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EARLY CT FINDINGS TO PREDICT EARLY DEATH IN PATIENTS WITH TRAUMATIC BRAIN INJURY: MARSHALL AND ROTTERDAM CT SCORING SYSTEMS COMPARED IN THE MAJOR TERTIARY CARE HOSPITAL IN NEPAL

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EARLY CT FINDINGS TO PREDICT EARLY DEATH IN PATIENTS WITH TRAUMATIC BRAIN INJURY: MARSHALL AND ROTTERDAM CT SCORING SYSTEMS COMPARED IN THE MAJOR TERTIARY CARE HOSPITAL IN NEPAL

A THESIS SUBMITTED FOR PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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2012-2015

Dedicated

to

DEPARTMENT OF NEUROSURGERY

ABBREVIATIONS

CT	-	Computerised tomography
DAI	-	Diffuse axonal injury
EDH	-	Extradural hematoma
GCS	-	Glascow coma score
ICP	-	Intracranial pressure
ICU	-	Intensive care unit
IVH	-	Intraventricular haemorrhage
MLS	-	Midline shift
PPV	-	Positive predictive value
TBI	-	Traumatic brain injury
TCDB	-	Trauma coma data bank
TSAH	-	Traumatic subarachnoid haemorrhage

ABSTRACT

Title: EARLY CT FINDINGS TO PREDICT EARLY DEATH IN PATIENTS WITH TRAUMATIC BRAIN INJURY: MARSHALL AND ROTTERDAM CT SCORING SYSTEMS COMPARED IN THE MAJOR TERTIARY CARE HOSPITAL IN NEPAL

Background: In clinical practice, the severity of TBI is generally classified as severe, moderate or mild according to the level of consciousness as measured using the Glasgow Coma Scale (GCS). The increased use of early sedation, intubation and ventilation in more severely injured patients has decreased the value of the full GCS for the purposes of TBI classification, because patients need to be conscious and able to respond verbally. An alternative in such patients is the classification of TBI according to morphological criteria based on computed tomography (CT) investigations. Although TBI can also be classified using magnetic resonance imaging characteristics, which may be more sensitive for detecting small white matter lesions in later phases, CT examination remains the investigation of choice to identify the presence and extent of structural damage in the acute phase.

Aims and objectives: CT plays a crucial role in early assessment of patients with traumatic brain injury (TBI). Marshall and Rotterdam are the mostly used scoring systems, in which CT findings are grouped differently. We sought to determine the scoring system and initial CT findings predicting the death at hospital discharge (early death) in patients with TBI.

Methods: We include consecutive 634 traumatic neurosurgical patients with mild-to-severe TBI from 2013 January to 2014 April. Their initial CT and status at hospital

discharge (dead or alive) were reviewed, and both CT scores were calculated. We examined whether each score is related to early death; compared the two scoring systems' performance in predicting early death, and identified the CT findings that are independent predictors of early death.

Results: Both Marshall and Rotterdam score can be used to predict mortality in patients with traumatic brain injury with high predictive value. Individual CT characteristics that can be used to predict mortality are traumatic SAH, midline shift and status of the cisterns.

Conclusion: We conclude that the Marshall CT classification has strong predictive power, but greater discrimination can be obtained if the individual CT parameters underlying the CT classification are included in a prognostic model. Consequently, for prognostic purposes, we recommend the use of individual characteristics rather than the CT classification. Performance of CT models for predicting outcome in TBI can be significantly improved by including more details of variables and by adding other variables to the models

Keywords: TBI, Marshall Score, Rotterdam score, CT variables, prognosis

CONTENTS

INTRODUCTION

CT scan is necessary not only for diagnosis and management of traumatic brain injury (TBI) but also for prognosis of the patients. Both individual CT scan features and classification system are important for prognosis. Presence of abnormalities, CT classification, compressed basal cisterns, traumatic subarachnoid hemorrhage (tSAH), basal cisternalSAH, extensive tSAH features have Class I and II evidence for >70% positive predictive value (PPV) in TBI. But there are some problems with the previous classifications. They predict death but not functional recovery. Except for Marshall, other classifications have not been independently validated because of the lack of their generalisability. Also who actually read the scans and whether observers were blinded to the clinical status are not clarified. No independent blinded review of the scans was done. Interrater variability in classifying the overall appearance of scans has still to be established .In the trauma coma data bank (TCDB) classification, the categorization of mass lesions (into “evacuated” or “non-evacuated”) depended on knowing what subsequently actually happened to the patient .As patient management could vary between individual neurosurgeons the hematoma categorization might be difficult to apply prospectively to guide management. It does not capture the predictive information in as closely as other parameters like overall appearance of CT scan. It is also not a significant independent outcome predictor in the multivariate model once clinical features are included .There is lack of tSAH, basis of volume of mass lesion as 25 cc is not clear ,does not classify type of hematoma, does not further categorize extent of basal cisterns compression and cannot be used as grading system. Rotterdam CT grading overcomes limitations to some extent.

LITERATURE REVIEW

Traumatic brain injury (TBI) is a common and potentially devastating problem. The classification of TBI is necessary to make accurate diagnoses and predict the outcome, and requires patients to be grouped according to specific characteristics. In clinical practice, the severity of TBI is generally classified as mild, moderate and severe according to the level of consciousness as assessed using the Glasgow Coma Scale (GCS).[1] The increased use of early sedation, intubation and ventilation in more severely injured patients has decreased the accuracy of the full GCS for the purposes of TBI classification, because patients need to be conscious and able to respond verbally.[2-5] An alternative approach such patients is the classification of TBI according to morphological criteria based on computed tomography (CT) scan investigations. Although TBI can also be classified using magnetic resonance imaging characteristics, which is more sensitive for detecting small white matter lesions in later phases,[6, 7] CT scan of head remains the investigation of choice to identify the presence and extent of structural damage in TBIin the acute phase.

Since the introduction of CT scan , the treatment of patients with head injury has improved considerably and it has become a powerful tool for improving clinical care in TBI, significantly reducing both morbidity and mortality.[8, 9] In patients with moderate and severeTBI, the outcome is much better in the absence of intracranial abnormalities.[10] The prognostic value of individual CT characteristics has been well documented, including the status of basalcistern,[11-19]midline shift[13,14,18-23] traumatic SAH[11,13,14,19,22,24-30]and the presence and type of intracranial lesions .[11,14,18,22,31-33]

In 1991, Marshall etal.[34] proposed a CT classification for grouping patients with TBIaccording to multiple CT characteristics. Currently, this CT classification is the

most frequently used tool for prognostication of TBI that incorporates the anatomical nature of the injury in the determination of outcome after acute TBI. The Marshall CT classification uses the findings from CT scans on the status of the mesencephalic cisterns, the degree of midline shift and the presence or absence of local lesions to categorize patients into six different groups. This system allows the identification of patients at risk from deterioration from intracranial hypertension and offers the possibility of early intervention. Since its introduction in 1991, this classification has been increasingly used for predicting outcome, including overall survival, GOS, elevated intracranial pressure (ICP) and neuropsychological consequences. There is a very strong relationship between the Marshall CT classification, mortality and the frequency of elevated ICP.[34] The presence of a midline shift of > 5 mm on the initial brain CT scan and a high or mixed density lesion > 25 cm^3 in volume have both been correlated with early death.[35] The relative risk of requiring a delayed operation has been shown to be related to the Marshall CT classification of initial CT scans (diffuse injury IV, 30.7%;diffuse injury III, 30.5%; non-evacuated mass, 20.0%; evacuated mass, 20.2%; diffuse injury II, 12.1%; diffuse injury I, 8.6%).[36] When studying outcomes at 6 months following trauma using the GOS, Ono et al.[17] found that all diffuse brain injury I patients recovered well. In the diffuse brain injury II group, age, the GCS score and the presence of multiple parenchymal lesions on CT scans significantly correlated with outcome. For the diffuse brain injury III and IV groups, the only significant prognostic factor was the GCS score. In patients with a mass lesion, the GCS score was the only significant prognostic factor in the epidural haematoma group, whereas it was only predictive factors in the acute subdural haematoma group. Outcomes were unfavourable in the majority of patients with intracerebralhaematoma. With regard to the frequency of elevated intracranial

pressure (ICP), Hileretal.[37] reported that the Marshall CT classification correlated significantly but weakly with ICP measured during the first 24 h of monitoring but not with mean ICP over the total time spent in intensive careunit. In contrast, the 6 month Glasgow outcome score (GOS) correlated with the initial CT scan findings. These results all suggest that the Marshall CT scan classification provides accurate predictions regarding the likelihood of a fatal or non-fatal outcome.

Although the Marshall CT classification is an adjunct to clinical parameters and is easy to use, it does not take into account all the possible prognostic factors visible on CT and clearly have some limitations. An important limitation is that the classification is partially based on arbitrary assessments and isdependent on the accuracy of measured volumes of focal mass lesions. Furthermore, TCDB categories V (mass lesion surgically evacuated) and VI (mass lesion not operated)are, in part, retrospective in nature as they depend on the decision to operate or not. Voset et al.[38] evaluated the TCDB CT classification in severe head-injury patients and found that it had a high inter-observer and intra-observer reliability, but suggested that inter-observer agreement could be further improved by considering diffuse injury groups III and IV together and groups V and VI together. In addition, the Marshall CT classification does not take the presence of traumatic SAH into account. Documented traumatic SAH in patients with severe TBI is 23 to 63%.[39]It is most common in patients with subdural haematoma or haemorrhage contusion and is associated with a worse prognosis.[39-41]. Adding SAH to any CT classification system may enhance its predictive power for outcome and may have consequences for treatment and outcome issues, and in clinical trials.[39,40] A number of other CT classifications exist [42,22,43 – 48] but none of these has been as extensively evaluated as the Marshall CT classification.

In 2005, a study by Maas etal.[11] compared alternative CT models with the Marshall CT classification and found it was preferable to use combinations of individual CT predictors rather than the Marshall CT classification for prognostic purposes in TBI. Later, in 2007, Maas etal.[14] again evaluated the prognostic value of CT scan characteristics in TBI and found that individual CT characteristics added substantially to the prognostic value of the CT classification alone. They found that making greater use of individual CT characteristics allowed them to improve on the already sizeable predictive value of the original Marshall CT classification scheme. These findings need to be corroborated through further prospective investigations.

RATIONALE AND OBJECTIVES

CT plays a crucial role in early assessment of patients with TBI. Marshall and Rotterdam are the mostly used scoring systems, in which CT findings are grouped differently. This study soughts to determine the efficacy of the scoring system and initial CT findings in predicting the death at hospital discharge in patients with TBI.

MATERIALS AND METHODS

This study includes consecutive 634 traumatic neurosurgical patients with mild-to-severe TBIadmitted in the Department of Neurosurgery, College of Medical Sciences Bharatpur, Nepal, from 2013 January to 2014 August. Each CT score will be calculated by the resident and consultant on call for the day and then be talliedwith the final score in the rounds.Thisstudy examines whether each score is related to early death; compares the two scoring systems' performance in predicting early death, and identifies the CT findings that are independent predictors of early death. The results will be formatted, calculated and p value willbe assessed using the SPSS 20software.

Table 1: Marshall CT Classification

Category	Definition
Diffuse injury 1 (no visible pathology)	No visible intracranial pathology on CT scan
Diffuse injury 2	Cisterns are present with midline shift of 0–5 mm and/or lesions densities present; no high or mixed density lesion >25 cm3 may include bone fragments and foreign bodies
Diffuse injury 3 (swelling)	Cisterns compressed or absent with midline shift of 0–5mm; no high or mixed density lesion >25 mm
Diffuse injury 4 (shift)	Midline shift >5 mm; no high or mixed density lesion >25 cm3
Evacuated mass lesion	Any lesion surgically evacuated
Non evacuated mass lesion	High or mixed density lesion >25 cm3; not surgically evacuated

Table 2: Rotterdam score system

Predictor value	Score
Basal cisterns	
Normal	0
Compressed	
Absent	
Midline shift	
No or <5 mm	0
Shift >5 mm	1
Epidural mass lesion	
Present	0
Absent	1
Intraventricular blood or tSAH	
Absent	0
Present	1
Sum score	+1

RESULTS

Relationship between Marshall CT scoring and mortality

Table 3 Relationship between Marshall Score and mortality

Marshall score	Mortality		Mortality (%)	Inference
	No	Yes		
1	185	0	0	P <0.001
2	251	0	0	
3	15	10	40	
4	1	0	0	
5	121	28	18.79	
6	1	22	95.66	
Total	574	60		

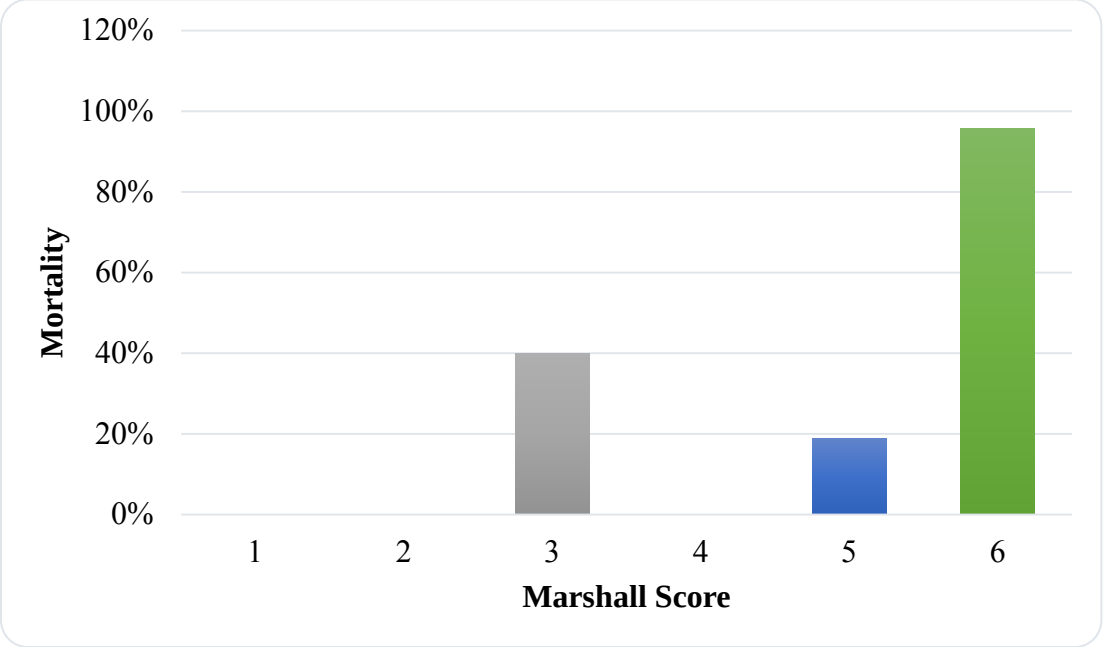

Figure 1: Relationship between Marshall Score and mortality

This signifies the importance of Marshall Score in predicting mortality in the patients with TBI. The mortality in patients with Marshall score 1 and 2 is 0%, for score 3 is

40%, for score 4 is 0%, for score 5 is 18.79% and for score 6 is 95.66%.This clearly proves the value of evacuation of mass lesion (Marshall score 5) in patient with traumatic brain injury in reducing the mortality compared to the patient with compressed cisterns, midline shift and non-evacuated >25mlblood. Also there are minimal patients in the group 4 because most of the patients with midline shift (MLS)are taken up for operative evacuation regardless of the GCS of the patient. The mortality in the patients who had undergone operative evacuation (Marshall score 5),which is the overall operative mortality in cases of TBI is 18.79%. The mortality is highest for Marshall score 6 (95.66%).

Relationship between Rotterdam and mortality of the patient

Table 4 Relationship between Rotterdam score and mortality

Rotterdam score	Mortality		Mortality (%)	Inference
	No	Yes		
1	49	0	0	P <0.001
2	328	0	0	
3	130	8	6	
4	43	23	35	
5	19	22	53.65	
6	5	7	58.33	
Total	574	60		

The mortality in the patient with Rotterdam score 1 and 2 is 0%, for score 3 is 6%, for score 4 is 35%, for score 5 is 53.65% and for score 6 is 58.33%.This proves that higher Rotterdam score in patients with TBI has added risk of mortality.

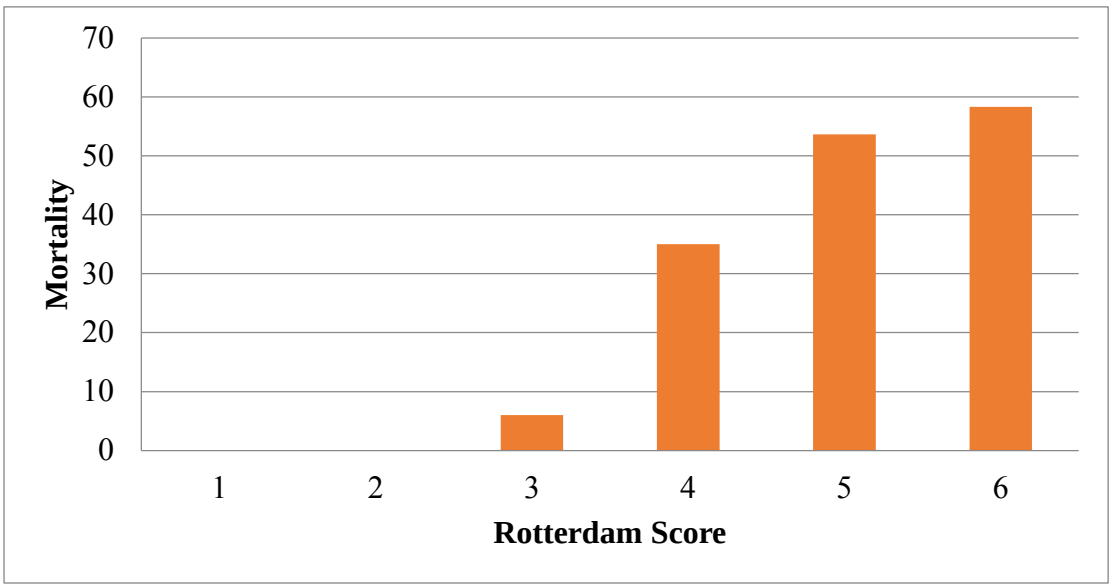

Figure 2: Relationship between Rotterdam score and mortality

This shows positive correlation between increasing Rotterdam score and the respective mortality in the patients with traumatic brain injury in the respective

category. There is similar correlation between the increasing Rotterdam score and the subsequent mortality in the respective patients between us and the study by mass et al.

Table 5 Marshall Score in moderate and severe head injury

Marshall	Mortality		Mortality	Inference
	No	Yes		
1	7	0	0	P < 0.001
2	40	0	0	
3	1	9	90	
4	49	23	31.97	
5	0	21	100	
Total	97	53		

When the Marshall score is adjusted only for the patients with moderate and severe head injury, then the mortality in patients with score 1 and 2 is 0%, for score 3 is 90%, for score 4 is 31.97%, for score 5 is 31.97% and for score 6 is 100%.This also shows that Marshall Score has positive predictive value in predicting mortality in the patients with traumatic head injury.

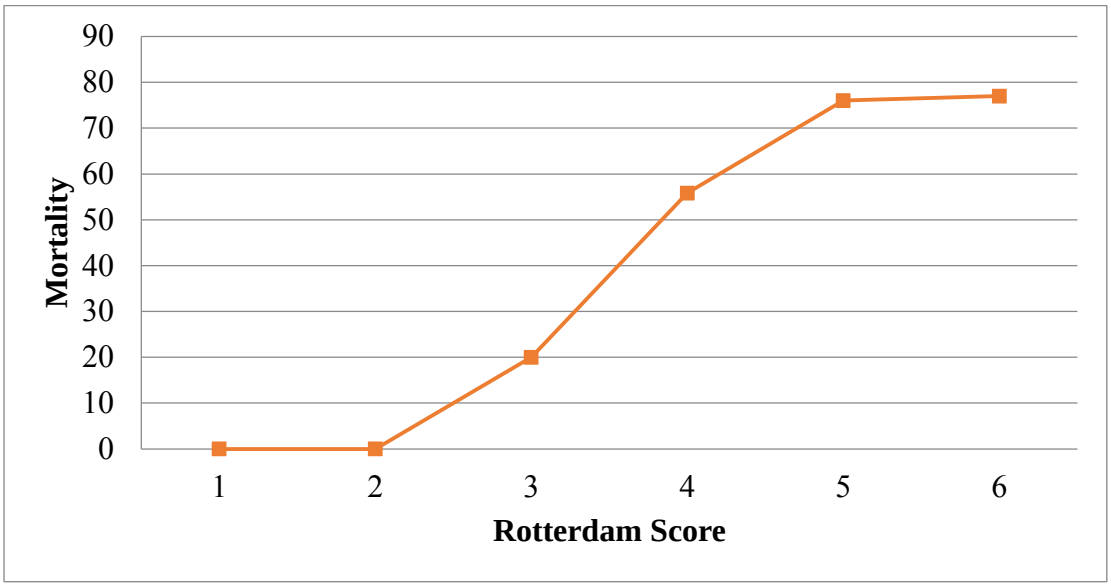

Figure 3:Relationships between Rotterdam score in moderate and severe head

injury

The Rotterdam score adjusted for the patient with moderate and severe head injury shows that the mortality for the patients with score 1 and 2 is 0%, for score 3 is 20%, for score 4 is 55.85%, for score 5 is 76% and for score 6 is 77%.

Table 6 Rotterdam score in moderate and severe head injury

Rotterdam	Mortality		Total
	No	Yes	
1	6	0	6
2	36	0	36
3	32	8	40
4	15	19	34
5	6	19	25
6	2	7	9
Total	97	53	150

Table 7: Correlation between Rotterdam and Marshall CT score

Marshall	Rotterdam						Total
	1	2	3	4	5	6	
1	0	184	1	0	0	0	185
2	46	114	86	5	0	0	251
3	0	0	9	14	2	0	25
4	0	0	0	0	1	0	1
5	3	30	39	40	30	7	149
6	0	0	3	7	8	5	23
Total	49	328	138	66	41	12	634

Relationship between cisternal anatomy and mortality

The mortality in the patients with compressed cisterns is 19.16% and in the patients with absent cisterns is 53.62% in this study. There is no mortality in the patients with normal cisternal anatomy (p value < 0.0001).

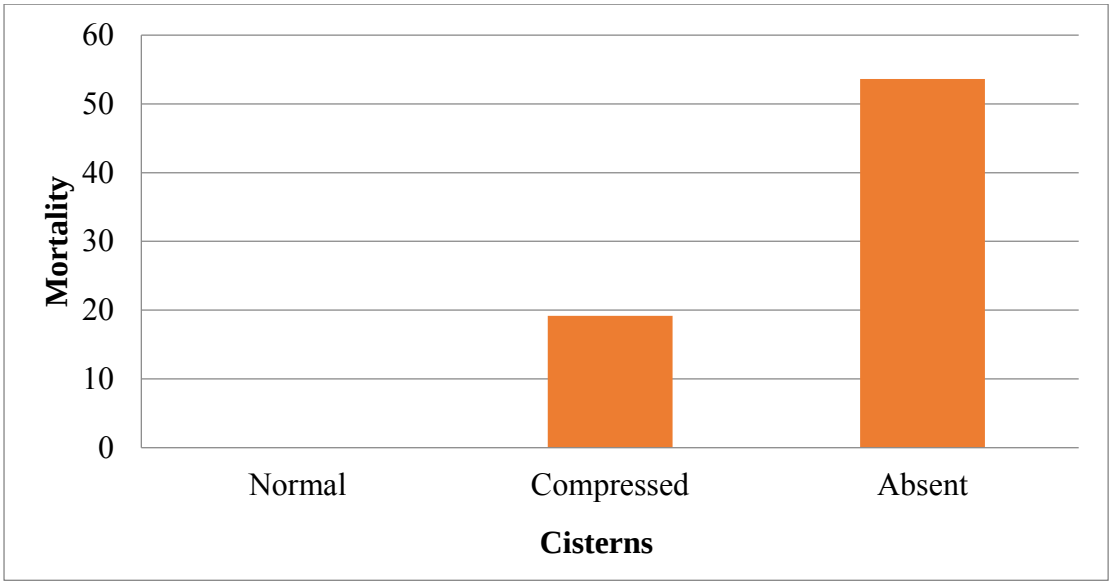

Figure 4: Relationships between status of cisterns and mortality

Table 8 Significance between status of cisterns and mortality

Cistern anatomy	Mortality		Mortality(%)	Inference
	No	Yes		
Normal	445	0	0	P <0.001
Compressed	97	23	19.16	
Absent	32	37	53.62	
Total	574	60		

Relationship between midline shift, traumatic SAH and EDH with mortality

The mortality in the patient with midline shift is 34.31% in this study. Mortality in the patients without midline shift is 4.69% (p value < 0.001).

Table 9 Significance between MLS and mortality

MLS	Mortality		Mortality(%)	Inference
	No	Yes		
No	507	25	4.69	P <0.001
Yes	67	35	34.31	
Total	574	60		

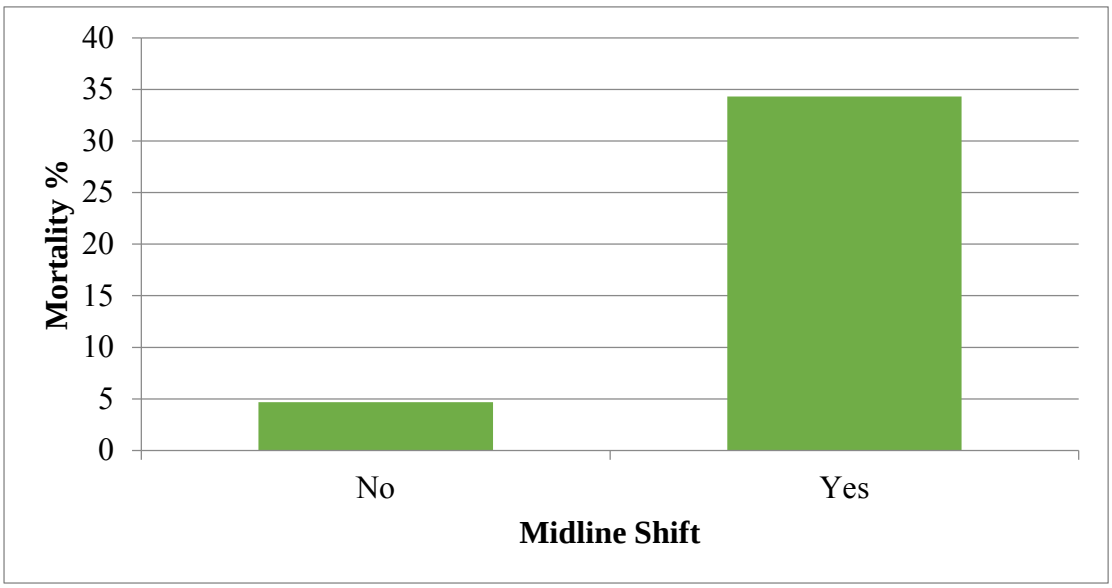

Figure 5:Relationships between MLS and mortality

The incidence of traumatic SAH in this study is 27.12%. The mortality in the patient with traumatic SAH is 16.27% whereas in the patients without SAH it is 6.92% (p value < 0.001).

Table 10: Relation between tSAH and Mortality

tSAH	Mortality		Mortality(%)	Inference
	No	Yes		
No	430	32	6.92	P< 0.001
Yes	144	28	16.27	
Total	574	60		

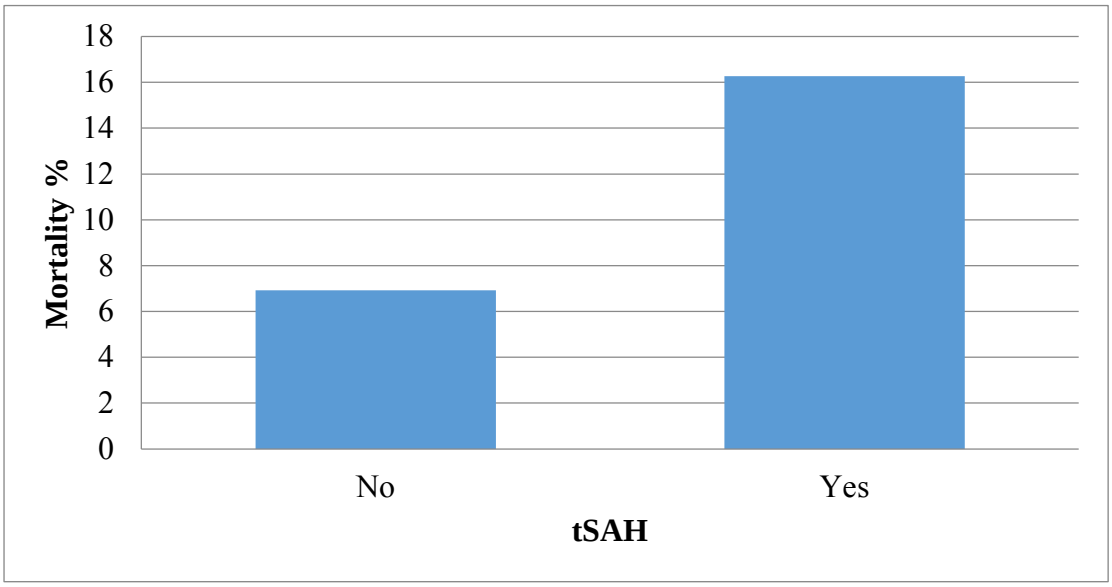

Figure 6: Relationship between tSAH and mortality

The mortality in the patient with EDH is 8.20% and in the patients without EDH is 9.80% (p value 0.576).

EDH	Mortality		Mortality(%)	Inference
	No	Yes		
No	451	49	9.80	P=0.576
Yes	123	11	8.20	
Total	574	60		

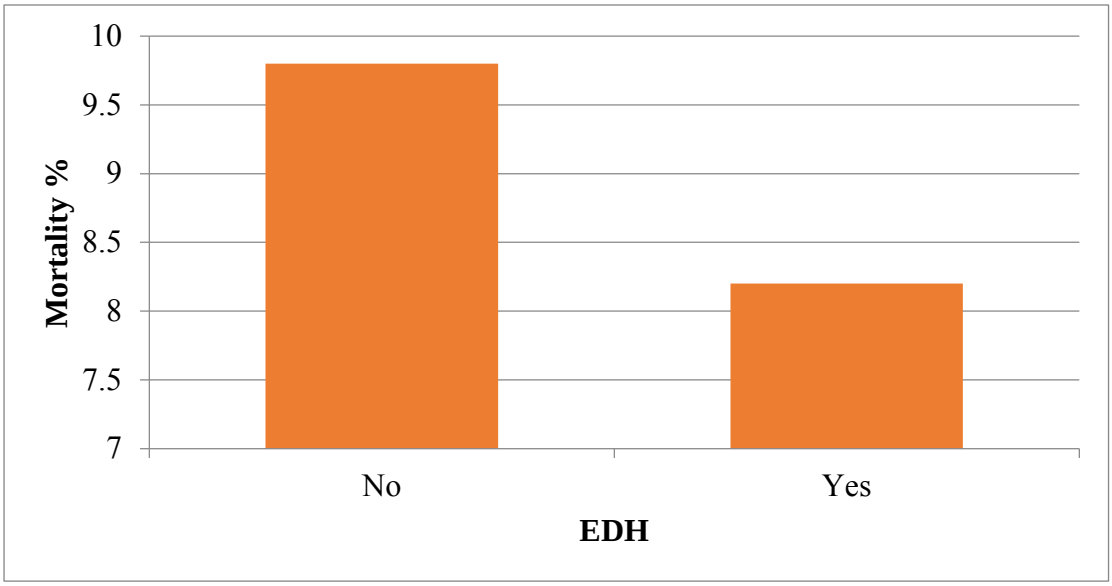

Figure 7:Relationships between EDH and mortality

Relationship between GCS score and mortality

This study is also consistent with the norm that the mortality increases with the increase in the severity of traumatic brain injury(p value < 0.001).The mortality in the patients with mild head injury is 1.44%, in patients with moderate head injury is 14.60% and in patients with severe head injury is 65.57%.

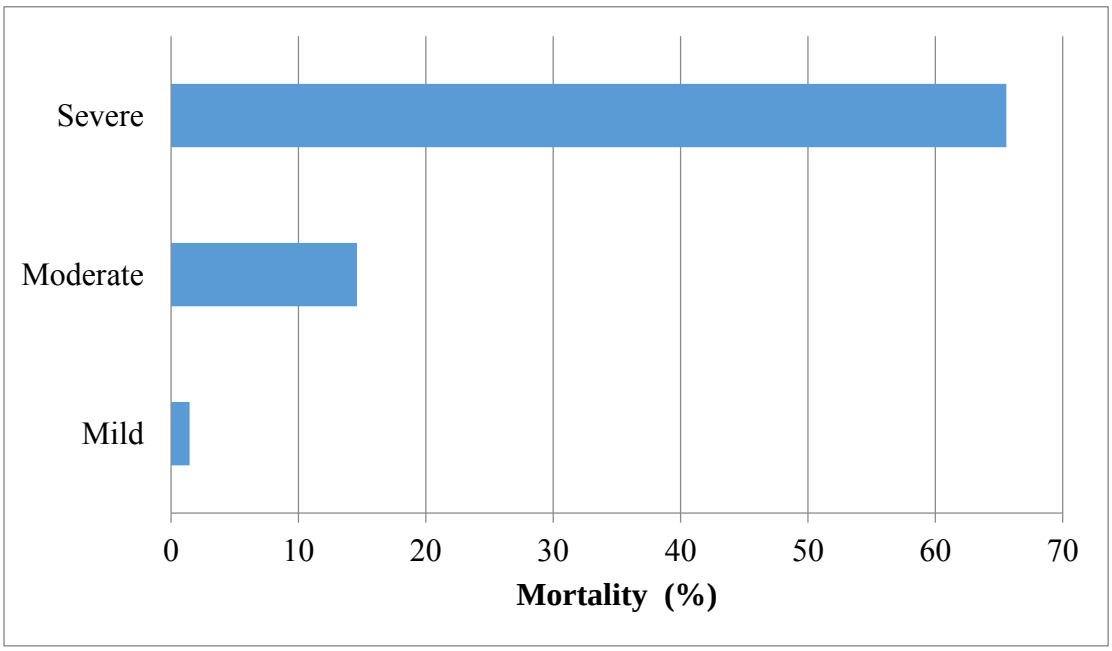

Figure 8: Relationship between GCS score and mortality

Relationship between Age, Sex and mortality

Table 12: Co-relationship between GCS score and mortality

Sex	Mortality		Mortality(%)	Inference
	No	Yes		
Female	161	14	8	P=0.437
Male	413	46	10	
Total	574	60		

This study does not show sexof the patient as a predictor for bad outcome in TBI (p value 0.437).

Table 13: Age category and mortality

Age category (years)	Mortality		Mortality (%)	P value
	No	Yes		
Below 10	121	2	1.62	0.003
10-30	212	19	31.66	
30-50	173	28	46.67	
50-70	54	8	13.34	
70 above	14	3	5.00	
Total	574	60		

This study shows that the mortality is highest in the patients of age group of 30-50 years (46.67%) with p value of 0.003 followed by patients in age group of 10-30 years (31.66%), age group of 50-70 years (13.34%),age group of 70 above (5%) and below 10 (1.62%).

Table 14: Age category among patient with moderate and severe head injury

GCS	Age category (years)					Total
	Below 10	10-30	30-50	50-70	70 above	
Moderate	8	29	36	15	2	90
Severe	5	22	27	4	3	61
Total	13	51	63	19	5	151

Table 15: Mortality among patient in moderate and severe head injury

Age category (years)	Mortality		Mortality (%)	P value
	No	Yes		
Below 10	11	2	3.77	0.118
10-30	36	15	33.77	
30-50	35	28	41.72	
50-70	14	5	12.58	
70 above	2	3	3.31	
Total	98	53		

Table 15:Mortality among patient in moderate and severe head injury

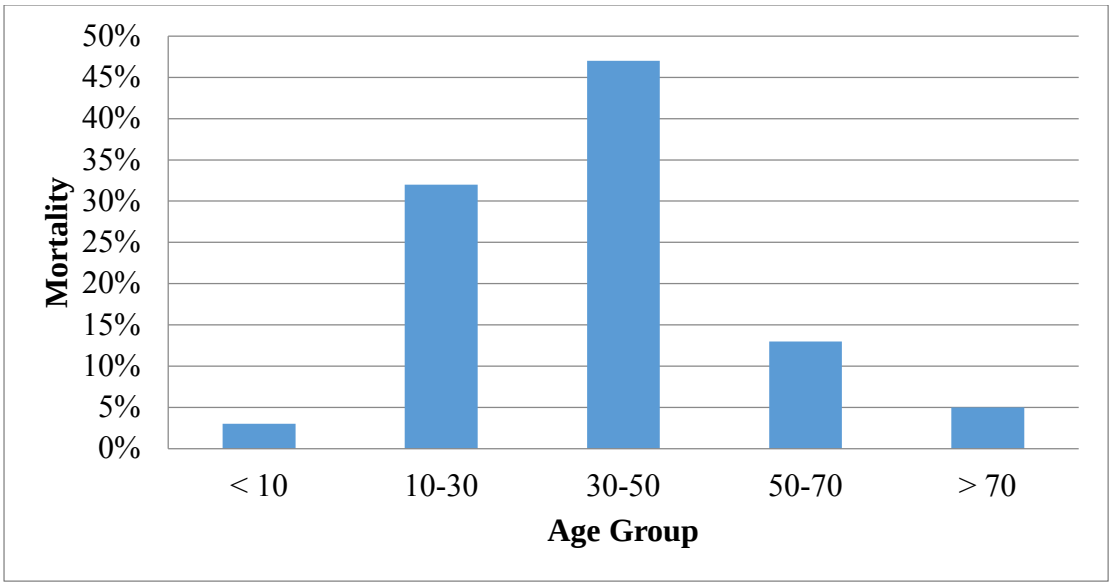

Figure 9: Mortality among patient in moderate and severe head injury

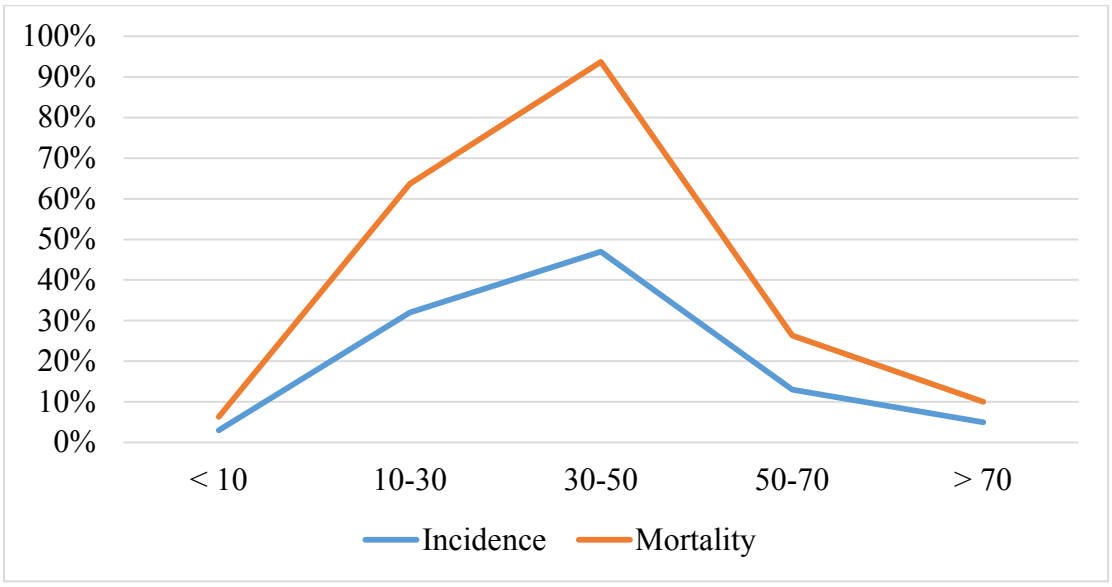

Figure 10:Co-relationships between age group and mortality among patient with moderate and severe head injury

When age group is adjusted for patients only with moderate and severe head injury then the number of patients is highest in the age group of 30-50 years (47%) followed

by age group of 10-30 years (32%), age group of 50-70 years (13%), age group of above 70 (5%) and age group below 10 years (3%).The mortality is highest in the age group of 30-50 years (46.66%) followed by age group of 10-30 years (31.66%), age group of 50-70 years (13.33%), age group of above 70 years (5%) and finally age group below 10 years (3.33%).

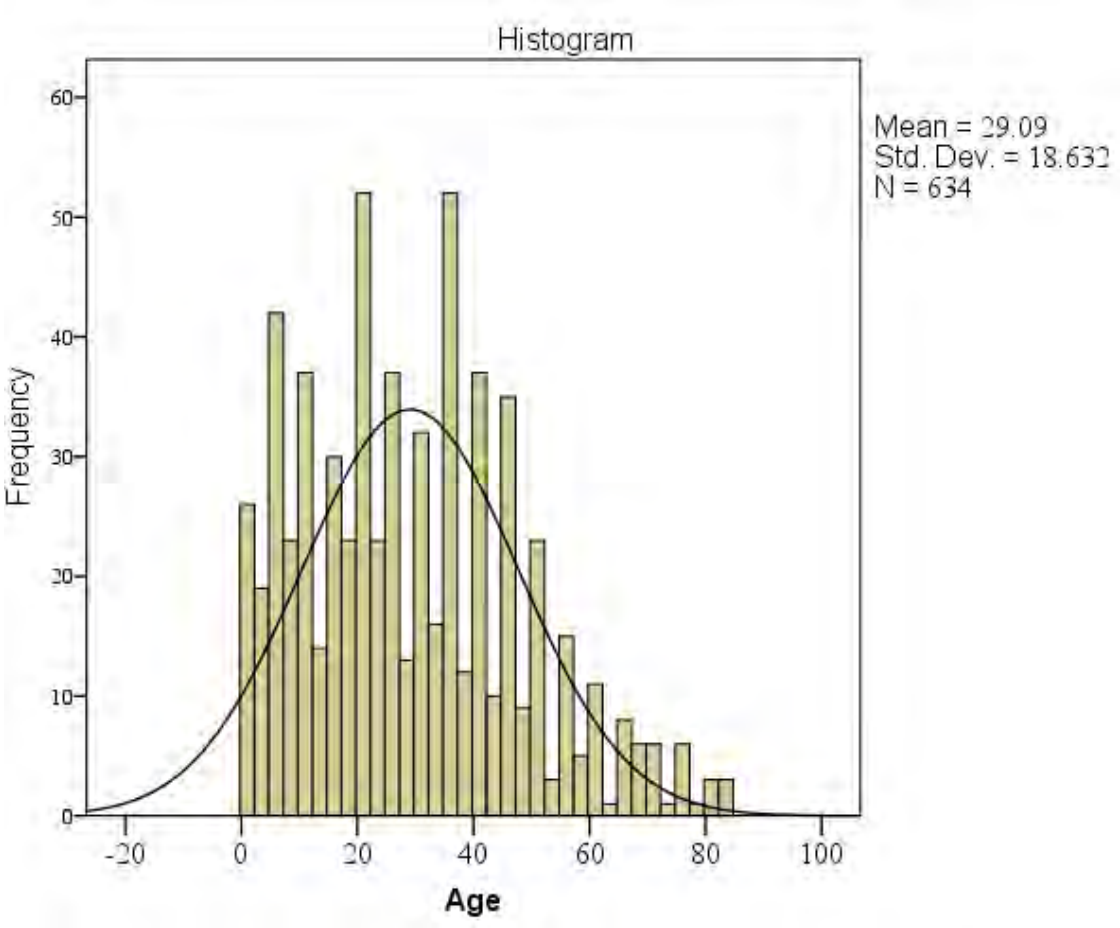

Figure11:Histogram showing age group of patients

Mean age of the patient with head injury is 29.09 years and the age category with the maximum inclusions of moderate and severe head injury as well as the mortality is 30-50 years.

Table 16: GCS and age category of the patient

GCS	Age category (years)					Total
	Below 10	10-30	30-50	50-70	70 above	
Mild	110	180	138	43	12	483
Moderate	8	29	36	15	2	90
Severe	5	22	27	4	3	61
Total	123	231	201	62	17	634

DISCUSSION

Prognosis of TBIstill remains a challenge to this day. Prognosis is an essential element of medicine and estimation of prognosis is a frequent component of clinical decision making therapeutic and diagnostic actions are aimed to improve prognosis. The science of clinical decision making and advances in statistical modeling have made it possible to be more confident about what is likely to happen and to consider prognosis in terms of probabilities rather than prophecies. From socioeconomic standpoint, prognostic models are essential to support a cost effective clinical decision making and facilitating reliable comparison for outcomes between different patient series and variation in results over time.

The increase in Marshall Score showed increase prediction for higher mortality (p value <0.001).The mortality in the operated group was also lower than the non-evacuated lesion > 25 ml of same Marshall score.The overall operative mortality in this study is 26.67%, which may be because of inclusion of severely injured patients with non reacting pupils and CT showing features of infarction; because of the insisting nature of the patient party for operative modality even after thorough counseling.The mortality in patients with Marshall score 1 and 2 is 0%, for score 3 is 40%, for score 4 is 0%, for score 5 is 18.79% and for score 6 is 95.66%.This clearly proves the value of evacuation of mass lesion (Marshall score 5) in patient with traumatic brain injury in reducing the mortality compared to the patient with compressed cisterns, midline shift and non-evacuated >25ml blood. Also there are minimal patients in the group 4 because most of the patients with midline shift (MLS) are taken up for operative evacuation regardless of the GCS of the patient. The mortality in the patients who had undergone operative evacuation (Marshall score 5), which is the overall operative mortality in cases of TBI is 18.79%. The mortality is

highest for Marshall score 6 (95.66%). When the Marshall score is adjusted only for the patients with moderate and severe head injury, then the mortality in patients with score 1 and 2 is 0%, for score 3 is 90%, for score 4 is 31.97%, for score 5 is 31.97% and for score 6 is 100%.This also shows that Marshall Score has positive predictive value in predicting mortality in the patients with traumatic head injury.

The Rotterdam score also has high predictive value for assessing mortality and even so its individual variables such as tSAH, status of cisterns and midline shift are markers for prognosticating negative outcome in TBI (p value < 0.001). The mortality in the patient with Rotterdam score 1 and 2 is 0%, for score 3 is 6%, for score 4 is 35%, for score 5 is 53.65% and for score 6 is 58.33%. The Rotterdam score adjusted for the patient with moderate and severe head injury shows that the mortality for the patients with score 1 and 2 is 0%, for score 3 is 20%, for score 4 is 55.85%, for score 5 is 76% and for score 6 is 77%.This proves that higher Rotterdam score in patients with TBI has added risk of mortality.

This study is also consistent with the norm that the mortality increases with the increase in the severity of traumatic brain injury (p value < 0.001).The mortality in the patients with mild head injury is 1.44%, in patients with moderate head injury is 14.60% and in patients with severe head injury is 65.57%.

The incidence of tSAH in this study is 27.12% and the mortality is 16.27 % (p value <0.001). The mortality in the Mass et al group was 30%.First described by Wilkins (1859)[49]tSAH was thought to be caused by rupture of the intracranial arteries and bridging veins.[50, 51]Newbarr and Courville[52]hypothesized tearing of superior cerebral veins at their entry point in superior sagittal sinus. There is probable rupture of fine vessels of pia-arachnoid during shearing strains under the dura. Freytag

(1963)[53]reportedSAH in head injured patients due to venous rupture. Thin walled veins are more liable to rupture than rupture of thick walled arteries. Traumatic SAH is one of the important factors influencing the overall outcome in head injured patients.[13]The mortality is 2-3 times higher in patients with tSAH than those without SAH in CT scan. Eisenberg etal.[13] in 1990 reported mortality among tSAH patients twice as high as no SAH patients. In patients with tSAH, unfavorable outcome is reported in 60-70% cases. Head injury patients with tSAH showed higher incidence of unfavorable outcome than mild head injury without SAH.[54, 55]The outcome of patient with tSAH is directly related to clinical state and amount of subarachnoid blood seen on the first CT scan.[56]

The mortality in the patient with MLS >5mmis 34.14 % in this study whereas in the study by Mass et al it was 49%. In a study by Singh et al. (2012)[57] greater degree of midline shift on CT scan was associated with unfavorable outcome. It was 37.5% for midline shift of <1 mm, 57.58% for<5 mm and 71.43%for midline shift of >5 mm. Among all the CT findings which they studied, midline shift was the most important factor that influences the outcome.[58,59,60]In their study, there was increase in mortality with increase in midline shift, with mortality reaching up to 61.90% in patients with midline shift of more than 5 mm.

The mortality in the EDH groupis 8.20% whereas it was 17% in study by Mass et al. Therefore, this study endorses the views of Hooper, which in a setting like ours a mortality rate of less than 10% would be a reasonable goal.[61]It appears that Bricolo and Pasut's goal of zero mortality is yet a dream. [62]

Gender differences in the physiological response to TBI are increasingly being described. Although an age threshold has been suggested, current evidence suggests a

continuous relationship between increasing age and worsening outcome after TBI. It is believed that this may reflect in decreased brain plasticity, as well as increased susceptibility to the complications of TBI. Additionally, some investigations reported better outcomes below the age of 40-50 years, while other studies reported outcome as a continuous function of age without threshold values.[64]Despite the fact that age is a significant factor in predicting mortality, this study did not find this factor having correlation (p value 0.437).[63-71]

This study shows that the mortality is highest in the patients of age group of 30-50 years (46.67%) with p value of 0.003 followed by patients in age group of 10-30 years (31.66%), age group of 50-70 years (13.34%),age group of 70 above (5%) and below 10 (1.62%). This study shows that the mortality is highest in the patients of age group of 30-50 years (46.67%) with p value of 0.003 followed by patients in age group of 10-30 years (31.66%), age group of 50-70 years (13.34%),age group of 70 above (5%) and below 10 (1.62%). When age group is adjusted for patients only with moderate and severe head injury then the number of patients is highest in the age group of 30-50 years (47%) followed by age group of 10-30 years (32%), age group of 50-70 years (13%), age group of above 70 (5%) and age group below 10 years (3%).The mortality is highest in the age group of 30-50 years (46.66%) followed by age group of 10-30 years (31.66%), age group of 50-70 years (13.33%), age group of above 70 years (5%) and finally age group below 10 years (3.33%). Mean age of the patient with head injury is 29.09 years and the age category with the maximum inclusions of moderate and severe head injury as well as the mortality is 30-50 years. In a study by Langlois etal.[72]rates of TBI are highest in the very young (age group zero to four years) and in adolescents and young adults (15 to 24 years); there is another peak in incidence in the elderly (age >65 years).

The mortality in the patients with compressed cisterns is 19.16% and in the patients with absent cisterns is 53.62% in this study. There is no mortality in the patients with normal cisternal anatomy (p value < 0.0001). The relationship of outcome to the appearance of the basal cisterns as seen on initial computerized tomography (CT) scanning was assessed in 218 consecutive severely head-injured patients entered into the second phase of the National Pilot Traumatic Coma Data Bank.[73] Outcome could be directly related to the status of the basal cisterns on the initial CT scan. The mortality rates were 77%, 39%, and 22% among those with absent, compressed, and normal basal cisterns, respectively. This association between cisterns and outcome was shown to be strong after adjusting for Glasgow Coma Scale (GCS) score (p < 0.001). The state of the cisterns was more important for those with higher GCS scores (scores 6 to 8) than for those with lower scores (scores 3 to 5). Patients with GCS scores of 6 to 8, with cisterns absent or not visualized, suffered nearly a fourfold additional risk of poor outcome, compared to those with normal cisterns. This indicates that the status of the cisterns can be used as an early noninvasive method of identifying patients at high risk of death or severe disability, in whom the initial neurological examination would potentially suggest otherwise.

A number of limitations of previous studies should be recognized. First, their studies were performed on a large patient series including only patients with severe and moderate injury. Results cannot, therefore, be extrapolated towards patients with mild injuries. Secondly, they focused their studies on analysis of data from the initial CT examination performed within 4 hours after injury. Other studies[74] have shown that the worst CT scan obtained during the clinical course has greater predictive value. Third, the predictive analysis presented was conducted versus 6 months mortality. For this we chose mortality rather than the GOS dichotomized into unfavorable versus favorable as this constitutes a hard and objective endpoint without any missing outcome data.

Mortality at discharge would be related to complications of Intensive care unit (ICU stay),associated injuries (e.g. pneumonia,pulmonary embolism,sepsis, multiple organ dysfunction syndromes) and co morbidities leading to mistaken conclusions. Furthermore sepsis and multiple organ failure (critical illness, systemic inflammatory response syndrome)develop in the majority of patient who received mechanical ventilation for >7 days in major ICUs. Some have suggested even taking mortality at 1 week into account.[75]

The prediction of outcome for head injury patients based on CT scans has significant shortcomings even in terms of inter-observer error and predictions of outcome. In a study by Havilletal.,[76] there was significant variation in grading by experienced radiologists. Their results showed that competent radiologists will vary in their grading of diffuse injury (DI)by at least 1 category in almost one third of cases. They also varied in their assessment of mass lesions. In their study, one radiologist recorded a non-evacuated mass lesion in 47% of assessments where the other radiologist did not. In almost all of these grading the alternative radiologist chose a DI category.

Predicting outcome following traumatic brain injury is valuable but difficult. To plan and distribute treatment in a just and cost-effective way, with the endpoint of improved satisfaction for professionals, patients and their families, is of paramount importance. For prognostication to be clinically useful, outcomes must provide a reasonable impression of what life will be like for the patient in the longer term. Dichotomising outcomes into ‘good’ or ‘poor’ may not be an accurate enough reflection of the future to justify a change in medical management, or to counsel patients or their families sufficiently. In the future, it will be important to develop prognostic models that will be available for the majority in the world, and not just the privileged few.

Table 9 Studies of the prediction of outcome in TBI based on the status of the basal cisterns on CT

vanDongenet al.(1983)[15]	The state of the basal cisterns proved to be a very powerful prognostic indicator. The percentage of accurate predictions was markedly higher with a combination of clinical and CT features than with clinical or CT features alone
Cordobéset al.(1986)[12]	The presence of ventriculocisternal collapse and an unfavourable outcome correlated with raised intracranial pressure
Eisenberg et al.(1990)[13]	Compression or obliteration of the mesencephalic cisterns was related to abnormal intracranial pressure and death
Selladuraiet al.(1992)[16]	Perimesencephalic cistern obliteration was associated with a poor outcome
Liu et al.(1995)[17]	A grading system using changes in the brainstem and the perimesencephalic cistern was well correlated to dynamic changes in intracranial hypertension
Kakariekaet al.(1995)[18]	A system based on the status of the mesencephalic cisterns, the degree of midline shift and the presence or absence of mass lesions allowed high risk patients to be identified and outcome to be predicted
Servadeiet al.(2000)[19]	Haematoma thickness, midline shift, status of the basal cisterns and presence of subarachnoid haemorrhage were related to outcome when identified on the initial (early) CT examination
Maas et al.(2005)[11]	Prediction of outcome was further increased by adding intraventricular and traumatic subarachnoid haemorrhage and by more detailed differentiation of mass lesions and basal cisterns
Maas et al.(2007)[14]	Partial obliteration of the basal cisterns, traumatic subarachnoid haemorrhage or midline shift were strongly related to a poorer outcome

Table 11 Studies of the prediction of outcome in traumatic brain injury based on midline shift based on CT

Young et al. (1981)[25]	GCS scores and shift data were highly accurate indicators of outcome
Eisenberg etal.(1990)[13]	Midline shift was related to abnormal intracranial pressure and death
Quattrocchietal.(1991)[21]	Quantification of midline shift was a predictor of poor outcome
Kakariekaet al.(1995)[18]	A system based on the status of the mesencephalic cisterns, the degree of midline shift and the presence or absence of mass lesions allowed high risk patients to be identified and outcome to be predicted
Servadeiet al.(2000)[19]	Haematoma thickness, midline shift, status of the basal cisterns and presence of subarachnoid haemorrhage were related to outcome when identified on the initial (early) CT examination
Azianet al. (2001)[22]	Predictors of outcome included intracerebralhaemorrhage (ICH), extradural haemorrhage (EDH), intraventricularhaemorrhage, subarachnoid haemorrhage, subdural haemorrhage, the site of the ICH, the volume of the EDH, and midline shift
Pillai et al.(2003)[23]	The most important predictors of poor outcome were the horizontal oculocephalic reflex, the motor score of the GCS, and midline shift on CT scan
Maas et al. (2007)[14]	Partial obliteration of the basal cisterns, traumatic subarachnoid haemorrhage or midline shift were strongly related to a poorer outcome

Table 13: Studies of the prediction of outcome in traumatic brain injury based on traumatic subarachnoid hemorrhage on CT

Eisenberg et al.(1990)[13]	The presence of subarachnoid blood was related to abnormal intracranial pressure and death
Kakariekaet al. (1995)[18]	The outcome of patients with traumatic SAH was significantly worse than that of patients whose first CT scan did not show subarachnoid blood
Greene et al.(1996)[28]	Patients with traumatic SAH associated with a non-penetrating head injury had a worse outcome than similar patients without traumatic SAH
Servadeiet al.(2000)[19]	Haematoma thickness, midline shift, status of the basal cisterns and presence of SAH were related to outcome when identified on the initial (early) CT examination. Patients with SAH on early CT were at highest risk for associated evolving contusions
Ono et al.(2001)[24]	The GCS score and the presence of SAH were predictive factors in the acute subdural haematoma group
Azianet al.(2001)[22]	Predictors of outcome included intracerebralhaemorrhage (ICH), extradural haemorrhage (EDH), intraventricularhaemorrhage, subarachnoid haemorrhage, subdural haemorrhage, the site of the ICH, the volume of the EDH, and midline shift
Servadeiet al.(2002)[29]	Traumatic SAH on admission CT scans was an independent prognostic factor. Death among patients with traumatic SAH was related to the severity of the initial mechanical damage rather than to the effects of delayed vasospasm and secondary ischaemic brain damage
Mattioliet al.(2003)[27]	Traumatic SAH is associated with more severe CT findings and a worse patient outcome
Maas et al.(2005)[11]	Prediction of outcome was further increased by adding intraventricular and traumatic subarachnoid haemorrhage and by m The prognosis was poor in patients with poor GCS scores on admission, cisternal or fissuralhaemorrhage, traumatic SAH with cerebral contusion, or acute subdural haematomaore detailed differentiation of mass lesions and basal cisterns

Oktenet al.(2006)[41]	The prognosis was poor in patients with poor GCS scores on admission, cysternal or fissuralhaemorrhage, traumatic SAH with cerebral contusion, or acute subdural haematoma
Hernández et al. (2006)[30]	Baseline predictors of outcome studied were age, motor score, pupillary reactivity, CT classification, traumatic SAH, hypoxia, hypotension, glycaemia and haemoglobin. Covariate adjustment for strong predictors should be incorporated in the analysis of future trials of traumatic brain injury
Maas et al.(2007)[14]	Partial obliteration of the basal cisterns, traumatic SAH or midline shift were strongly related to a poorer outcome

SUMMARY AND CONCLUSION

This study concludes that the Marshall CT classificationhas strong predictive power, but greater discrimination can be obtained if the individual CT parameters underlyingthe CT classification are included in a prognostic model AS IN Rotterdam score. Consequently,for prognostic purposes, this study recommends the use ofindividual characteristics rather than the CT classification.

Performance of CT models for predicting outcome in TBI canbe significantly improved by including more details of variablesand by adding other variables to the model. We suggestthat such models should include the following characteristics:status of basal cisterns, shift, tSAH and/or IVH and presenceof mass lesions with differentiation between EDH versus intradural lesions. For more easy clinical application, modelscan be translated into a score chart.

Even adding clinical parameters such as time of arrival to hospital, presence of anisocoria, presence of secondary insults like hypoxia and hypotension, presence of polytrauma and time to surgery in cases of evacuated lesions will further adds to the prognostic value of such score system.

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APPENDIX I

PROFORMA

I.P. No.

Name:

Age:

Sex:

Address:

GCS:

Marshall Score:

Rotterdam Score:

tSAH:

Midline Shift:

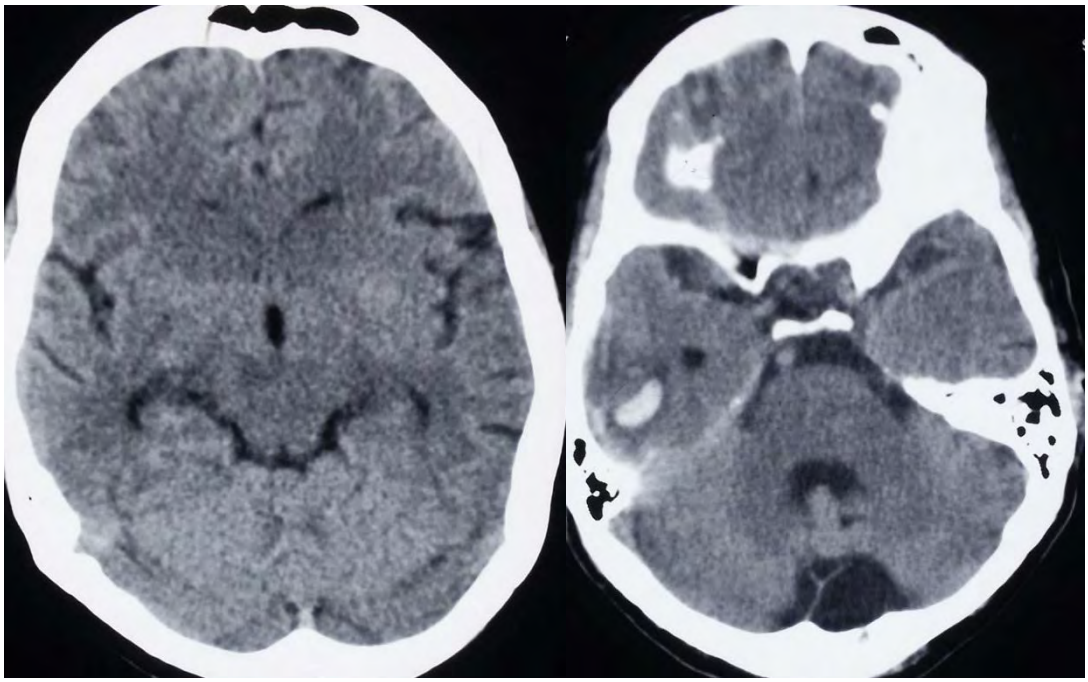
Cistern:

EDH:

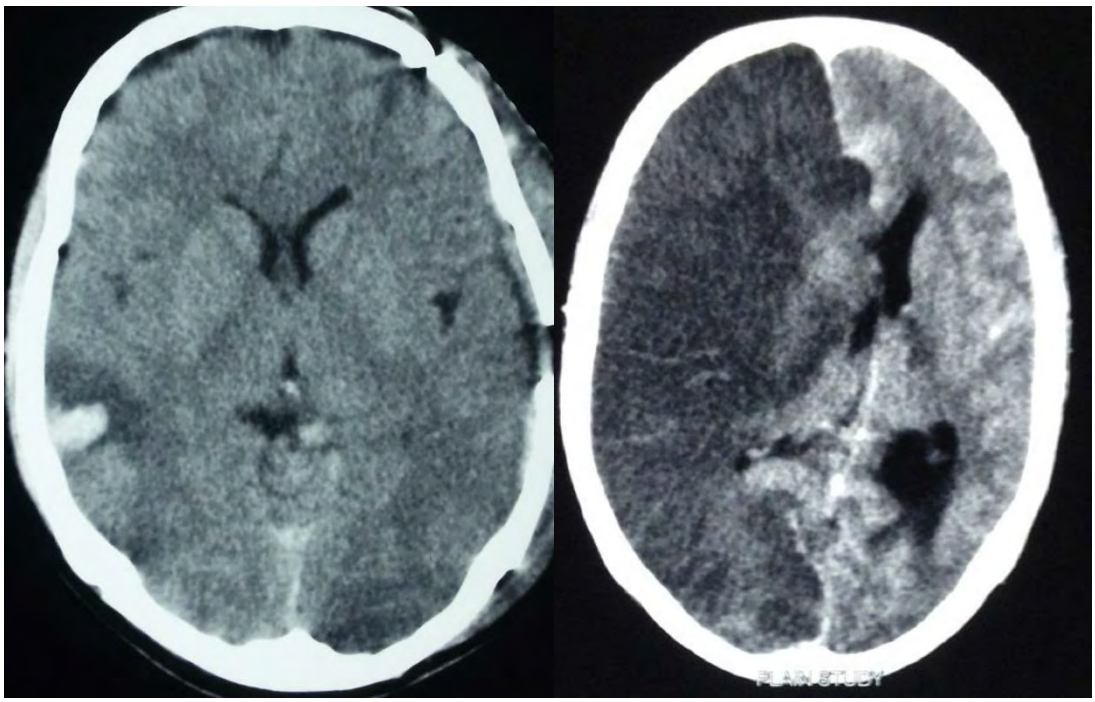
Mortality:

APPENDIX II

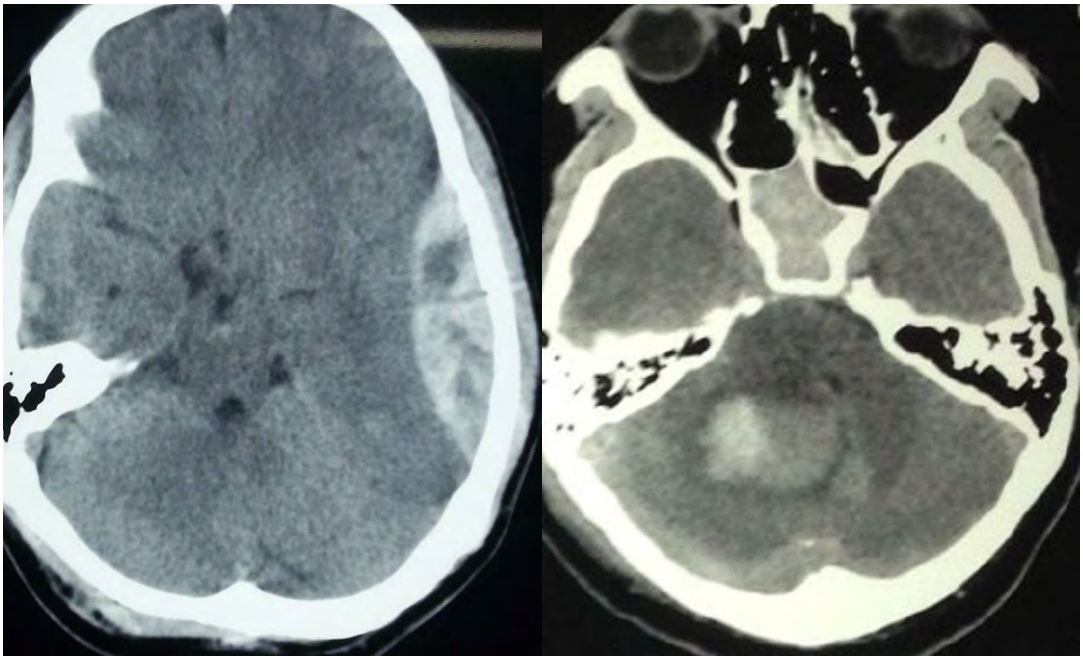
PHOTOGRAPHS



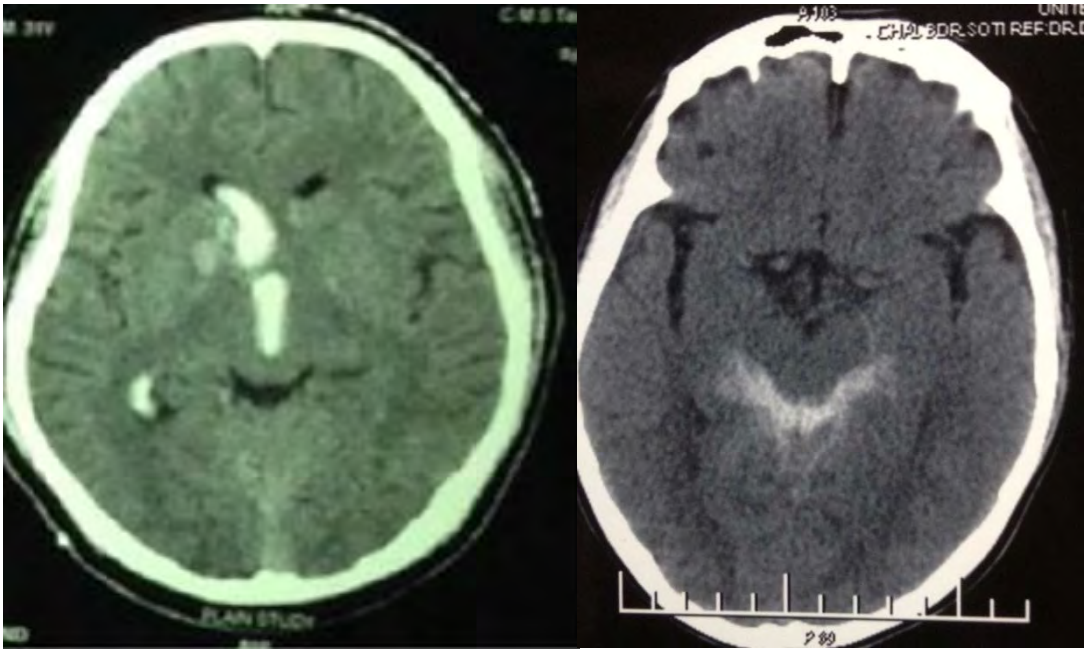
Marshall Score 1 **Marshall Score 2**



Marshall Score 5 **Marshall Score 6**



Compressed Cistern **Absent CP Cistern**



Traumatic Intraventricular Haemorrhage **Traumatic SAH**

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