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ORIGINAL ARTICLE

Predictors of Outcome in Patients with Post-Traumatic Brain Contusion

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ABSTRACT

Background: Traumatic brain injury is the leading cause of mortality, morbidity and disabilities in children and young adults.

Aim is to evaluate the factors that may predict outcome of post-traumatic brain contusion.

Patients and Methods: A prospective study, where 50 patients with traumatic brain contusion categorized into 2 groups. Group A treated conservatively and Group B treated surgically. on admission GCS recorded then initial CT brain done. In group A, CT brain again redone after 24 hours and when indicated. In group B we did post-operative CT before discharge. patients followed up for 3 months. Glasgow outcome scale (GOS) used to assess functional outcome.

Results: 46 patients included, group A (n=21) and group B (n=25). In group A, mean initial GCS score was 12.95 ± 2.18 . Average midline shift in initial CT was 0.19 ± 0.51 mm. In group B, mean initial GCS score was 10.24 ± 2.18 . Average initial midline shift was 3.96 ± 1.62 mm while after 2nd CT was 6.40 ± 1.35 mm. At 3 months follow up, average GOS was 4.2 ± 1.1 for group A, and 4.19 ± 1.12 for Group B.

Conclusion: in those patients, initial GCS, radiological findings (initial and follow up midline shifts, initial and follow up brain contusion volumes) and mechanism of trauma are the most important predictors of functional outcome and duration of hospital stay. A combination of clinical deterioration with increased midline shift and/or increased volume of brain contusion are the most reasonable indications for surgical intervention in such patients.

Key words: Traumatic brain contusion, Glasgow coma scale, Glasgow outcome scale.

INTRODUCTION

A cerebral contusion is a type of injury that causes a bruise of brain tissue.[1] Traumatic brain injury (TBI) is a leading cause of death and disability, despite concentrated efforts during the last decades towards the improvement of prevention and care. [2,3] The incidence of TBI is increasing, mainly due to growing use of motor vehicles and to the aging of population in developed countries. [4,5]

Head trauma is a big public health problem and is a frequent cause of death and disability in young people with considerable demand on health services.[6] Assessment of outcome is usually based on the integrity of neurological function and it may give information about cognitive functions, since 1970's Glasgow coma scale (GCS) and computed tomography (CT) scan had been used in evaluating head injury patients.[7] Head trauma presents with

variety of injuries needing rapid evaluation, and intervention to save life and prevent permanent disability.[8]

We aimed in this study to evaluate in patients with post-traumatic brain contusion, the factors that may predict the possible clinical progression and the need for surgical intervention and how such predictors may influence the outcome in those patients.

Methods:

A prospective clinical study conducted from April 2020 to April 2021 on 50 consecutive patients with post-traumatic cerebral contusion, the included patients were selected from school age (6-12 years) or more to facilitate evaluation of consciousness using GCS and the functional outcome using Glasgow outcome score (GOS)

All included patients had initial evaluation and management of traumatized patients in ER, where

examination was done including the general examination, neurological and other systems. Initial CT brain scan was done on admission, then after 24 hours and also immediately when needed. Complete blood count (CBC), blood coagulation profile, liver and kidney function tests were done. Data was collected and analyzed regarding age, sex, mechanism of trauma (poly or local), cause of trauma, Glasgow coma scale (GCS) and neurological deficits. The effect of those factors on the outcome was studied. Radiological evaluation of post-traumatic cerebral contusion was done by CT brain regarding the initial volume and site of brain contusion as well as extent of midline shift and any associated intracranial pathology

Patients selected for surgery based on criteria of Brain Trauma Foundation for urgent surgical intervention [9] when the GCS scores ≤ 8 , volume of frontal or temporal hemorrhagic contusion $> 20 \text{ cm}^3$ and /or midline shift $\geq 5 \text{ mm}$ or cisternal compression.

Patients were categorized into two groups:

Group A (25 patients): Those patients received initial conservative treatment based on their initial CT brain on admission and their clinical status. They had one follow up CT scan 24 hours after the initial one. Those patients were closely followed up to assess their clinical status during their hospital stay and final assessment of their neurological status was done 3 months after trauma meanwhile in case of any new neurological deterioration a new follow up CT brain was done. When surgical intervention is decided for any of them based on clinical status deterioration and follow up CT brain, the patient received the same follow up protocol as in patients of group B.

Group B (25 patients): Those patients received surgical management based on their 1st CT brain or surgically treated after initial period of conservative management based on their follow-up CT brain done within 24 hours after trauma together with the

changes in their clinical status. Follow up post-operative CT brain was done before discharge.

Follow up was done for all patients for 3 months. To assess survival rate and neurological outcome we used GOS, a five-point scale expressing functional outcome. Glasgow outcome scale: 5 – Good recovery ,4 – Moderate disability, 3 – Severe disability, 2 – Persistent vegetative state and 1 – Deaths. GOS 4, 5 were classified as favorable outcome while GOS 1,2 and 3, were classified as unfavorable outcome.[10]

Informed consent and ethics committee approval:

This research has given approval by Research Ethics Committee (REC) of faculty of medicine. A written informed consent was obtained from each patient or the legal guardians in case the patient is unable to sign the informed consent after explaining all steps of this study to them. All procedures performed involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Statistical analysis: The collected data were described in terms of frequency and percentage for qualitative data and mean \pm Standard Deviation (SD) and range for quantitative data. Comparisons between the different study groups were carried out using the Chi-square test (χ^2) and the Fisher Exact test (FET) to compare categorical data. The Mann-Whitney test (Z) and the Kruskal Wallis (KW) test were used to compare two and more than two groups regarding non-parametric quantitative data, respectively. Spearman correlation coefficient (ρ) was used to examine the correlation between outcome indicators for post-traumatic brain contusion and quantitative patients ‘parameters. P-values <0.05 were considered statistically significant. All statistical analyses were carried out using STATA/SE version 11.2 for Windows (STATA corporation, College Station, Texas).

Table 1 : shows comparisons between the studied groups

Variable		Group A (conservative management) n.=21		Group B (surgical management) n.=25	
		No.	%	No.	%
Age (years)	<15	5	23.81	5	20.00
	15-	6	28.57	4	16.00
	30-	5	23.81	8	32.00
	45-65	5	23.81	8	32.00
	Mean \pm SD	28.01 \pm 19.00		32.78 \pm 19.11	

Variable		Group A (conservative management) n.=21		Group B (surgical management) n.=25	
		No.	%	No.	%
Gender	Range	9-60		7-65	
	Female	4	19.05	5	20.00
	Male	17	80.95	20	80.00
Cause of trauma	Falling from height	4	19.05	7	28.00
	Direct head trauma	4	19.05	4	16.00
	RTA	13	61.90	14	56.00
Type of trauma	Local trauma	4	19.05	4	16.00
	Polytrauma	17	80.95	21	84.00
Neuro-deficit	No	17	80.95	12	48.00
	Aphasia	0	0.00	3	12.00
	Lt. side weakness	3	14.29	9	36.00
	Rt. Side weakness	1	4.76	1	4.00
Other systems affection	No	15	71.43	20	80.00
	Cardiothoracic	2	9.52	2	8.00
	Orthopaedic	4	19.05	3	12.00
Associated medical problems	No	20	95.24	23	92.00
	Cardiac	0	0.00	2	8.00
	Hypertension	1	4.76	0	0.00
Initial GCS score	Mild (13-15)	14	66.67	3	12.00
	Moderate (9-12)	5	23.81	16	64.00
	Severe (3-8)	2	9.52	6	24.00
	Mean ± SD	12.95±2.18		10.24±2.18	
	Range	7-15		5-14	
Initial volume of brain contusion after 1 st CT (cm ³)	Mean ± SD	14.90±1.81		22.36±3.84	
	Range	10-17		17-28	
Volume of brain contusion after 2 nd CT (cm ³)	Mean ± SD	14.90±1.80		27.00±2.36 ^a	
	Range	10-18		25-32	
Initial midline shift after 1 st CT (mm)	Mean ± SD	0.19±0.51		3.96±1.62	
	Range	0-2		1-7	
Midline shift after 2 nd CT (mm)	Mean ± SD	0.26±0.80		6.40±1.35 ^a	
	Range	0-3.5		5-9	

SD: Standard Deviation; RTA: Road Traffic Accident; GCS: Glasgow Coma Scale; CT: Computed Tomography. a: These were calculated for ten patients, four from Group A and six other patients on indication.

Table 2: shows correlation between outcome indicators at 3 months follow up and patients 'characteristics

Character		Group A (conservative management) n.=21		Group B (surgical management) n.=25	
		Duration of hospital stay (days)	3 months follow up GOS	Duration of hospital stay (days)	3 months follow up GOS
Age (years)	Rho	0.28	0.22	-0.45	-0.11
	P	0.21	0.34	0.02*	0.60

Character		Group A (conservative management) n.=21		Group B (surgical management) n.=25	
		Duration of hospital stay (days)	3 months follow up GOS	Duration of hospital stay (days)	3 months follow up GOS
Initial GCS score	Rho	-0.86	0.73	-0.79	0.69
	P	<0.001***	0.0002***	<0.001***	0.0001***
Initial volume of brain contusion (cm ³)	Rho	0.19	-0.27	0.36	-0.14
	P	0.40	0.23	0.08	0.49
Volume of brain contusion after 2 nd CT (cm ³)	Rho	0.04	-0.17	0.19	-0.18 a
	P	0.85	0.45	0.59	0.62
Initial midline shift (mm)	Rho	0.57	-0.53	0.21	-0.52
	P	0.007**	0.01*	0.31	0.01*
Midline shift after 2 nd CT (mm)	Rho	0.57	-0.53	0.26	-0.42 a
	P	0.007**	0.001*	0.47	0.26

CT: Computed Tomography; GCS: Glasgow Coma Scale; GOS: Glasgow Outcome Scale; Rho: Spearman correlation coefficient; P: Probability; *: Significant difference (P<0.05); **: Significant difference (P<0.01); ***: Significant difference (P<0.001). a: These were calculated for ten patients, four from Group A and six other patients on indication.

Table 3: Variations in outcome indicators by the characteristics of patients in Group A (n.=21)

Variable	No.	Duration of 3 months follow up GOS				Alive/died n.=21				
		Mean ± SD	Range	Mean ± SD	Range	Alive n.=19		Died n.=2		
						No.	%	No.	%	
Age (years)	<15	5	4.4±1.9	2-7	4.2±1.8	1-5	4	There 21.05	1	50.0
	15-	6	7.3±3.5	2-10	3.3±1.9	1-5	5	26.32	1	50.0
	30-	5	5±2	3-7	5±0	5	5	26.32	0	0.00
	45-65	5	8.2±4.1	3-14	4.6±0.9	3-5	5	26.32	0	0.00
Test			KW=4.46		KW=5.74		FET			
P			0.21		0.12		1.00			
Gender	Female	4	7±2.9	3-10	4.7±0.5	4-5	4	21.05	0	0.00
	Male	17	6.1±3.4	2-14	4.1±1.6	1-5	15	78.95	2	100.0
Test			Z=0.73		Z=0.39		FET			
P			0.47		0.69		1.00			
Cause of trauma	Falling from height	4	5.7±3	3-10	4.25±0.5	4-5	4	21.05	0	0.0
	Direct head trauma	4	4.2±2.2	2-7	4.5±1	3-5	4	21.05	0	0.0
	RTA	13	7.1±3.4	2-14	4.08±1.31	1-5	11	57.89	2	100.0
Test			Z=2.52		Z=0.56		FET			
P			0.28		0.75		1.00			

Variable		No.	Duration of hospital stay (days)		3 months follow up GOS		Alive/died n.=21 Alive n.=19 Died n.=2			
			Mean ± SD	Range	Mean ± SD	Range	No.	%	No.	%
Type of trauma	Local trauma	4	4.2±2.2	2-7	4.5±1	3-5	4	21.05	0	0.0
	Poly trauma	17	6.8±3.3	2-14	4.12±1.15	1-5	15	78.95	2	100.0
Test			Z=1.45		Z=0.68		FET			
P			0.14		0.50		1.00			
Initial GCS score	Mild (13-15)	14	4.57±2.03	2-8	4.9±0.3	4-5	14	73.68	0	0.0
	Moderate (9-12)	5	9.6±2.88	7-14	3.6±1.7	1-5	4	21.05	1	50.0
	Severe (3-8)	2	9.5±0.71	9-10	1.5±0.71	1-2	1	5.26	1	50.0
Test			KW=11.09		KW=11.86		FET			
P			0.004**		0.003**		0.10			

RTA: Road Traffic Accident; GCS: Glasgow Coma Scale; GOS: Glasgow Outcome Scale; SD: Standard Deviation; KW: Kruskal Wallis test; Z: Mann Whitney test; FET: Fisher Exact Test; P: Probability; *: significant difference (P<0.05); **: significant difference (P<0.01).

Table 4: shows variations in outcome indicators by the characteristics of patients in Group B (n.=25)

Variable		No.	Duration of hospital stay (days)		3 months follow up GOS		Alive/died n.=25 Alive n.=20 Died n.=5			
			Mean ± SD	Range	Mean ± SD	Range	No.	%	No.	%
Age (years)	<15	5	18.2±3.8	14-21	2.8±1.6	1-4	4	20.00	1	20.00
	15-	4	11±8	4-21	4.5±0.6	4-5	4	20.00	0	0.0
	30-	8	8±3.8	5-14	4.4±1.4	1-5	6	30.00	2	40.00
	45-65	8	8.4±4.6	5-14	2.5±2.1	1-5	6	30.00	2	40.00
Test			KW=8.42		KW=6.55		FET			
P			0.04*		0.09		0.83			
Gender	Female	5	15.4±3.1	14-21	2.2±1.6	1-4	4	20.00	1	20.00
	Male	20	9.4±6.1	4-21	3.8±1.7	1-5	16	80.00	4	80.00
Test			2.02		2.08		FET			
P			0.04*		0.04*		1.00			
Cause of trauma	Falling from height	7	14.4±7.2	5-21	2.3±1.6	1-4	5	25.00	2	40.00
	Direct head trauma	4	4.7±0.5	4-5	4.5±0.58	4-5	4	20.00	0	0.0
	RTA	14	10.4±5.1	5-21	3.6±1.8	1-5	11	55.00	3	60.00
Test			KW=7.57		KW=8.23		FET			
P			0.02*		0.016*		0.81			
Type of trauma	Local trauma	4	4.7±0.5	4-5	4.5±0.58	4-5	4	20.00	0	0.0
	Polytrauma	21	11.8±6.0	5-21	3.2±1.8	1-5	16	80.00	5	100.0
Test			2.56		2.15		FET			

Variable		No.	Duration of hospital stay (days)		3 months follow up GOS		Alive/died n.=25			
			Mean ± SD	Range	Mean ± SD	Range	Alive n.=20		Died n.=5	
							No.	%	No.	%
P			0.01*		0.03*		0.55			
Initial GCS score	Mild (13-15)	3	4.67±0.58	4-5	5±0	5	3	15.00	0	0.0
	Moderate (9-12)	16	9.1±5.2	4-21	3.84±1.75	1-5	14	70.00	2	40.00
	Severe (3-8)	6	17.5±3.8	14-21	2.9±1.64	1-4	3	15.00	3	60.00
Test			KW=11.20		KW=5.98		FET			
P			0.0037**		0.05		0.16			

RTA: Road Traffic Accident; GCS: Glasgow Coma Scale; GOS: Glasgow Outcome Scale; SD: Standard Deviation; KW: Kruskal Wallis test; Z: Mann Whitney test; FET: Fisher Exact Test; P: Probability; *: significant difference (P<0.05); **: significant difference (P<0.01).

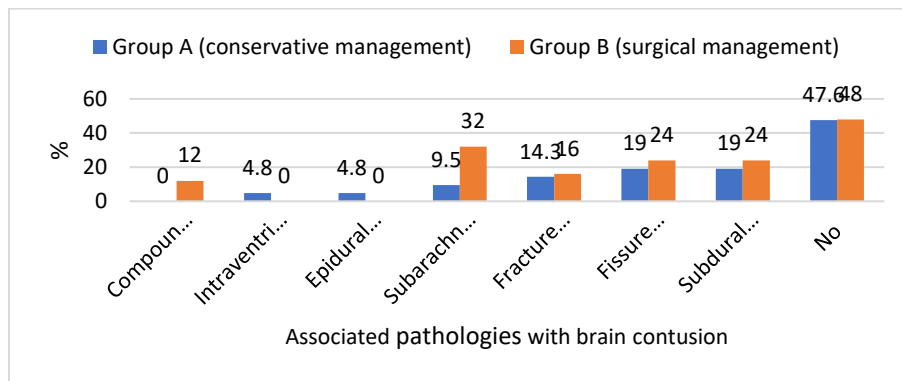


Figure 1: Frequency distribution of the studied groups according to associated pathologies with brain contusion

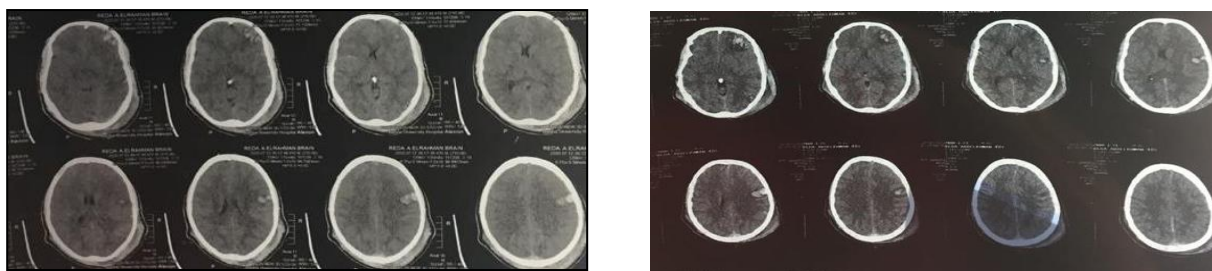


Figure 2: shows case 1: male patient ,35 years old had RTA with GCS 14 (a), initial CT brain showed left frontoparietal contusion with no midline shift (b) follow up CT, 24 hours later showed the same contusion with no progression, the patient treated conservatively and discharged after 5 days with GCS 15

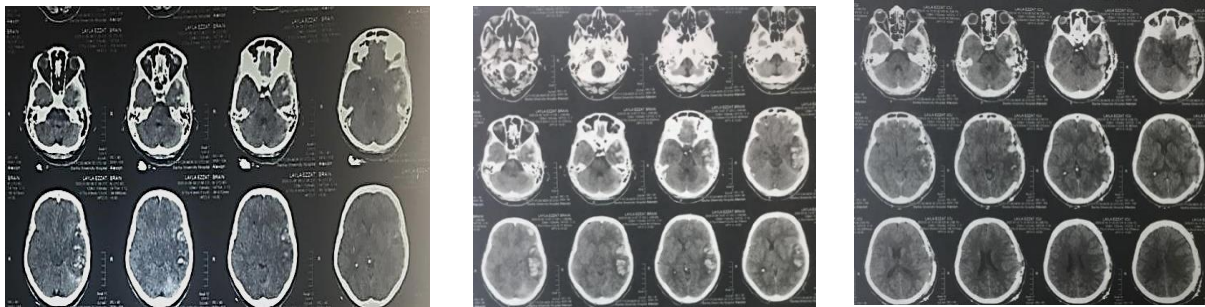


Figure 3: shows case 2: female patient, 62 years old had RTA with GCS 10 and aphasia, (a) initial CT brain showed left temporo-parietal contusion with 3 mm midline shift (b) 2nd CT was done after deterioration of GCS to 8 showed increase in the midline shift to 6 mm, surgical intervention was done. (c) showed 24 hours post-op CT brain. The Patient discharged 10 days after surgery with GCS 15 with aphasia

RESULTS

Forty-six consecutive patients with post-traumatic cerebral contusion were included in this prospective clinical study and were classified into two groups according to criteria clarified before in methodology. We started with 25 patients in the conservative group and 21 in the surgical group and 4 patients were shifted from the conservative to the surgical group because of deterioration.

Table 1 shows comparisons between the conservative group (Group A; n=21) and the surgical group (Group B; n=25) regarding their demographic and clinical characteristics.

In group A, the age of patients ranged between 9 and 60 years and 80.95% were males. The most frequent cause of trauma was road traffic accidents (61.9%). The mean of initial GCS score was 12.95 ± 2.18 . The average volume of brain contusion in initial CT brain and after 24 hours remained almost the same ($14.9 \pm 1.81 \text{ cm}^3$). The average of midline shifts in initial CT brain and after 24 hours were $0.19 \pm 0.51 \text{ mm}$ and $0.26 \pm 0.8 \text{ mm}$, respectively.

In group B, the age of patients ranged between 7 and 65 years and 80% were males. The most frequent cause of trauma was road traffic accidents (56%). The mean of initial GCS score was 10.24 ± 2.18 , and the average volume of brain contusion in initial CT brain was $22.36 \pm 3.84 \text{ cm}^3$. The average volume of brain contusion after 24 hours calculated for four patients, who had initial conservative management and due to clinical deterioration were recorded to the surgical group, and six patients, who we had the chance to do for them 2nd CT brain before surgery, was $27 \pm 2.36 \text{ cm}^3$. The average of initial midline shift was $3.96 \pm 1.62 \text{ mm}$ while after 24 hours calculated for only ten patients who had 2nd CT brain, was $6.40 \pm 1.35 \text{ mm}$.

Regarding the site of brain contusion, in Group A, the most frequent site was parietal (28.57%) followed by temporal (23.81%), frontal (19.05%), fronto-temporal and deep (9.52%), fronto-parietal and occipital (4.76%). In Group B, the most frequent sites were parietal, and temporo-parietal (28%) followed by temporal (20%), and occipital and frontal (12%).

Figure 1 shows the frequency distribution of studied groups according to associated pathologies with brain contusion. About 47.6% and 48% of patients in Group A and Group B had no associated pathologies, respectively. Fissured fracture and subdural haemorrhage were the most frequent associated pathologies in Group A (19%) while in Group B subarachnoid haemorrhage was the most frequent associated pathology (32%).

The average GOS was 3.9 ± 1.04 at discharge and 4.2 ± 1.1 at 3 months follow up for group A, while the average GOS was 3.68 ± 1.4 at discharge and 4.19 ± 1.12 at 3 months follow up for Group B. The average duration of hospital stay was 6.28 ± 3.24 days and 10.64 ± 6.09 days for Groups A and B, respectively. All patients in Group A who presented with neuro deficit were improved, while 53.85% of Group B patients with neuro deficit showed improvement. About 9.52% and 20% of Group A and Group B were died, respectively.

Table 2 shows significant negative correlations between the duration of hospital stay and initial GCS score in Group A ($\rho = -0.86$; $P < 0.001$) and Group B ($\rho = -0.79$; $P < 0.001$). There were significant positive correlations between 3 months follow up GOS and the initial GCS score in Group A ($\rho = 0.73$; $P = 0.0002$) and Group B ($\rho = 0.69$; $P = 0.0001$). for Group A, the duration of hospital stay was directly correlated with the initial and 24 hours-later midline shifts ($\rho = 0.57$; $P = 0.007$). There were

significant negative correlations between 3 months follow up GOS and the initial midline shift in both Group A ($\rho = -0.53$; $P = 0.01$) and Group B ($\rho = -0.52$; $P = 0.01$).

Table 3 shows variations in the duration of hospital stay, 3 months follow up GOS, and mortality rate by demographic and clinical characteristics of patients in Group A. There were significant differences in the duration of hospital stay and 3 months follow up GOS by the grades of initial GCS ($P = 0.004$ and $P = 0.003$, respectively).

Table 4 shows variations in the duration of hospital stay, 3 months follow up GOS, and mortality rate by demographic and clinical characteristics of patients in Group B. There were significant differences in the duration of hospital stay by age ($P = 0.04$) with the longest duration among <15 years old patients. Female patients had longer hospital stay ($P = 0.04$). Direct head trauma caused the shortest hospital duration ($P = 0.02$). Patients with poly trauma had longer duration compared to those with local trauma ($P = 0.01$). Patients with severe head injury (initial GCS 3-8) had the longest hospital stay ($P = 0.0037$). The 3 months GOS was higher among males ($P = 0.04$) and patients with direct head trauma ($P = 0.016$).

Figure 2 shows ex., of a case of group (A), figure 3 shows ex., of a case of group (B)

DISCUSSION

Brain contusions are the most frequent type of post-traumatic intracerebral lesions and because they usually occur in combination with other types of hematoma, it is difficult to collect a pure series of patients with isolated brain contusions.[11] Unlike most of previously published studies, our study included those patients with brain contusion as the main lesion to evaluate the factors that may predict its possible clinical and radiological progression and the need for surgical intervention and how such predictors may influence the functional outcome in them.

In the present study, in group A, GOS at 3 months follow up had significant positive correlation with the initial GCS score and significant negative correlation with the initial midline shift. the duration of hospital stay had significant negative correlation with initial GCS score and was significantly direct correlated with the initial and 24 hours-later midline shifts. There were significant differences in the duration of hospital stay and 3 months follow up GOS by the grades of initial GCS with the longest duration of hospital stay in patients with severe head

injury (GCS=3-8) and the best GOS at 3 months follow up with mild head injury (GCS=13-15).

In group B, GOS at 3 months follow up was higher in males than females and in patients with direct head trauma than those with polytrauma, with significant positive correlation with initial GCS and significant negative correlation with the initial midline shift. And the duration of hospital stay was longer in female patients, in patients with poly-trauma compared to those with local trauma and the patients with severe head injury (initial GCS 3-8) had the longest hospital stay and there were significant differences in the duration of hospital stay by age with the longest duration among <15 years old patients.

Iaccarino C. et al., reported that in traumatic brain injury patients with brain contusion, the beginning of clinical deterioration is predicted when the midline shift starts or increases and by compression of basal cisterns. The most reasonable indication for surgical intervention was a combination of clinical deterioration and increased midline shift/basal cistern compression. Only the midline shift and compression of cisterns were able to describe with accuracy the brain compression leading to clinical deterioration. [12] which is in accordance with our results regarding clinical deterioration together with increase in midline shift to 5 mm or more in follow up CT brain as indication for surgery.

Chiewvit P. et al., found that the increased midline shift in CT brain in patients with head trauma related to the severity of head injury and was significantly related to poor final clinical outcome. [13] This also in accordance with our findings where the more midline shift, we had in initial or follow up CT was associated with bad GCS and we found that GOS at 3 months follow up had significant negative correlation with the initial midline shift. and significant positive correlation with the initial GCS score in both groups A and B.

Although Neşe Keser, reported that the age had a significant effect on mortality and it increases with increasing age.[14] We couldn't proof such association in our study may be due to limited number of our cases, but it is worthy to mention that in Group B, we found significant differences in the duration of hospital stay by age ($P = 0.04$) with the longest duration in patients <15 years old.

Alahmadi H. et al., reported that not all patients with hematoma progression subsequently showed clinical deterioration. [15] While Narayan RK et al., documented a link between increase in hematoma

volume and clinical deterioration.[16] In our study, in both groups A and B, we observed that initial and follow up volumes of brain contusion had a negative correlation with GOS at 3 months follow up and a direct correlation with duration of hospital stay.

Until now the factors currently used as guidelines typically include clinical deterioration, hematoma progression, and increased ICP (in monitored comatose patients). [17]

Smith J S. et al., reported that 5% of the patients of his study required surgery after routine follow-up CT brain showing delayed cerebral contusions and those patients always had associated clinical changes. [18] In our study we had 4 patients treated conservatively based on their clinical status and initial CT brain findings on admission and within their 1st 24 hours follow up they showed neurological deterioration and new radiological findings on their follow up CT and they underwent surgery and reported in group B of our study although they were classified initially as group A.

Alahmadi H et al., reported that about half of the brain contusions managed conservatively would progress radiologically during follow up. but, not all of them showed clinical deterioration or required surgery [15] and we may explain that in some of those patients the changes in radiological findings may not reach the level enough to justify brain compression and clinical deterioration so will be no need for surgery in them.

The main limitations of this study were the small number of patients included and short term follow up and these to be considered in future studies.

Conclusion: in patients with post-traumatic brain contusion, initial GCS, radiological findings (initial and follow up midline shifts, initial and follow up brain contusion volumes) and mechanism of trauma are the most important predictors of functional outcome and also the duration of hospital stay. A combination of clinical deterioration with increased midline shift and/or increased volume of brain contusion are the most reasonable indications for surgical intervention in such patients.

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Authorship

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acquisition of data, analysis and interpretation of data, (2) drafting the article and revising it for important intellectual content, (3) final approval of the version to be submitted.

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