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Original Article

Paediatrics Section

Plasma D-dimer as a Prognostic Marker in ICU Admitted Egyptian Children with Traumatic Brain Injury

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ABSTRACT

Background: Traumatic brain injury (TBI) is a leading cause of morbidity and mortality in children. This study aimed at evaluation of the D-dimer blood levels as a new marker to predict prognosis and outcome of traumatic brain injuries among children.

Materials and Methods: This case control study was conducted at the Paediatric Intensive Care Unit (ICU), Alharm Hospital in Giza, Egypt during 2012-2013, on 46 Paediatric cases admitted to ICU with head injury and 20 normal age-matched controls. Clinical data and venous blood samples were prospectively collected at 1st, 3rd and 14th day of admission, in addition to examination finding as Glasgow coma scale (GCS), cranial brain computed tomography (CT), routine laboratory investigations (CBC, CRP, SGOT, SGPT, urea, creatinine, random blood glucose, Na, K and arterial blood gases) plasma D-dimer, INR, PT, aPTT and PC. Data analysis was carried out accordingly and ROC curve was performed to explore the discriminating ability of D-dimer through estimation of its accuracy in differentiating temporal survivorship of those with TBI.

Results: Cases were classified according to outcome into survivors and non-survivors. Significant difference was observed between cases and controls and between survivors and non-survivors during 1st, 3rd and 14th day of the follow up including GCS, blood levels of D-dimer, PT and aPTT. ROC curve analysis for D-dimer showed decline in both sensitivity from 89.5% to 73.7% and specificity from 100% to 81.5% along the study days respectively. D-dimer time measurements showed significant decline among survivors from 4.2 to 0.7, while in the non survivor group this decline was much higher from 27.9 to 1.4.

Conclusion: Low plasma D-dimer suggests the absence of brain injury, and good prognosis.

Keywords: Brain injury, Biomarker, Children, D-dimer, Head trauma

INTRODUCTION

Traumatic brain injury (TBI) is the leading cause of death and disability in children. Previous analyses showed that almost half of patients with TBI each year in the United Kingdom are children less than 16 y [1]. TBI results in considerable health care costs, and for many survivors, permanent disability with a sizable socioeconomic burden [2]. Head injuries (HI) among children are increasing because of the high rate of road traffic injuries [3] and falls at home, HI can lead to persistent cognitive, neurobehavioral deficits and personality adjustment problems [4,5]. Pere et al., have found that many researchers are motivated to find new diagnostic methods for brain injury and believed that an accurate assessment of prognosis is important when they made decisions about methods of treatment [6]. While Glasgow coma scale (GCS) and brain computed tomography (CT) are most widely used methods for detection and assessment of TBI in children [7] where, the Glasgow outcome scale (GOS) is the usual method for assessing outcome after head injury [8]. Nevertheless, its power predicting poor outcome by itself or in combination with other risk factors is still under study [9]. With the increasing use of CT scans there are increasing concerns about the risks of radiation received by the children. Currently it is estimated that the use of CT is the reason of 20 % of cancers in the United States [10]. In Egypt, there is scarcity about the prevalence of HI and depends on a limited hospital-based studies as that done by Montaser et al., where moderate and severe injuries accounted for 17.2% of the total TBI cases during 4 months study period, 17% of cases were among Paediatric age group (1-18 y), and fall from height was the leading cause (34%), followed by motor vehicle collision (21%) [11]. D-dimer is a breakdown product produced by the normal process of clotting. It is normally present in small quantities in the blood; when increased it is suggestive of increased clotting activity [12]. D-dimer level is rarely elevated in healthy individuals and increases during TBI [13]. In clinically suspected TBI, D-dimer has gained widespread clinical use as a parameter for detection of in vivo fibrin formation in the presence of a thrombotic condition. However, there has been a clear relationship found between high levels of plasma D-dimer and poor patient prognosis, poor outcome, and mortality [14]. Hoffmann et al., tried to employ D-dimer as an early prognostic marker for TBI severity and poor patient prognosis and mortality [15].

To the author's knowledge no previous Egyptian study assessed the predictors of TBI among children which would help physician in assessing the patients' outcome. The aim of the present study was to investigate the value of D-dimer as a prognostic marker in TBI in children admitted to the Intensive Care Unit (ICU) in Cairo Egypt, to be used in routine practice as an indicator of child prognosis.

MATERIALS AND METHOD

Setting and Design: Hospital-based case-control prospective design carried out during the period from April 2012 to May 2013. The study was conducted at the Paediatric Intensive Care Unit at Alharam general hospital, one of the major hospitals in Giza Governorate, Egypt with 500 beds.

Patients

Cases: All cases of TBI admitted to Paediatric ICU during the study period (46 cases) fulfilled the following inclusion and exclusion.

Criteria included: Those with isolated non surgical head trauma with any of the following CT brain findings; brain contusion or laceration, intra cerebral hemorrhage, subarachnoid hemorrhage, intra ventricular hemorrhage and patients with extramural or subdural hematoma.

Exclusion criteria: Patients aged < 1 or > 16 y old, with isolated brain oedema, received any type of blood products during the first 24h of admission, poly traumatized patients and those who were operated for hematoma evacuation.

All cases were clinically examined and scored according to Glasgow Coma Scale (GCS) on admission, followed by computed cerebral tomography (CT) scan.

	Whole subjects			Cases only		
	Cases (n=46)	Controls (n=20)	p-value	Non-survivors (n=19)	Survivors (n= 27)	p-value
HB (gm %)	11.1 ± 1.5	12.5 ± 1.2	0.001	10.9 ± 1.4	11.3 ± 1.5	0.4
TLC (mm^3)	20.8 ± 8	8.7 ± 2.3	<0.001	21.1 ± 7.1	20.7 ± 8.7	0.9
Platelet count (mm^3)	283.2 ± 89.8	334.9 ± 84.2	0.03	271.3 ± 106	291.5 ± 77.9	0.5
CRP n, % +VE -VE	 15 (32.6 %) 31 (67.4 %)	 0 (0.0 %) 20 (100.0 %)	 0.003 <0.001	 7 (36.8 %) 12 (63.2 %)	 8 (29.6 %) 19 (70.4 %)	 0.8 0.1
RBG (mg %)	164.6 ± 56.7	90.7 ± 14.1	<0.001	180 ± 62	153.8 ± 51.1	0.2
Na (mEq/L)	136 ± 4	140 ± 3.1	0.4	137 ± 3.8	135.3 ± 4	0.3
K (mEq/L)	4 ± 0.4	3.9 ± 0.3	0.003	3.9 ± 0.5	4 ± 0.3	0.1
SGOT (mg %)	333.3 ± 678	21.7 ± 6.3	0.005	543.2 ± 928	185.5 ± 382	0.2
SGPT (mg %)	335.4 ± 694	32.6 ± 5.4	<0.001	496.8 ± 833	221.8 ± 567	0.6
Urea (mg %)	22.6 ± 6.4	15.1 ± 3.6	0.7	22 ± 6.4	23.1 ± 6.5	0.2
Creatinine (mg %)	0.6 ± 0.1	0.6 ± 0.1	0.7	0.7 ± 0.1	0.6 ± 0.1	0.2

[Table/Fig-1]: Routine laboratory investigation results among the study sample.,*HB= hemoglobin, TLC= total leucocytic count, CRP= C-reactive protein, RBG= random blood glucose, Na= sodium, K= potassium. P value: t-test for independent samples*

Controls: Twenty matched controls were included, from those attended for vaccination services. For both cases and controls, demographic data were collected at admission and the followings investigations were done on1st, 3rd and 14th day of admission.

-Vital signs, examination findings (GCS), Cranial CT scanning, abdominal ultrasonography, and full radiological studies.

-Venous plasma samples were taken to test plasma D-dimer, INR, PT and aPTT and other routine laboratory investigations (CBC, CRP, SGOT, SGPT, Urea, Creatinine, Random Blood Glucose, Na, K, and Arterial blood gases). D-dimer was processed using Path fast D-dimer test kits, manufactured by IVD for in vitro diagnostic company and the device used is chemiluminescent enzyme immunoassay.

STATISTICAL ANALYSIS

Data were analysed using Statistical Package of Social Sciences (SPSS) software program for windows version [15]. Categorical data were expressed in proportion and percentage, using Chi square and Fisher's exact as tests of significance for comparisons of different groups and subgroups. Continuous variables were expressed as means (±SD) and subgroups evaluated by t-tests for independence. Repeated measures one way ANOVA test was done to differentiate the progression of different laboratory findings in each sub-group separately, namely cases and controls or survivors and non-survivors groups. Receiver Operating Characteristics (ROC) curve analysis was performed. The area under the ROC curve was estimated to explore the discriminating ability of D-dimer differentiating between non-survivors and survivors at each time measurement. p-value<0.05 was considered as statistically significant.

Ethical Considerations

The study was approved by Cairo University Research Ethics Committee, all procedures included individual data were treated with confidentiality following Helsinki Declaration.

RESULTS

A total of 46 Paediatric cases and 20 controls were included. Cases were classified according to the outcome into survivors and non-survivors. The mean age for cases was 6.9±3.8 y, and 6.8±2.3 y for controls. Males represented 56.5% of the total .The mean age for survivors was lower compared to non-survivors 6±3.8 y vs. 8.1±3.6 for non survivors. The mean (standard deviation) of weight was 25.8±11.2 kg and 29.4±11.1 among cases and controls respectively, and 26.8±8.4 and 25.1 ±12.9 kg for non-survivors and survivors respectively. Intra-cerebral hemorrhage (ICHg) was the most frequent diagnosis encountered among the cases (63% among the total), and (73%) and (55%) among non- survivors and survivors respectively.

	Whole subjects			Cases only		
	Cases (n=46)	Controls (n=20)	P* value	Non-survivors (n=19)	Survivors (n= 27)	P-value
GCS (1st day)	7.4 ± 3.1	15 ± 0	<0.001	5.7 ± 1.2	9.7 ± 1.6	<0.001
GCS (3rd day)	9.2 ± 3.5		<0.001	5.5 ± 1.1	11.8 ± 1.5	<0.001
GCS (14th day)	11.2 ± 4.3		<0.001	5.7 ± 1.7	14.7 ± 0.6	<0.001
D-Dimer (1st day)	14 ± 14.7	0.18 ± 0.1	<0.001	27.9 ± 13.6	4.2 ± 2.4	<0.001
D-Dimer (3rd day)	5.3 ± 5.2		<0.001	9.9 ± 5.3	2 ± 1.1	<0.001
D-Dimer (14th day)	1 ± 0.5		<0.001	1.4 ± 0.6	0.79 ± 0.41	<0.001
PT (1st day)	19.8 ± 11.4	11.4 ± 0.9	<0.001	27.7 ± 14.4	14.2 ± 1.7	0.001
PT (3rd day)	18.5 ± 10.7		<0.001	26.4 ± 13.3	13 ± 1	<0.001
PT (14th day)	17.2 ± 9.4		<0.001	25.1 ± 10.4	11.6 ± 0.7	<0.001
APTT (1st day)	44.8 ± 13.5	29.9 ± 2.9	<0.001	55.1 ± 15	37.5 ± 5	<0.001
APTT (3rd day)	40 ± 11.2		<0.001	49.1 ± 10.7	33.6 ± 6	<0.001
APTT (14th day)	35.9 ± 10.9		0.001	44.4 ± 11.7	29.9 ± 4.3	<0.001
PC (1st day)	69.9 ± 18.8	88.1 ± 4.3	<0.001	58 ± 16.5	78.3 ± 15.6	<0.001
PC (3rd day)	77.7 ± 16.1		<0.001	64.9 ± 12.3	86.7 ± 11.9	<0.001
PC (14th day)	88 ± 13.7		0.9	77.5 ± 13.1	95.4 ± 8.3	<0.001
INR (1st day)	1.4 ± 0.4	1 ± 0.1	<0.001	1.7 ± 0.4	1.3 ± 0.2	<0.001
INR (3rd day)	1.4 ± 0.4		<0.001	1.7 ± 0.4	1.2 ± 0.3	<0.001
INR (14th day)	1.2 ± 0.3		<0.001	1.5 ± 0.4	1 ± 0.1	<0.001

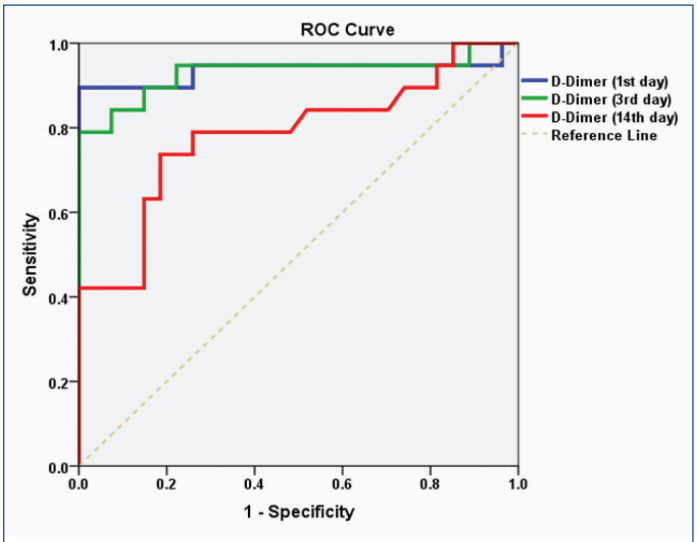
[Table/Fig-2]: GCS and coagulapathy results among the study sample during 1st, 3rd, and 14th days of follow up
GCS= Glasgow coma scale, PT= prothrombin time, PC= prothrombin concentration, PTT= partial thromboplastin time
p-value: * repeated measure ANOVA, **t-test for independent samples

[Table/Fig-1] depicts the results of routine laboratory investigation for the study sample, and its distribution in relation to cases/controls, and among cases in relation to survivorship. Among cases survivors who were accounted for 27/46(52.2%), HB, TLC, platelets count, CRP, RBG, Na, SGOT, SGPT and urea showed a significant difference between cases and controls but without significant difference between the non-survivors and survivor.

[Table/Fig-2] demonstrates the GCS and coagulapathy results among the study sample during 1st, 3rd, and 14th day of the follow up period. The results shows a significant difference between cases and controls and among survivors and non-survivors in 1st, 3rd and 14th day in relation to GCS, D-dimer, PT, APTT and INR blood levels. PC was significantly different in 1st and 3rd day among cases and controls also among survivors and non-survivors, while in the 14th day significant difference was found only among survivors and non-survivors.

	Whole subjects			Cases only		
	Cases (n=46)	Controls (n=20)	p* value	Non-survivors (n=19)	Survivors (n= 27)	p-value
PH (1st day)	7.32 ± 0.09	7.4 ± 0	<0.001	7.3 ± 0.11	7.33 ± 0.08	0.2
PH (3rd day)	7.34 ± 0.06		0.001	7.34 ± 0.08	7.34 ± 0.04	1
PH (14th day)	7.37 ± 0.08		0.08	7.33 ± 0.11	7.39 ± 0.05	0.02
PC^{o}_{2} (1st day)	31.7 ± 7.3	39 ± 2.7	<0.001	32 ± 9	31.5 ± 6	0.8
PC^{o}_{2} (3rd day)	34.9 ± 8		0.001	34.3 ± 10.7	35.2 ± 5.7	0.7
PC^{o}_{2} (14th day)	36.6 ± 7.1		0.03	35.1 ± 8.7	37.6 ± 5.6	0.2
HC^{o}_{3} (1st day)	19.5 ± 6	21 ± 2.9	0.1	20.1 ± 6.1	19.1 ± 6.1	0.6
HC^{o}_{3} (3rd day)	21.9 ± 5.3		0.5	21.5 ± 5.9	22.3 ± 5	0.6
HCo_{3} (14th day)	23.9 ± 6.1		0.02	21.4 ± 6.6	25.8 ± 5.1	0.01

[Table/Fig-3]: Blood gas analysis results among the study sample during 1st, 3rd, and 14th days of follow up
p-value: * repeated measure ANOVA, **t-test for independent samples



[Table/Fig-4]: The ability of D-Dimer to differentiate between survivors and non-survivors with TBI results among the study sample during 1st,3rd, and 14th day of follow up period

[Table/Fig-3] Displays blood gas analysis results during 1st, 3rd, and 14th day of the follow up period. For blood gases; PH was statistically significant in 1st and 3rd day and PCO_2 was statistically significant in 1st, 3rd, and 14th day among cases and controls.

[Table/Fig-4] displays the ROC curve analysis and demonstrates the discriminated ability of D-dimer to differentiate between survivors and non-survivors with TBI results among the study sample during 1st,3rd, and 14th day of the follow up period. Area under the curve (AUC) was 0.936, 0.930 and 0.784 with 95% CI (0.836 – 1.00, 0.836 – 1.00 and 0.640 – 0.927) respectively. The best cut-off point at 1st day was 10.5 with sensitivity 89.5 %, specificity 100.0 %, PPV(positive predictive value) 100.0% and NPV(negative predictive value) 93.1 % while the cut-off point at 3rd day was 3.6 with sensitivity 84.2 % specificity 92.6 %, PPV 88.9 % and NPV 89.3 %. Finally, at 14th day measurement was 1.1 with sensitivity 73.7 %, specificity 81.5 %, PPV 73.7 % and NPV 81.5 %.

[Table/Fig-5] shows changes in the prognostic markers among non-survivors and survivors at 1st, 3rd, and 14th day. In the current study the mean value of D-dimer among the non-survivors was

Markers	Non-survivors (n=19)	Post hoc	P Value	Survivors (n= 27)	Post hoc	P value
GCS (1st day)	5.7 ± 1.2	A	0.6	9.7 ± 1.6	A	<0.001
GCS (3rd day)	5.5 ± 1.1	A		11.8 ± 1.5	B	
GCS (14th day)	5.7 ± 1.7	A		14.7 ± 0.6	C	
D-Dimer (1st day)	27.9 ± 13.6	A	<0.001	4.2 ± 2.4	A	<0.001
D-Dimer (3rd day)	9.9 ± 5.3	B		2.0 ± 1.1	B	
D-Dimer (14th day)	1.4 ± 0.6	C		0.79 ± 0.41	C	
PH (1st day)	7.30 ± 0.11	A	0.3	7.33 ± 0.08	A	<0.001
PH (3rd day)	7.34 ± 0.08	A		7.34 ± 0.04	A	
PH (14th day)	7.33 ± 0.11	A		7.39 ± 0.05	B	
PC^{o}_{2} (1st day)	32.0 ± 9.0	A	0.8	31.5 ± 6.0	A	0.001
PC^{o}_{2} (3rd day)	34.3 ± 10.7	A		35.2 ± 5.7	AB	
PC^{o}_{2} (14th day)	35.1 ± 8.7	A		37.6 ± 5.6	B	
PT (1st day)	27.7 ± 14.4	A	0.2	14.2 ± 1.7	A	<0.001
PT (3rd day)	26.4 ± 13.3	A		13.0 ± 1.0	B	
PT (14th day)	25.1 ± 10.4	A		11.6 ± 0.7	C	
APTT (1st day)	55.1 ± 15.0	A	0.02	37.5 ± 5.0	A	<0.001
APTT (3rd day)	49.1 ± 10.7	AB		33.6 ± 6.0	B	
APTT (14th day)	44.4 ± 11.7	B		29.9 ± 4.3	C	
PC (1st day)	58.0 ± 16.5	A	0.001	78.3 ± 15.6	A	<0.001
PC (3rd day)	64.9 ± 12.3	B		86.7 ± 11.9	B	
PC (14th day)	77.5 ± 13.1	C		95.4 ± 8.3	C	
INR (1st day)	1.7 ± 0.4	A	0.003	1.3 ± 0.2	A	<0.001
INR (3rd day)	1.7 ± 0.4	A		1.2 ± 0.3	A	
INR (14th day)	1.5 ± 0.4	B		1.0 ± 0.1	B	

[Table/Fig-5]: Prognostic markers changes among non-survivors and survivors at 1st, 3rd, and 14th day
Measurements having different letter label are statistically significantly different at P value of 0.05 (post hoc Bonferroni test)

(27.9±13.6 µ/L, 9.9±5.3 µ/L and 1.4±0.6 µ/L at 1st day, 3rd day, 14th day respectively), while in the survivors it was (4.2±2.4µ/L, 2±1.1 µ/L and 0.79 ±0.41 µ/L at 1st day, 3rd day, 14th day respectively). D-dimer time measurements showed significant decline within both non-survivors and survivors (p <0.001), but GCS showed significant increase within survivors with no significant changes among non-survivors.

For coagulopathy parameters, the study tested PT, aPTT and INR. It was found that these parameters were significantly high in the non-survivor group especially around admission and 3rd day. As regard blood gases significant value along the time was noticed (p<0.001) in the survivors group.

DISCUSSION

The results of the current study suggesting that quantitative D-dimer level may be an important adjunct and helpful aid in the evaluation of children with head trauma, in light of concerns regarding the expanding use and adverse effects of head CT. In this study, further parameters were added by measuring PT, INR and finally a PTT as coagulopathy parameters to investigate the relation and role of coagulopathy in TBI. Routine investigations as Hg, TLC, platelets, RBG ,NA, K, SGOT, SGPT, Urea, Creatinine and Arterial blood gases was investigated also to find if they had some roles in assessment and evaluation of severity of TBI. The study concluded that the

routine investigations have some role in assessment and evaluation of severity of TBI, and its values change due to different factors associated with TBI as infection, activation of coagulation system, stress, shock, and dehydration. So they are not much reliable to predict outcome in TBI as D-dimer [16,17].

In this study, arterial blood gases, it showed significant changes in mean values more in the survivors group than the non-survivors group especially in the 1st day of injury. This means that all values of ABG improves with time through the period of the study, most probably due to acidosis ,bleeding, shock, dehydration and respiratory failure in end stage.

This study revealed that the GCS value as a prognostic indicator matches the findings in the study done in the year 2004, they found that patients with GCS from 3 to 8 had poor outcome compared to those with GCS 9-12 and even better outcomes when GCS ranged between 12 and 15 [18]. Also GCS was higher in patients with better outcome compared with those who had poor outcome at any point of time [18]. Coagulopathy has been widely studied as a contributor factor in TBI, and the relationship of its parameters namely PT, aPTT, INR, and D-dimer with poor patients outcome.

The results of coagulopathy parameters in this study along the time confirm the role of PT, and a PTT as good predictor of poor patient's prognosis in TBI. One possibility is that the coagulopathy preceded and contributed to ICH progression, this progression which normally occurs in the first 12h is the cause for GCS deterioration and increased odds for mortality in TBI patients.

Also, ICH progression occurred earlier preceding and perhaps contributing to the abnormal laboratory tests. So from this perspective it would be reasonable to assume that these parameters are merely a reflection for the changes that already occurred in the brain and correcting them would be useless [19].

Moreover, coagulopathy and ICH progression may be a complex process in which more coagulopathy leads to ICH progression leading to this [20].

Several previous studies supported the role of coagulopathy parameters, as those who investigated the role of coagulopathy in TBI and its association with mortality, where they had applied a post-hoc analysis method in randomized controlled trial including TBI 72 patients with a GCS less than 8 with serial CT scans done for them in the first 48h, they found that all patients with prolonged aPTT, PT, INR got ICH progression with increased risk of death [21]. Another retrospective chart review study was done on 253 patients with TBI and they concluded that abnormal values of INR, aPTT and platelets each independently correlated with ICH progression and mortality [20].

Study tried to determine the usefulness of fibrinolytic markers as early prognostic indicators in patients with isolated head trauma, where GCS and PT, aPTT, platelet count, fibrinogen, fibrin degradation products (FDP) and D-dimer were all measured in the first three hours, found a positive relationship (rs=0.688) between GCS and fibrinogen levels, but a markedly negative relationship between GCS and PT, PTT, FDP and D-dimer levels. Mortality strongly correlated with GCS, PT, FDP and D-dimer ($p<0.001$, $p<0.001$, $p<0.001$ and $p<0.001$, respectively) [22].

The changes in the mean of D-dimer in this study in relation to time between survivors and non-survivors, may be due to children in the non-survival group were more severely injured and had a significantly lower GCS on admission (5.7 in the non-survival group versus 9.7 in the survival group). From the analysis done, it was found that D-dimer difference between the non-survival group and the survival group gained statistical significance at 1st day, 3rd day and 14th day.

While the mean values of D-dimer in the survival group was higher but decreased gradually from 1st day to 3rd day to 14th day and this decrease was significant, which means that the more plasma D-dimer decreases in TBI patients, the better they become.

The results in the current study are consistent with another study on 98 TBI patients and 59 non TBI patients with ICH and a correlation was made between D-dimer and GCS, papillary light reflex, distance of midline shift on brain CT and the GOS. The study estimated the D-dimer levels within hours after acute insult and made the comparisons, and found a proportional inverse relation between initial GCS and D-dimer level in group of TBI patients, also found that D-dimer is correlated with poor patient outcome if D-dimer value is >1496 µ/L with sensitivity and specificity of 100% and 83% respectively [18]. Also same finding was confirmed in other study where, D-dimer levels on admission was found to be slightly higher in both peripheral venous (1115 µg/ml) and arterial blood (1288 µg/ml) than in jugular venous (888 µg/ml) blood, but these differences were not statistically significant [16].

Roc curve analysis results in the current study, to differentiate between prognosis of non-survivors and survivors along the time gave a best sensitivity (89.5% to 73.7%) and specificity (100% to 81.5%) respectively. This was in agreement with the results done in the Emergency Medicine Department in Tehran (2013), where the cut off point for D-dimer was 0.029 mg/ml with sensitivity of 91% and specificity of 86% [23].

D-dimer is still under research, and studying if it has definite relationship with poor patient's outcome in TBI patients, also if it can give a clue to the severity of brain insult, as well as give evidence of the start and progression of secondary brain insult sustained during the course of TBI, needs more studies. Most of these researches were on adults but researches about TBI in children are still few, so the aim of this current study, is to recommend D-dimer as a valuable marker in prognosis of TBI in children.

LIMITATIONS

Patients enrolled in the current study had isolated head injury and the results may not be generalized to patients with multiple trauma. Also, the small number of patient included may compromise the generalizability of the study's findings.

CONCLUSION

In children who meet clinical criteria for a head CT scan after trauma, low plasma D-dimer strongly suggests the absence of significant brain injury. This test may prove especially valuable to help access such patients with proper GCS and reduce the overall burden of head CT. D-dimer is a reliable marker that can be easily done in most ICUs. It has definite role in prediction of poor patient outcome in TBI, together with ability to mark the primary brain insult and its severity.

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