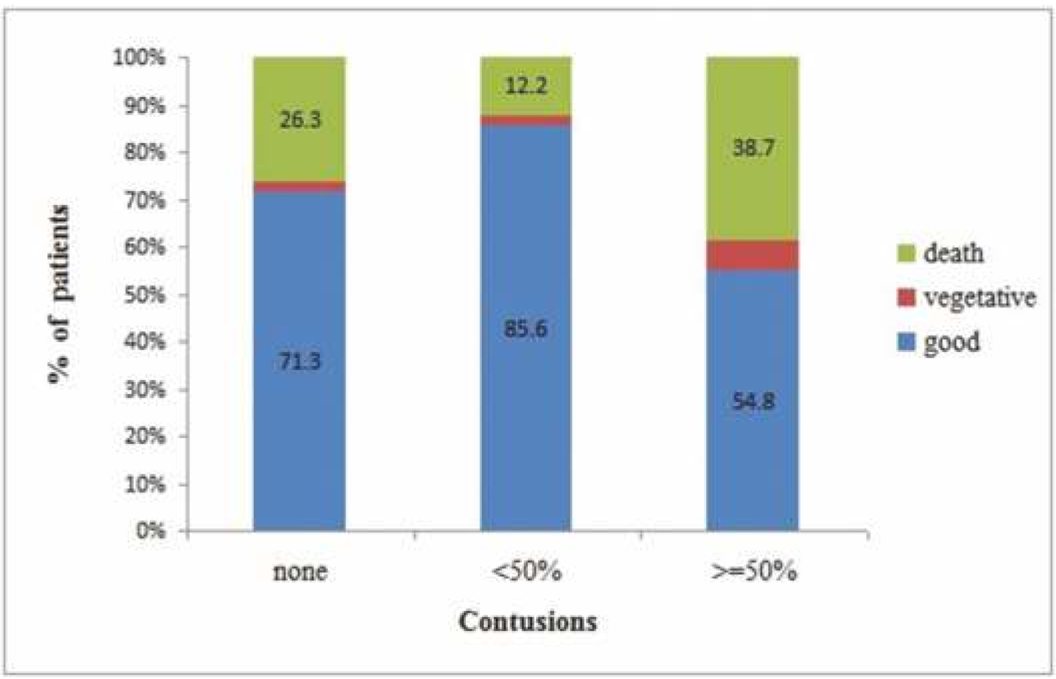

Fig.6: Outcome in Patients with Contusions

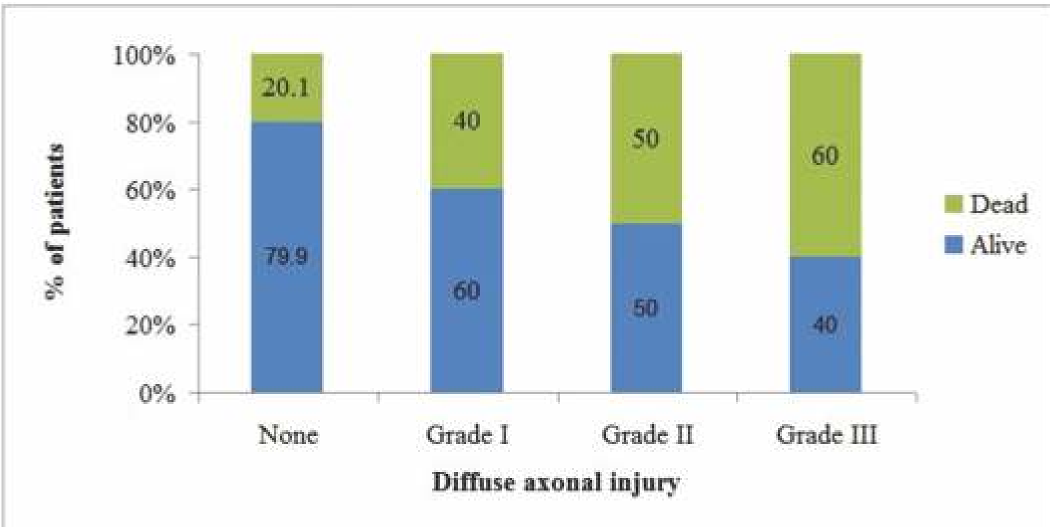

Fig. 7: Outcome in patients with Diffuse Axonal Injury

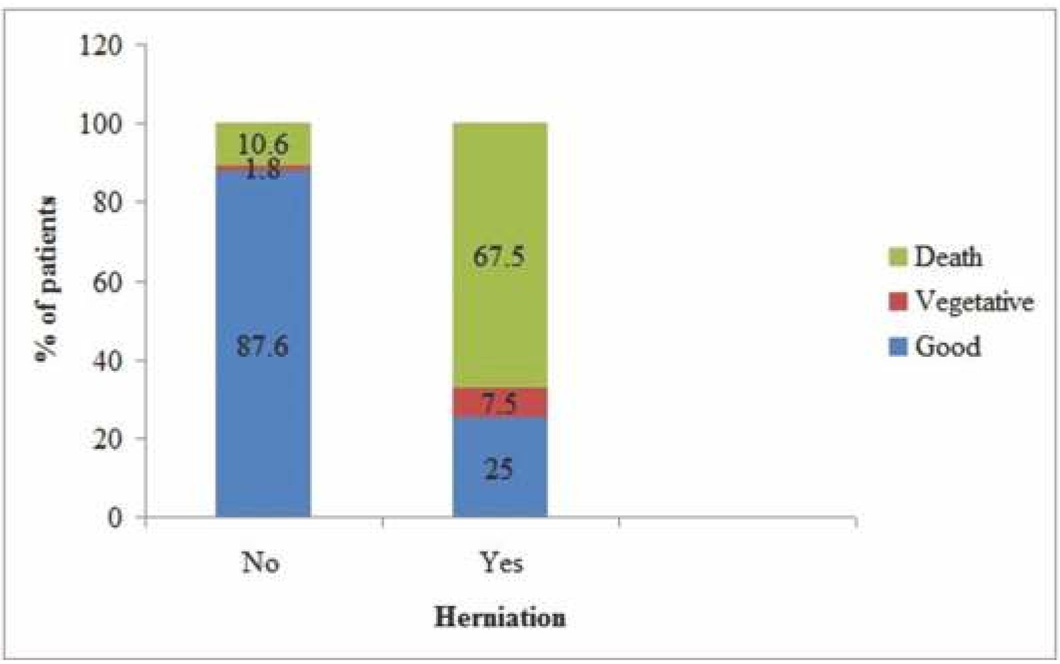

Fig. 8: Outcome in Patients with Herniation

Contusions

Contusions were observed in 124 (60.2%) patients. Among all cases of contusions, the size was of <50% width of the hemispheric width in 75.8%. There was mass effect by the contusions in 43 (35.2%) cases (Table 2). 124 subjects had contusions in 196 locations. One half (50.0%) of the patients had single contusions while the rest had multiple contusions. The location of the contusion involved cerebral and cerebellar hemispheres, basal ganglia and midbrain. There was no statistically significant difference of mortality when one or more contusions were found in the CT scan (p – 0.229). The mortality among the patients who had contusions involving less than and greater than 50% was 12.2 % and 38.7% respectively. Mortality rate in those who did not have contusions was 26.3% (Fig. 6).

Subarachnoid Hemorrhage

Subarachnoid hemorrhage was present in 123 (60, 0%) cases. Intraventricular extension was seen in 23 (18.7%) among those that had subarachnoid hemorrhage. Occurrence of intraventricular bleed or subarachnoid hemorrhage did not statistically significantly alter the mortality rate (p-0.387). When there was intraventricular bleed or subarachnoid hemorrhage, the mortality rate was 24.2% compared to 18.5% when there was none. The difference in the proportions was not strikingly apart to conclude significant association.

Diffuse Axonal Injury

Diffuse axonal injury was observed in 12 (5.8%) of the cases. Five each of them had grade I and III injuries and 2 had grade II injury. There was statistically significant association between presence of diffuse axonal injury and mortality as outcome (p-0.026). The proportion who died among those who had diffuse axonal injury was 50.0% compared to 20.1% among; those who did not (Fig. 7).

Peri-dural Hemorrhages

Extradural hemorrhage was seen in 46 (22.3%) cases. Patients who had extradural hemorrhage had slightly higher mortality (23.2%) compared to those who did not have it (17.4%). There was no statistically significant difference (p-0.543) though, between the mortality rates. 65% of the cases had subdural hemorrhage, of which 12 cases had it in two locations while in one case it was in 3 locations. The mortality rate among those that had subdural hemorrhage was 26.1% compared to 18.6% among those that did not have this condition. There was no statistically significant association between the finding of subdural hemorrhage in a CT and mortality (p-0.195).

Herniation among the Head Trauma Cases

41 patients had herniation with subfalcine herniation being the commonest (21 cases). 25% of these patients had good outcome; 67.5% of the cases ended with death (Fig. 8).

Over all outcome

The outcome of the management was good in 156 (75.7%) cases. Vegetative state/focal neurological deficit was the result in 6 (2.9%) cases. Mortality rate was 21.4% (44 cases).

Table 1: Incidence of Midline Shift on CT Following Head Injury

Midline shift (in mm)	Number
None	130
1-5	30
5-10	17
10-15	14
15-20	10
20-25	4
25-30	1

Table 2: Incidence of Contusions and Mass Effect

Contusions	**Number**	**%**
Yes	124	60.2
No	82	39.8
Contusion size		
<50% of hemisphere width	94	75.8
>50% of hemisphere width	30	24.2
Mass effect		
None	81	65.3
Yes	43	34.7

Discussion:

TBIs are a leading cause of morbidity, mortality, disability and socioeconomic losses in India and other developing countries. Due to widespread availability, affordability and shorter scan time along with superior delineation of bone fractures, CT is preferred over MRI as a primary investigation in cases of TBIs. Assessment of prognosis of traumatic brain injury is one of the neglected areas in research barring a few attempts to create scoring system. The first CT scan of TBI patient is vital not only in diagnosing underlying neuroparenchymal injury but also plays a predictive role. Various classification systems like the one given by Marshall *et al* (1991) [3] to the recent Rotterdam scoring system (2005) [4] have been applied to assess the prognosis of these patients.

As the fate of many patients with head injury is determined at the time of contact, CT scan done at the time of admission is extremely important in assessing the prognosis. In their pioneering work Merino-de Villasante and Taveras have found a direct relationship between number of abnormal CT findings and degree of neurological deterioration [5]. In 1979, Lawrence *et al* have found that the use of more accurate diagnostic criteria not only allows for more homogeneous comparisons but also permits the targeting of treatment for groups known to be at risk based on the clinical examination and initial CT scan [6].In 1983, Lobato *et al* noted that outcome in patients with pure extra cerebral hematomas, single brain contusion, general brain swelling and normal CT is significantly better than patients with extracerebral hematomas plus acute hemispheric swelling, multiple unilateral contusion, multiple bilateral brain contusions and diffuse axonal injuries [7]. In 1995, Greene *et al* have seen that the presence of SAH on CT scans obtained at admission in patients with severe penetrating and non penetrating head injuries have a worse prognosis than the injury alone. They have concluded that, in terms of the contribution to GCS scores at the time of discharge from hospitalization, basal cistern effacement has been the most significant variable in the regression model, followed by thickness of SAH, cortical sulcal effacement, presence of mass lesion(s), and location of SAH [8]. Wardlaw in 2002 has proposed that the overall appearance of CT scan and not the small and subtle injuries that affect the prognosis [9]. In 2005, Mass *et al*, have not only analyzed the existent Marshall classification but also confirmed its predictive value. In addition it was found that better discrimination can be obtained by making fuller use of individual CT characteristics underlying the Marshall CT classification particularly in patients with mass lesions like EDH and SDH. This has been confirmed by an easy to apply Rotterdam computed tomographic score given below was derived after studying a sample size of 2249 [4]. Most of the studies of prognosis of craniocerebral trauma have been from high income countries' population with only few studies from low and middle income countries, where most of the trauma occurs [10].

Epidural hematomas may result from fracture lacerating the middle meningeal artery /dural venous sinus. Subdural hematomas occurring due to stretching, tearing of bridging veins because of sudden change of velocity, are among the most lethal of all head injuries with 50% to 85% mortality in some reported series. Most patients with SDH have low GCS score on admission [11]. Subarachnoid hemorrhage occurring secondary to trauma is seen often in patients with worse outcome [12]. Diffuse axonal injury and cortical contusions represent nearly half of all primary intraaxial TBI. Occurring as a result of axonal shearing forces, axonal injury appear in specific areas like grey white matter interface, corpus callosum, dorsolateral aspect of upper brain stem. Despite profound clinical impairments, only 20-50% with axonal injury has abnormal initial CT examination and is seen as small petechial hemorrhages at the above said locations [13]. Cortical contusions are second most common primary traumatic neuronal injuries. Contusions most commonly involve the inferior frontal lobes and inferolateral temporal lobes and poles [14]. Intraventricular and choroid plexus hemorrhage is seen 1-5% patients of closed head injuries [15, 16]. Most cases have been associated with other manifestations of primary intraaxial brain trauma. Prognosis is poor although patients with isolated intraventricular hemorrhage have somewhat better outcome [16].

In our prospective study, which has included 307 patients with exclusive head injury, the CT findings which have been statistically significant to indicate mortality in the multivariate scenario were basal cistern effacement (p-0.012), herniation (p-0.004), diffuse axonal injury grade I (p-0.040) and grade III (0.028). A patient with basal cistern effacement had 5.0 times the risk of mortality relative to those that did not have it. Diffuse axonal injury (Grade III) posed the highest risk (RR - 13.3) of death, followed by Grade I, which had a relative risk of 9.4. Herniation had 5.8 times the risk of mortality compared to those that did not have herniation. There was statistically significant association between basal cisterns and the mortality ($p<0.0001$). Mortality rate among the patients with non effaced basal cisterns was 8.9% whereas the same was 56.4% (n-31) among those that had effacement of basal cisterns. Vegetative state was found more (7.3%) among patients with basal cistern effacement compared to those who did not have it (1.4%). The patients with effaced basal cisterns have had 5.4 times the risk of mortality relative to those without.

There has been a statistically significant ($p<0.0001$) higher mortality (67.5%) among the cases with herniation compared to those without herniation (10.6%). There has been higher (7.5%) incidence of vegetative outcome among the herniated cases. The mortality rate has been 40.5% among those with a midline shift as compared to 11% among those without a shift. Similarly vegetative outcome has been higher (5.4%) among the patients with midline-shift. The magnitude of the midline shift and mortality has been studied. There has been a marked increase in the morality rate as the magnitude of midline shift increased, and this increase was statistically significant ($p<0.0001$). Mortality has been 80 % in those with midline shift of 15-20 mm and 100 % in patients with midline shift >20 mm making this a strong predictor of mortality.

Variables like peridural bleeds and contusions with SAH did not stand out in the statistical analysis. Careful observation of these facts reveals that it's the 'effect ' that is produced by primary traumatic lesion that also affects the mortality.

Conclusion:

In our study, following factors on baseline CT scan have been noted to affect patient mortality adversely. If basal cisterns are effaced there is > 50 % chance of mortality. Midline shift > 15mm is associated with mortality as high as 80 % and 100% if it is >20 mm. Prognosis of diffuse axonal injury worsens with its grade, with grade 3 having 60 % mortality. Herniation is associated with close to 70 % mortality. The predicted percentage mortality gives a better insight about the patient's condition and the likely outcome to the patient's family which is vital especially in case of financial constraints. These factors should definitely be taken into consideration before deciding expensive therapeutic options.

References

1. Gururaj G. Epidemiology of traumatic brain injuries: Indian scenario. *Neurol Res* 2002 ; 24(1):24-8.
2. Pathak SM, Jindal AK, Verma AK, Mahen A. An epidemiological study of road traffic accident cases admitted in a tertiary care hospital. *Med J Armed Forces India* 2014; 70(1):32-5.
3. Marshall F, Bowers Marshall S, Klauber MR, Van Berkum Clark M, Eisenberg HM, Jane JA *et al*. A new classification of head injury based on computerized tomography. *Journal of Neurosurgery* 1991; 75, S14-S20.
4. Maas AI, Hukkelhoven CW, Marshall LF, et al. Prediction of outcome in traumatic brain injury with computed tomographic characteristics: a comparison between the computed tomographic classification and combinations of computed tomographic predictors. *Neurosurgery* 2005; 57(6):1173–1182.
5. Merino-de Villasante J, Taveras JM. Computerised tomography (CT) in acute head trauma. *AJR* 1976; 126:765-778.
6. Marshall FL, Gautilie T, Klauber MR, Eisenberg HM, Jane JA. The outcome of severe closed head injury. *J Neurosurg* 1991; 75(suppl):s28-s36.
7. Lobato RD, Cordobes F, Rivas JJ, de la Fuente M, Montero A, Barccna A et al. Outcome from severe head injury related to the type of intracranial lesion: A computerized tomography study. *J Neurosurg* 1983; 59:762-774.
8. Greene KA, Marciano Fs Johnson BA, jacobowitz R, Spetzler RF, Harrington TR. Impact of traumatic subarachnoid hemorrhage on outcome in nonpenetrating head injury. Part I: A proposed computerized tomography grading scale. *J Neurosurg* 1995; 83:445-452.
9. Wardlaw JM, Easton VJ, Statham P. Which CT features help predict outcome after head injury? *J Eurol Neurosurg Psychiatry* 2002; 72(2):188-92.
10. Deepika A, Prabhuraj AR, Saikia A, Shukla D. Comparison of predictability of Marshall and Rotterdam CT scan scoring system in determining early mortality after traumatic brain injury. *Acta Neurochir (Wien)* 2015; 157(11):2033-8.
11. Wilberger JE, Harris M, Diamond DL. Subdural hematoma: morbidity, mortality and operative timings. *J Neurosurg* 1991; 74:212-218.
12. Mattioli C, Beretta L, Gerevini S, Veglia F, Citerio G, Cormio M, Stocchetti N. Traumatic subarachnoid hemorrhage on the computerized tomography scan obtained at admission: a multicenter assessment of the accuracy of diagnosis and the potential impact on patient outcome. *J Neurosurg* 2003; 98(1):37-42.
13. Kelly AB, Zimmerman RD, Snow RB, Gandy SE, Heier LE, Deck MD. Head trauma. Comparison of MR and CT - Experience in 100 patients. *AJNR* 1998; 699-708.
14. Adams JH, Scott G, Parker LS, Graham DI, Doyle D. The contusion index: a quantitative approach to cerebral contusions in head injury. *Neuropathol Appl Neurobiol* 1980; 6(4):319-24
15. Lee JP, Lui TN, Change CN. Acute posttraumatic intraventricular hemorrhage, analysis of 25 patients with emphasis on final outcome. *Acta Neurol /Scand* 1991; 84:89-90.
16. LeRoux PD, Hagiundi MM, Newell DW *et al*. Intraventricular hemorrhage in blunt head trauma: An analysis of 43 cases. *Neurosurg* 1992; 31:678-685.

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