Effects of Computerized tomography scan features on outcome of traumatic brain injuries

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Background: ***Computerized tomography (CT) scan is the image modality of choice in acute traumatic brain injuries. It helps in identifying urgent surgical emergency lesions. We assessed the effect of computerized Tomography scan features on the functional outcome of traumatic brain injury patients managed in our center. The objective was to determine CT scan features that could predict outcome in traumatic brain injury patients.***
Methods: ***It was a prospective observational study carried out on our patients with traumatic brain injuries who did CT scan of the brain. Data were collected using structured proforma which was component of our prospective data bank that was approved by our ethics and research committee. The data were analyzed with Environmental Performance Index (EPI) info 7 software.***
Results: ***There were 173 patients whose CT scans were studied. One hundred and thirty five were males. The mean age was 30.61years. One hundred and thirty patients were involved in road traffic accident. Status of mesencephalic cistern, intra-ventricular hemorrhage, midline shift, and diffuse axonal injuries were significant predictors of functional outcome.***
Conclusion: ***Some CT scan features such as the status of mesencephalic cistern, midline shift, diffuse axonal injury, predicted outcome in our patients.***

Keywords: CT scan, traumatic brain injury, outcome.

Introduction

Traumatic brain injury is responsible for up to 45% of in-hospital trauma mortality.[1]Quick decision taking is essential in treating these patients. CT scan is the imaging modality of choice. It is cheap, fast to perform and readily available[2] It reveals urgent surgical emergency lesions[3] and helps in admission decision making.[4]Many CT scan characteristics such as basal cistern status,[5]midline shift,[6,7] traumatic subarachnoid hemorrhage[8,9,10] and intraventricular hemorrhage[11] predicted outcome. We prospectively studied the brain CT scan features of our patients and their relationships to outcome.

Methods

It was a prospective, observational study of traumatic brain injury patients managed in our center from August 2010 to July 2014. It was carried out on those who did CT scan of the brain.The patients were managed using our protocol for head injury: advance trauma life support protocol in accident and emergency, investigations, definitive treatment (conservative or surgery) and follow up of the patients in the out-patient clinic. Data were collected using structured proforma which was part of our prospective data bank that was approved by our hospital's ethics and research committee. Data collected included biodata, clinical findings (history and physical signs, including Glasgow Coma Score after resuscitation), CT scan of brain features (extradural hematoma, subdural haematoma, intracerebral hematoma/contusions, fractures, cerebral edema, intraventricular hemorrhage, subarachnoid hemorrhage, number of lesions, midline shift, mesencephalic cistern status, diffuse axonal injury features),treatment modalities (surgery or conservative), and Glasgow Outcome Scores (GOS) [12] three months post-injury. It had been found that GOS at three months post-injury predicted long term outcome.[13] In getting our CT scan findings, we did not apply time limit bearing in mind that up to 50% of CT lesions were observed to progress [14,15]. In patients with multiple CT scan, different findings were added to the first CT findings. Studies found that the worst CT scan obtained during the clinical course had greater predictive values [16, 17].

We did not pay much emphasis on subdural hematoma because of its age bias (common at both extremes) and its correlation to midline shift. We used midline shift as continuous variable parameter[18]. Subarachnoid haemorrhage and edema were scored if they were the only lesion seen or dominant lesion in multiple lesions. The data collected were analyzed using Environmental Performance Index (EPI) info 7 (Center for Disease Control and Prevention, Atlanta, Georgia, USA, EPI info 7 version 7.0.8.0 of 2011). At 95% confidence interval, $P \leq 0.05$ was considered significant.

Results

One hundred and seventy three patients were studied. There were 135 males and 48 females. Their mean age was 30.61years and their age ranged from one year to 76 years. Age group 20-< 30 had highest frequency (55), (Table 1). The commonest cause was road traffic crash (RTC), 75.14% (Table 2). Status of mesencephalic cistern was a strong predictor of outcome, $P = 0.004$, (Table 3). Midline shift also predicted outcome, $P = 0.0306$, (Table 4). Twenty eight had diffuse axonal injuries. Twenty of them had severe head injury, six moderate and two mild head injuries. All of them were involved in road traffic accident. Eight (28.57%) had skull fracture. Four patients (100%) who died from diffuse axonal injuries had severe head injury. Diffuse axonal injury was strong predictor of outcome, $P = 0.0015$ (Table 6).

Table 1. Age Distribution

Age	Frequency	Percentage
0 - < 10	18	10.40
10 - < 20	16	9.25
20 - < 30	55	31.79
30 - < 40	40	23.12
40 - < 50	24	13.87
50 - < 60	9	5.20
60 - < 70	6	3.47
70 - < 80	5	2.89
Total	**173**	**100**

Table 2. Distribution of Causes.

Aetiology	Frequency	Percentage
assault	16	9.25
fall	20	11.56
Gun shot	4	2.31
others	2	1.16
RTA	130	75.14
sports	1	0.58
Total	173	100

Table 3. Mesencephalic Cistern vs GOS

Mesencephalic cistern	Glasgow Outcome Score				
	1 (%)	3 (%)	4 (%)	5 (%)	Total (%)
Normal	6 (4.96)	0 (0.0)	13 (10.74)	102 (84.30)	121 (100)
Partially effaced	6 (12.77)	2 (4.26)	9 (19.15)	30 (63.83)	47 (100)
Totally effaced	2 (40.00)	0 (0.0)	1 (20.00)	2 (40.00)	5 (100)
Total	14 (8.09)	2 (1.16)	23 (13.29)	134 (77.46)	173 (100)
P = 0.004					

Table 4. Midline shift vs GOS

Midline shift	Glasgow Outcome Score				
	1 (%)	3 (%)	4 (%)	5 (%)	Total (%)
Yes	8 (14.29)	2 (3.57)	6 (10.71)	40 (71.43)	56 (100)
No	6 (5.13)	0 (0.0)	17 (14.53)	94 (80.34)	117 (100)
Total	14 (8.09)	2 (1.16)	23 (13.29)	134(77.46)	173 (100)
P = 0.0306					

Intraventricular hemorrhage was also a predictor of outcome, *P* = 0.0128, (Table 5).

Table 5. Intraventricular hemorrhage vs GOS

Intraventricular hemorrhage	Glasgow Outcome Score				
	1 (%)	3 (%)	4 (%)	5 (%)	Total (%)
Yes	2 (50.00)	0 (0.0)	1 (25.00)	1 (25.00)	4 (100)
No	12 (7.10)	2 (1.18)	22 (13.02)	133 (78.70)	169 (100)
Total	14 (8.09)	2 (1.16)	23 (13.29)	134 (77.46)	173 (100)
P = 0.0128					

Table 6. Diffuse axonal injury vs GOS

Diffuse axonal injury	Glasgow Outcome Score				
	1 (%)	3 (%)	4 (%)	5 (%)	Total (%)
Yes	4 (14.29)	1 (3.57)	9 (32.14)	14 (50.00)	28 (100)
No	10 (6.90)	1 (0.69)	14 (9.66)	120 (82.76)	145 (100)
Total	14 (8.09)	2 (1.16)	23 (13.29)	134 (77.46)	173 (100)
P = 0.0015					

Table 7. Number of lesions vs GOS

Number of lesions	Glasgow Outcome Score				
	1(%)	3(%)	4(%)	5(%)	Total(%)
0	1(5.88)	0(0.00)	0(0.00)	16(94.12)	17(100)
1	1(2.04)	0(0.00)	4(8.16)	44(89.80)	49(100)
2	7(13.73)	0(0.00)	6(11.76)	38(74.51)	51(100)
3	1(7.69)	0(0.00)	1(7.69)	11(84.64)	13(100)
4	0(0.00)	1(7.69)	3(23.08)	9(69.23)	13(100)
>4	4(13.33)	1(3.33)	9(30.00)	16(53.33)	30(100)
Total	14(8.09)	2(1.16)	23(13.29)	134(77.46)	173(100)
P = 0.0167					

Subarachnoid hemorrhage did not predict the outcome, *P* = 0.1862. The higher the number of lesions seen, the worse the outcome, *P* = 0.0167 (Table 7}.

All 20 patients with extradural hematoma (conservatively and surgically treated), had favorable outcome of GOS ≥ 4. Of interest were two patients with hemiparesis who did CT scan some days after the accident. Their CT scans showed subacute extradural hematoma of about 1.5cm in diameter. Because of their improving neurological status they were managed non-operatively. Three weeks after the accident, they had favorable recovery and repeat CT scan showed the haematomas had resorbed. Another interesting finding was a 21 year old girl that was involved in road traffic accident who presented with headache. Her Glasgow Coma Score was 14/15. Her CT scan showed bilateral acute subdural hematomas of about 1.2cm each. There was no midline shift. She was managed non-operatively with close monitoring. The headache gradually resolved over two weeks. She became fully conscious third week. Repeat CT scan showed the hematomas had resorbed. All patients with edema (14) had favorable outcome. Eighteen patients (10.40%) did not have any CT finding. Fourteen of them had mild head injury while four had moderate head injury. One patient (5.56%) among those without CT finding died from complications of musculoskeletal injuries while 17 patients had GOS score of five.

Discussion

In our study, majority of the patients were males. Road traffic crash was the commonest etiology of traumatic brain injury. The highest frequency was in the 20-40 years old age group. They were part of active work force of our nation trying to make ends meet for them and their families. In high unemployment developing countries like ours this group resorts to commercial motorcycle, tricycle and vehicle driving with majority not adequately trained and had poor knowledge of road safety rules. These have been documented by many authors [19, 20, 21].

In our study, we found midline shift, intraventricular hemorrhage, effacement of mesencephalic cistern, number of lesions, and diffuse axonal injuries as CT features predicting unfavorable outcome. Traumatic subarachnoid hemorrhage did not predict outcome. In their study of 2269 patients with moderate and severe head injuries, Maas et al [11] found midline shift, basal cistern, intraventricular hemorrhage and traumatic subarachnoid hemorrhage as significant predictors of mortality. Jacobs et al [22] in their study of 605 patients with moderate and severe head injuries found midline shift as significant predictor of outcome. They did not find any cut-off mark in midline shift; rather it was a continuous variable. We did not sign any cut-off number in our study; rather midline shift was a continuous variable. Nelson et al [18] also recommended the use of midline shift as a continuous variable. Many authors have documented the prognostic nature of midline shift [6, 7].

Many authors had shown diffuse axonal injuries to be related to outcome[23, 24] and noted that CT scan showed 20-50% of diffuse axonal injuries. All our patients with diffuse axonal injuries were involved in road traffic accident. Adams et al[25] in their study of 45 patients with diffuse axonal injuries also noted that all were from road traffic crash. Subarachnoid hemorrhage and intraventricular haemorrhage were documented as predictors of outcome by many authors.[8, 26]Jacobs et al [27] in their outcome prediction in mild head injury found number of contusions as significant predictor of outcome. In their study of 605 patients with moderate and severe head injuries, Jacobs et al [22] also found number of lesions as predictor of outcome. Other authors documented similar findings [28, 29.] The prognostic value of basal cistern had been documented by many authors [5,30]. Our findings were similar to the findings of above authors except subarachnoid hemorrhage. This might have been due to our assigning method to only or dominant lesion being subarachnoid hemorrhage. We believed that in lesions in which other lesions dominate, subarachnoid would play secondary role to the dominant lesions.

In our study, all patients with extradural haematoma had favorable outcome. Nelson et al [18] in their study of 890 CT scans, found that extradural hematoma was a positive predictor of outcome. This was also found by other authors [31, 32]. Our zero mortality in extradural haematoma care was in keeping with zero mortality in extradural haematoma as predicted by Bricolo et al [33].

The use of initial or admission CT scan to predict outcome by many authors has some problems. Many authors noted that severe and moderate head injuries were dynamic processes that progress with time [34, 35]. Narayan et al [14] noted that up to 50% of CT lesions were observed to progress after traumatic brain injury (TBI). Lobato et al [36] after their study, recommended that since one third of patients with normal admission CT scan developed new pathology within first few days of injury, a strategy for controlled scanning should be adopted. All these showed that most studies done with admission CT scan might not have been correct.

Many authors found that CT scan is unreliable method for detecting non-hemorrhagic brain injuries especially small contusions in diffuse axonal injuries [2, 37, 38]. Since diffuse axonal injury is an unfavorable outcome predictor and visible only in 20-50% [39], the strength of its prediction cannot be sure of and the effect on other predictors cannot be ascertained.

Future direction

The future of determining the outcome of traumatic brain injuries will lie on combination of CT scan and emerging imaging modalities of Magnetic Resonance Imaging (MRI) such as Susceptibility Weighted Imaging (SWI) and Diffusion Tensor Tractography (DTT) of Diffusion Tensor Imaging (DTI) which can circumvent the problems seen in CT scan.

Conclusion

Our study found that intraventricular hemorrhage, midline shift, diffuse axonal injuries, number of lesions, and status of mesencephalic cistern were negative predictors of outcome. Extradural hematoma was positive predictor of outcome.

Due to inability of CT scan to detect diffuse axonal injuries in large percentage of patients, we feel that CT scan, susceptibility weighted imaging and diffusion tensor tractography combination study will be a better synergistic study in determining outcome of traumatic brain injury patients.

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