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ORIGINAL ARTICLE

Leukocytosis: Predictor of Radiological and Neurological Outcome of Patients of Traumatic Brain Injury Presented to Jinnah Hospital, Lahore (JHL)

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ABSTRACT

Background/Objective: *Catecholamines and cortisol cause raised TLC (total leukocyte count) and brain inflammation after injury. We found out that weather leukocytosis is predictive for radiological and neurological outcome in patientswith TBI presenting to JHL.*

Materials and Methods: *Blood samples of patients (n = 100) were collected on presentation in the emergency room, after 72 hours and on the 5th day for TLC count.CT Brain was obtained on presentation in emergency, after 72 hours and on the 5th day. The progression of imaging findings on CT scan were assessed and compared with TLC count. The outcome of these patients was assessed according to the Extended Glasgow Outcome Scale.*

Results: *TLC after TBI is raised initially and then it declined afterwards in mild and moderate TBI, but remained on the upper limit in moderate TBI. In severe TBI, TLC was raised initially and then it progressed to higher limits afterwards.These results showed that there is a strong relation between TLC and TBI.Regarding the association between radiological assessment and severity of injury along with raised TLC, it was observed that the patients having EDH had raised TLC along with expansion of hematoma, while patients with contusions, T-SAH (traumatic sub-dural hematoma) and SDH had TLC on upper limit, but there was no significant resolution of radiological severity.*

Conclusion: *WBC count can be used as a predictor of radiological outcome, as it was found that patients with severe head injury had raised TLC. TLC count can be used to assess the severity of injury and prognosis.*

Keywords: *Traumatic brain injury (TBI), Total leukocyte count (TLC), Extradural hematoma (EDH), Subdural hematoma (SDH), Traumatic subarachnoid hemorrhage (T-SAH), White blood cells (WBC), Glasgow outcome scale extended (GOSE).*

INTRODUCTION

The association between the TBI (traumatic brain injury), TLC and progressive CT scan findings in relation with the outcome is still debatable. This current prospective study was conducted to find out that weather leukocytosis is predictive for radiological and neurological outcome in patients of TBI presenting to JHL.The burden of TBI was estimated to be 27.08 million in 2016, with incidence rates of 369 per 100,000.[1] Studies from developed countries like US estimated the rate to be 400+ per 100,000. TBI, although on top for cause of deaths,[2] is predicted to be the leading cause of casualties and hospital admission in developing and developed countries because of decrease rates of communicable disease in the future.The incidence is notably more in males[3]. An

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injury to the brain releases catecholamines inside the brain.[4-6] Catecholamines in turn are responsible for an increase in circulating neutrophils by releasing them from the walls of the vessels. On the other hand, there is also a surge of cortisol,[7-8] which inhibits the movement of leukocytes from vessels into the tissue and directly affect activation of leukocytes[9-13], hence, causing raised TLC and brain inflammation after injury. CT scan imaging is an important modality and is most commonly used for radiological assessment of TBI. Progressive imaging findings can also help us regarding severity of injury in repeated CT scans. The association between the TBI, TLC and progressive CT scan findings in relation with the outcome is still debatable. The objective of the study was to look for the importance of TLC and CT scan findings in predicting outcome of TBI.

CT brain is the most common imaging modality used for the radiological assessment of severity of traumatic brain injury. CT brain plain is available round the clock in JHL for traumatic brain injury patients. The association between severity of TBI and the increased TLC count has been studied. But the relation between progressions of CT scan finding and variation of the TLC count along with the significant impact on the outcome is still debatable.

MATERIALS AND METHODS

Study Design

A prospective study was conducted at the Neurosurgery Department of JHL from January 2019 to July 2019.

Inclusion Criteria

100 patients who met inclusion criteria were included. Patients of both genders with an age range from 3-80 years were included with informed and written consent, who came to Emergency Department of JHL after traumatic brain injury after RTA and had CT Brain plain in an emergency along with the TLC count.

Exclusion Criteria

Patients with polytrauma, history of fall from height, penetrating brain injury and medical co-morbidities were excluded from the study.Those patients who had surgery were excluded. Patients who had depressed fractures were also excluded. Patients having more than one radiological findings (e.g., EDH and SDH) were excluded. Patients with severe traumatic brain injury usually develop pneumonia, UTI etc. We followed TLC and CT scan parameters on 5th day and these patients usually develop infection by 5th day. We excluded those patients of severe TBI from our study who developed early radiological signs of infection. Those patients who developed radiological signs of infection, e.g., X-ray findings or positive cultures were excluded from this study. The raised TLC on presentation and at 72 hours cannot be due to infection, because infective condition take few days to prevail. We also excluded all patients with co morbidities and surgery in order to minimize the cofounder of raised TLC by them.

Data Collection

Blood samples were collected on presentation in the emergency room, after 72 hours and on the 5th day for TLC count.CT Brain was obtained on presentation in emergency, after 72 hours and on the 5th day.The progression of imaging findings on CT scan were assessed and it was compared with TLC count. Patients were also divided into 3 categories according to severity of injury. The relation between severity of imaging, TLC count and CT scan finding was established to infer results. The outcome of these patients was assessed according to the Extended Glasgow Outcome Scale. Tabulation was done for the relationship between progression of radiological finding on CT scan with TLC and severity of injury. SPSS Version 24 was used for data analyses.

RESULTS

Gender Distribution

Out of 100 patients, 78 (78%) were males and 22 (22%) were females.

Age Range

It was observed that youngest patient was 3 years old and oldest was 80 years old. Out of total patients, 41% patients had age range from 21-40 years, as shown in the Table 1.

Table 1: *Age distribution.*

Age Range (Years)	No of Patients (n = 100)	Percentage (%)
3 – 20	22	22%

21 – 40	41	41%
41 – 60	28	28%
61 – 80	9	9%

Clinical Presentation and Management

Out of 100 patients, 40% patients suffered from Moderate TBI, 37% patients had Severe TBI and 23% patients sustained Mild TBI, as shown in the Table 2.

Table 2: *Distribution of head injury.*

Characteristics	No of Patients (n = 100)	Percentage (%)
Mild head injury	23	23%
Moderate head injury	40	40%
Severe head injury	37	37%

It was observed that TLC count on the presentation was raised as compared to normal, but the TLC count variation among mild, moderate and severe TBI was not much significant, i.e. in mild head injury was 17.9 × 10^9/L, in moderate 18.35 × 10^9/L, and in severe 18.25×10^9/L (Table 3). On the other hand, TLC count on 5th day was remarkably raised up to the range of 25.15×10^9/L in STBI which is much higher than TLC count on the 5th day in mild and moderate head injury as shown in the Tables 3, 4 and 5.

Table 3: *Mild head injury.*

Time	Range	Mean Value
On presentation	9.7-26.1 × 10^9/L	17.9 × 10^9/L
After 72 hours	7.8-28.6 × 10^9/L	18.2 × 10^9/L
On 5th day	3.8-14.0 × 10^9/L	8.9 × 10^9/L

Table 4: *Moderate head injury.*

Time	Range	Mean value
On presentation	6.7-30.0 × 10^9/L	18.35 × 10^9/L
After 72 hours	4.6-21.7 × 10^9/L	13.15 × 10^9/L
On 5th day	3.0-23.2 × 10^9/L	13.1 × 10^9/L

Table 5: *Severe head injury.*

Time	Range	Mean value
On presentation	6.5-30.0 x 10^9/L	18.25 x 10^9/L
After 72 hours	3.3-20.8 x 10^9/L	12.05 x 10^9/L
On 5th day	3.0-47.3 x 10^9/L	25.15 x 10^9/L

Tabulation was done for progression of pattern of injury on CT scan and its relation with type of injury and TLC.21% of total patients had EDH. The radiological progression for mild TBI with EDH at 72 hours was found to be 67% resolved, whereas at 5th day, it was 33% resolved. For moderate TBI with EDH, radiologicalprogression was found to be 25% resolved at 72 hours and 50% resolved at 5th day. For severe TBI with EDH, it was 25% expanded at 72 hours and 62% expanded at 5th day. The mean value of TLC for mild EDH was found to be 18.15 × 10^9/L at presentation, 12.75 × 10^9/L at 72 hours and 8.25 × 10^9/L at 5th day. The mean value of TLC for moderate EDH was found to be 18.15 × 10^9/L at presentation, 14 × 10^9/L at 72 hours and 10.35 × 10^9/L at 5th day. The mean value of TLC for severe EDH was found to be 13.15 × 10^9/L at presentation, 10.15 × 10^9/L at 72 hours and 25.15 × 10^9/L at 5th day (Table 6).

Operational Definitions for Radiological Parameters are as Follows:

Radiological resolution will be considered significant clinically if volume reduced by 10ml for fronto-parieto-occipital EDH and 5ml for temporal and posterior fossa EDH. Patients with SDH was observed 19%. The radiologicalprogression for mild TBI with SDH at 72 hours and 5th day was found to be 50% resolved. For moderate TBI with SDH, radiology was found to be 25% resolved at 72 hours and no further resolution was recorded at 5th day. For severe TBI with SDH, it was 7.6% expanded at 72 hours and no further resolution was recorded at 5th day. The mean value of TLC for mild TBI with SDH was found to be 15.6 × 10^9/L at presentation, 20.3 × 10^9/L at 72 hours and 12.95 × 10^9/L at 5th day. The mean value of TLC for moderate TBI with SDH was found to be 16.85 x10^9/L at presentation, 9.3 × 10^9/L at 72 hours and 8.15 × 10^9/L at 5th day. The mean value of TLC for severe TBI with SDH was found to be 19.5 × 10^9/L at presentation, 13 × 10^9/L at 72 hours and 13.6 × 10^9/L at 5th day (Table 7).

Table 6: *TLC count at different time intervals for EDH.*

			TLC Count on:		
			Presentation	**72 Hours**	**5th Day**
EDH (21%)	**Mild**	***Radiology***	--	67% resolved	33% resolved
		TLC range (mean)	10.2-26.1 × 10^9/L (18.15 × 10^9/L)	8.6-16.9 × 10^9/L (12.75 × 10^9/L)	3.8-12.7 × 10^9/L (8.25 × 10^9/L)
	Moderate	***Radiology***	--	25% resolved	50% resolved
		TLC range (mean)	7.5-30.0 × 10^9/L (18.75 × 10^9/L)	9.4-18.6 × 10^9/L (14 × 10^9/L)	8.3-12.4 × 10^9/L (10.35 × 10^9/L)
	Severe	***Radiology***	--	25% expanded	62% expanded
		TLC range (mean)	6.5-19.8 × 10^9/L (13.15 × 10^9/L)	3.3-17.0 × 10^9/L (10.15 × 10^9/L)	3.0-47.3 × 10^9/L (25.15 × 10^9/L)

Table 7: *TLC count at different intervals for SDH.*

			TLC Count on:		
			Presentation	**72 Hours**	**5th Day**
SDH (19%)	**Mild**	***Radiology***	--	50% resolved	50% resolved
		TLC range (mean)	14.7-16.5 × 10^9/L (15.6 × 10^9/L)	12.0-28.6 × 10^9/L (20.3 × 10^9/L)	11.9-14.0 × 10^9/L (12.95 × 10^9/L)
	Moderate	***Radiology***	--	25% resolved	No further resolution
		TLC range (mean)	11.5-22.2 × 10^9/L (16.85 × 10^9/L)	6.5-12.1 × 10^9/L (9.3 × 10^9/L)	4.7-11.6 × 10^9/L (8.15 × 10^9/L)
	Severe	***Radiology***	--	7.6% resolved	No further resolution
		TLC range (mean)	9.0-30.0 × 10^9/L (19.5 × 10^9/L)	6.4-19.6 × 10^9/L (13 × 10^9/L)	5.6-21.6 × 10^9/L (13.6 × 10^9/L)

Operational Definition for SDH Resolution.

Radiological resolution will be considered significant clinically if midline shift reduced by 0.5cm. 39% patients were found to have brain contusions. The radiology for mild TBI with contusions at 72 hours was found to be 33.3% resolved, whereas, it was found to be 44.4% resolved at 5th day. For moderate TBI with contusions, radiology was found to be 23% resolved at 72 hours and no further resolution was recorded at 5th day. For severe TBI with contusions, no resolution was found at 72 hours and 5th day. The mean value of TLC for mild TBI with contusions was found to be 17.45 × 10^9/L at presentation, 18.9 × 10^9/L at 72 hours and 11.5 × 10^9/L at 5th day. The mean value of TLC for moderate TBI with contusions was found to be 16.8 × 10^9/L at presentation, 13.25 × 10^9/L at 72 hours and 13.15 × 10^9/L at 5th day. The mean value of TLC for severe TBI with contusions was found to be 18 × 10^9/L at presentation, 12.6 × 10^9/L at 72 hours and 13.35 × 10^9/L at 5th day (Table 8).

Operational Definition for Radiological Resolution for Contusions:

Radiological resolution will be considered significant clinically if the volume of contusion reduced by 5ml.The radiological findings of T-SAH was observed in 9%. The radiological progression for mild TBI with T-SAH at 72 hours and 5th day was found to be 33.3% resolved. For moderate TBI with T-SAH, radiology was found to be 25% resolved at 72 hours and 50% resolved at 5th day. For severe TBI with T-SAH, it was 7.6% expanded at 72 hours and no further resolution was recorded at 5th day. The mean value of TLC for

Table 8: *TLC count at different intervals for contusions.*

			TLC count on:		
			Presentation	**72 Hours**	**5th Day**
Contusions (39%)	**Mild**	***Radiology***	--	33.3% resolved	44.4% resolved
		TLC range (mean)	9.7-25.2 × 10^9/L (17.45 × 10^9/L)	9.2-28.6 × 10^9/L (18.9 × 10^9/L)	9.0-14.0 × 10^9/L (11.5 × 10^9/L)
	Moderate	***Radiology***	--	23% resolved	No further resolution
		TLC range (mean)	7.6-26.0 × 10^9/L (16.8 × 10^9/L)	4.8-21.7 × 10^9/L (13.25 × 10^9/L)	3.0-23.2 × 10^9/L (13.15 × 10^9/L)
	Severe	***Radiology***	--	No resolution	No resolution
		TLC range (mean)	7.9-28.1 × 10^9/L (18 × 10^9/L)	4.4-20.8 × 10^9/L (12.6 × 10^9/L)	5.8-20.9 × 10^9/L (13.35 × 10^9/L)

Table 9: *TLC count at different intervals for T-SAH.*

			TLC Count on:		
			Presentation	**72 Hours**	**5th Day**
T-SAH (9%)	**Mild**	***Radiology***	--	33.3% resolved	33.3% resolved
		TLC range (mean)	12.0-21.9 × 10^9/L (16.95 × 10^9/L)	5.6-14.0 × 10^9/L (9.8 × 10^9/L)	8.9-10.0 × 10^9/L (9.45 × 10^9/L)
	Moderate	***Radiology***	--	25% resolved	50% resolved
		TLC range (mean)	10.1-17.0 × 10^9/L (13.55 × 10^9/L)	4.6-11.6 × 10^9/L (8.1 × 10^9/L)	6.0-16.2 × 10^9/L (11.1 × 10^9/L)
	Severe	***Radiology***	--	No resolution	No resolution
		TLC range (mean)	17.1-19.3 × 10^9/L (18.2 × 10^9/L)	9.7-11.6 × 10^9/L (10.65 × 10^9/L)	7.6-10.8 × 10^9/L (9.2 × 10^9/L)

Table 10: *TLC count at different intervals for DAI.*

			TLC count on:		
			Presentation	**72 Hours**	**5th Day**
DAI (12%)	**Mild (16.6%)**	***TLC range (mean)***	18.1-19.3 × 10^9/L (18.7 × 10^9/L)	10.6-12.0 × 10^9/L (22.6 × 10^9/L)	10.0-11.3 × 10^9/L (10.65 × 10^9/L)
	Moderate (41.6%)	***TLC range (mean)***	9.3-14.8 × 10^9/L (12.05 × 10^9/L)	7.1-16.7 × 10^9/L (11.9 × 10^9/L)	6.8-11.0 × 10^9/L (8.9 × 10^9/L)
	Severe (41.6%)	***TLC range (mean)***	7.9-22.3 × 10^9/L (15.1 × 10^9/L)	8.0-16.8 × 10^9/L (12.4 × 10^9/L)	3.5-10.0 × 10^9/L (6.75 × 10^9/L)

mild TBI with T-SAH was found to be 16.95 × 10^9/L at presentation, 9.8 × 10^9/L at 72 hours and 9.45 × 10^9/L at 5th day. The mean value of TLC for moderate TBI with T-SAH was found to be 13.55 × 10^9/L at presentation, 8.1 × 10^9/L at 72 hours and 11.1 × 10^9/L at 5th day. The mean value of TLC for severe TBI with

T-SAH was found to be 18.2 × 10^9/L at presentation, 10.65 × 10^9/L at 72 hours and 9.2 × 10^9/L at 5th day (Table 9).

Operational Definition for Radiological Resolution for Traumatic Subarachnoid Hemorrhage:

Radiological resolution will be considered significant if blood resolved.DAI was observed in 12%. The mean value of TLC for mild DAI was found to be 18.7 × 10^9/L at presentation, 22.6 × 10^9/L at 72 hours and 10.65 × 10^9/L at 5th day. The mean value of TLC for moderate DAI was found to be 12.05 × 10^9/L at presentation, 11.9 × 10^9/L at 72 hours and 8.9 × 10^9/L at 5th day. The mean value of TLC for severe DAI was found to be 15.1 × 10^9/L at presentation, 12.4 × 10^9/L at 72 hours and 6.75 × 10^9/L at 5th day (Table 10).

Out of 37 patients of severe head injury, GOS extended (Glasgow outcome scale) score of 16 patients was 1, GOSE of 11 patients was 2 and GOSE score of 8 patients was 5.In patients with moderate head injury, GOSE score of 31 patients was 8 and GOS extended score of 9 patients was 7. In case of mild head injury GOSE (Glasgow outcome scale extended) score of all 23 patients was 8 at the time of discharge.

DISCUSSION

An injury to the brain causes release of catecholamines in the brain. Catecholamines and cortisol, which inhibit movement of leukocytes from vessels into the tissue and directly affect activation of leukocytes hence, causing raised TLC (total leukocyte count) and brain inflammation after injury. TBI is considered as a one of the common conditions leading to Grave outcomes.Assessment of TBI is routinely done with the help of GCS formulated by Teasdale and Jennett (1974).[14] Hematological and radiological assessment also play a pivotal role in the management of TBI, but the correlation between TLC and severity of TBI is still debatable.[15-17] There is a lack of evidence in quantification of CT scan findings for the assessment of severity TBI and TLC.Our study showed that TLC after TBI is raised initially and it declined afterwards in mild and moderate TBI, but remained on the upper limit in moderate TBI.In severe TBI, TLC was raised initially and it progressed to higher limits afterwards. These results showed that there is a strong relation between TLC and TBI. Regarding the association between radiological assessment and severity of injury along with raised TLC it was observed that patients having EDH had raised TLC along with expansion of hematoma while patients with contusions, T-SAH and SDH had TLC on upper limit but there was no significant resolution of radiological severity. Our findings are comparable with the Gurkanlar et al.[18] representing a direct association between raised TLC and CT progression, but when we segregated the CT findings, it was observed that EDH patients had much significantly high TLC and expansion compared to brain contusions, T-SAH and SDH.[7,19-20.]

CONCLUSION

WBC count can be predictor of radiological outcome as it was found that patients with severe head injury had raised TLC and there was significantly less resolution of CT scan findings in patients with raised TLC. Therefore, TLC count can be used to assess the severity of injury and prognosis.

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Additional Information

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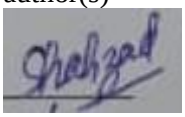
1.	**Syed Shahzad Hussain** (Main/Principal Author).	1. Proposed Topics and Basic Study Design, Methodology.	Signature by the author(s) 
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