Degree of Midline Shift from CT Scan Predicted Outcome in Patients with Head Injuries

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Objective: *To evaluate the relationship between the degree of midline shift by Computed Tomography (CT) finding and Glasglow Coma Score (GCS) as a predictive of clinical outcome in patients after head injury.*
Method and Method: *The present study was performed by retrospectively reviewing 216 consecutive cases of traumatic head injury admitted to the trauma center in Siriraj Hospital from 1999 until 2004. All patients were evaluated for level of consciousness by a neurosurgeon determining by GCS and underwent CT brain for evaluation of intracranial hemorrhage and midline shift. The final clinical outcome was also divided into two groups; good outcome for the patients who recovered well with moderate disability and the poor outcome for the patients who suffered severe disability, vegetative status and death. Then, the authors compared midline shift vs. GCS and midline shift vs. clinical outcomes.*
Results: *Total of 216 cases, the three most common types of head injury were motorcycle accident, fall or assault and car accident. 96 of 216 patients had midline shifting, 53 of 96 patients had CT scan of midline shifting less than 10 mm whereas 37 of 96 patients had a CT scan of greater than 10 mm of midline shifting. 63.3% with midline shifting up to 10 mm had severe head injury and up to 81% with brain shifting greater than 10 mm had severe head injury. The clinical outcome also showed that poor clinical outcomes correlated to midline shifting greater than 10 mm.*
Conclusion: *The increased degree of midline shift in patients with head injuries by CT scan was related to the severity of head injury (GCS = 3-12) and was significantly related to poor final clinical outcome.*

Keywods: *Degree of Midline shifted, CT scan, Glasglow Coma Score, Head Injury*

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Degree of midline shift after traumatic brain injury is widely recognized as an important marker of severe injury. Numerous reports describe the association of a large amount of midline shift on Computed Tomography (CT) scan with poor outcome or other adverse sequelae of traumatic brain injury[1,5-10]. A study by Englander J, et al[2] in 2003 concluded that the presence of either a midline shift greater than 5 mm or a subcortical concussion on acute CT scan is associated with a greater need of assistance with ambulation, activities of daily living (ADLs), and global supervision at rehabilitation discharge. Although other variables such as Glasgow Coma Score (GCS), age, abnormal motor responses, other CT findings, pupillary abnormalities, and episodes of hypoxia and hypertension, have been subsequently introduced to build more complex and accurate prognostic model[4,5]. The present study was to evaluate the relationship between the degree of midline shift by CT finding and Glasglow Coma Score as a predictive of clinical outcome in patients after head injury.

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Material and Method

The present study was retrospectively reviewed in 216 consecutive cases of traumatic head injury admitted to the trauma center in Siriraj Hospital

from 1999 until 2004. The criteria for inclusion of patients in the present study were 1) all traumatic head injury patients 2) all patients who had initial cranial Computed Tomography (CT) scan after head injury 3) available clinical data recorded of initial Glasglow Coma Scores (GCS) and final clinical outcome. Cranial CT imaging of each patient was reviewed separately from the clinical information. The CT findings such as midline shifting and types of intracranial hemorrhage such as epidural hematoma, subdural hematoma, intracerebral hematoma and diffuse brain injury were obtained. The degree of midline shifting was divided into three groups; no shifting (Fig. 1), midline shifting up to 10 mm (Fig. 2) and midline shifting greater than 10 mm (Fig. 3). Clinical information such as age, gender, mechanism of head injury (motorcycle accident, car accident, fall and assault, blunt injury), GCS and final clinical outcome were collected. Severity of head injury was classified into 3 subgroups:

Mild degree (GCS = 15)

Moderate degree (GCS = 13-14)

Severe degree (GCS = 3-12)

The final clinical outcome was divided into two groups; good outcome for the patients who recovered well with moderate disability and the poor outcome for the patients who suffered severe disability, vegetative status and death. Then, the authors compared midline shift vs. GCS and midline shift vs. clinical outcomes by using univariate and multivariate analysis. Description and backward stepwise multiple logistic regression method was applied to select the most appropriate statistical model to determine the predictors of the present study. Odds ratio with 95% confidence interval was used to estimate the association and strength of the determinant to the outcome.

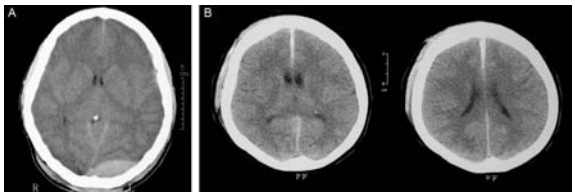

Fig. 1 A) Head injury with epidural hematoma in the left occipital region with no midline shift. B) Head injury with a small amount of interhemispheric subdural hematoma with no midline shift

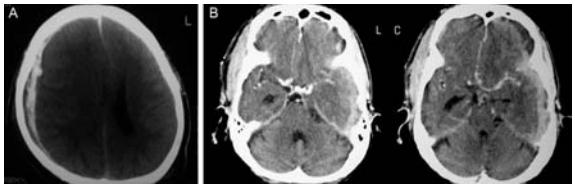

Fig. 2 A) Small amount of acute subdural hematoma in the right frontoparietal region with mild degree in midline deviation to the left side (less than 10 mm). B) Left subdural hematoma with shift of midline less than 10 mm

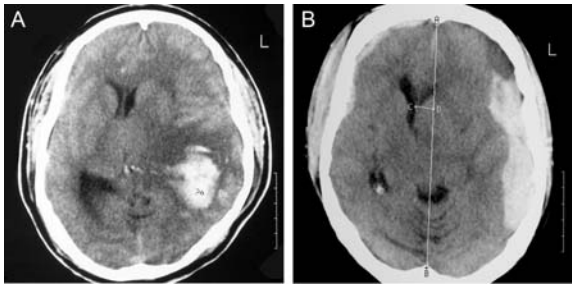

Fig. 3 A) Intracerebral hematoma with midline shift greater than 10 mm. B) Large subdural hematoma in the left frontotemporal region with midline shift greater than 10 mm

Results

Out of a total of 216 cases, the demographic data (Table 1) showed that the majority of patients with head injuries were male (n = 177) and only 39 cases were female. The three most common types of head injury were motorcycle accident (n = 102), fall and assault (n = 86) and car accident (n = 19) (Table 2). There were 137 patients with severe head injuries, 33 patients with moderate injuries and 46 patients with a mild degree of injury from initial clinical status. Cranial CT scan showed common intracranial hemorrhage associated with head injury, such as subdural hematoma (n = 100), intracerebral hematoma (n = 70) and epidural hematoma (n = 44). Among these patients 96 out of 216 patients had midline shifting, 59 of 96 patients had CT scan of midline shifting lesser than 10 mm whereas 37 of 96 patients had CT scan of greater than 10 mm of midline shifting (Table 4). The authors found that 63.3% with midline shifting up to 10 mm had severe head injury (GCS = 3-12) and up to 81% with brain shifting greater than 10 mm had severe head injury (GCS = 3-12) (Table 4). The clinical outcome also showed that poor clinical outcomes correlated to midline shifting greater than 10 mm (Table 3, 5).

Table 1. Demographic characteristic of patients brain injury with midline shift

	Total (n = 216)	No shift (n = 120)	Shift up to 10 mm (n = 59)	Greater than 10 mm (n = 37)
Age (years)	35.7	32.29	37.88	42.02
Sex	M = 177	M = 99	M = 48	M = 30
	F = 39	F = 21	F = 11	F = 7
Mechanism	MCA = 104	MCA = 58	MCA = 27	MCA = 18
	Car = 19	Car = 16	Car = 3	Car = 0
	Fall = 52	Fall = 20	Fall = 18	Fall = 14
	Blunt = 35	Blunt = 21	Blunt = 10	Blunt = 3
	Other = 8	Other = 5	Other = 1	Other = 2
GCS (8 or more)	148	85	43	18
Surgery	102	28	45	29
CT scan				
SDH	100	30	37	33
EDH	44	16	20	8
ICH	70	34	27	9
DAI	15	11	2	2
Final outcomes				
Complete	28	20	4	4
Improve	141	84	39	18
Death	47	16	16	15

MCA = motor cycle accident, SDH = subdural hematoma, EDH = epidural hematoma, ICH = intracerebral hematoma, DAI = diffuse axonal injury

Table 2. Causes of head injury were also related to age

		5 mechanisms relate to head injury					Total
		MCA	CAR	FALL	Hit or blunt object	Other or missing	
Age group	0-20 yr	27	1	8	8	3	47
	21-40 yr	47	9	14	19	1	90
	41-60 yr	20	7	15	7	2	51
	> 60 yr	8	2	15	-	3	28
Total		102	19	52	34	9	216

Discussion

Some authors such as Gan BK et al[11] indicated that age and sex play a major role in the prognosis of head injury and also showed that the mortality rate of the elderly group was slightly more than double that of the younger group and age must be considered an independent factor in outcome prediction in the elderly with moderate and severe traumatic brain injury. In study by Shameran Slewa-Younan et al they concluded that men's levels of injury severity were greater than women's despite the same admission criteria being applied to both sexes[12]. The present study found that causes of head injury were also related to age groups (p = 0.001): MCA was the highest (26.5%) in group I (0-20 years), hit or blunt objected assault was the highest (55.9%) in group II (21-40 years), car accident was the highest (36.8%) in group III (41-60 years) and fall was the highest (28.8%) in group IV (> 60 years).

GCS (Glasgow Coma Scale score) from Scottish Intercollegiate Guideline Network (SIGN) 2000 was found to have a predictive factor of outcome following statistical analysis[13]. The GCS score was well correlated with outcome in which higher mortality was associated with a lower GCS score (p = 0.0001).

Table 3. CT scan result and outcome of patients with head injury

CT scan result	Discharge status				Total
	Complete recovery	Improve	Death	Missing	
Normal	5	27	-		32
SDH	3	16	3	1	22
EDH	3	14	3		20
SAH	1	11	1		13
ICH and Contusion	3	21	2		26
SDH with midline shift	5	32	23		60
EDH with midline shift	3	16	4		23
IVH	-	1	-		1
Skull fracture	3	1	-		4
Severe head injury or DAI	2	0	13		15
Total	28	141	47	1	216

SDH = subdural hematoma, EDH = epidural hematoma, ICH = intracerebral hematoma, SAH= subarachnoid hemorrhage, IVH = intraventricular hemorrhage, DAI = diffuse axonal injury

Table 4. Midline shift and GCS score

Midline shift classification	GCS severity			Total
	Mild	Moderate	Severe	
No shift	31	19	69	119
Shift up to 10 mm	10	12	38	60
Shift greater than 10 mm	5	2	30	37
Total	46	33	137	216

GCS = glasgow coma score

Table 5. Midline shift and outcome

Mildline shifted classification	Discharge status				Total
	Complete recovery	Improve	Death	Miss	
No shift	19	84	17	-	120
Shift up to 10 mm	4	39	16	-	59
Shift greater than 10 mm	4	17	16	-	37
Total	27	140	49	-	216

The present study revealed that the lower GCS (≤ 12) was not statistically significant correlated with a large degree of midline shift (shift up to 10 mm and shift greater than 10 mm) in patient brain injury ($p = .061$). It found that degree of Midline shift in patients brain injury was also statistically significantly correlated with outcome ($p = .011$). GCS score has been widely adopted and used in classification of severity in head injury patients. Teasdale GM et al have demonstrated the predictive power of GCS to outcome, which was further demonstrated in the Traumatic Coma Data Bank analysis[13]. GCS score has been found to be a good indicator of outcome in many other studies including a local study by Selladurai BM et al[15] which showed

that over 95% of patients with a score of 4 or less are likely to have a poor outcome compared with those with a score of 8 or a more. In the present study, the authors demonstrated that out of 46 patients with GCS of 15, 2 had a poor outcome (13.3%) and 33 patients with GCS of 13-14, 1 case had a poor outcome (3.0%), while 136 patients with GCS score of $\leq$ 12, 46 cases had a poor outcome (33.8%). Lipper KH et al[16] showed a significant number of patients had a GCS score between 5 and 7 and that GCS was not very helpful in predicting outcome. Pupillary reflex or response to light was found statistically to be significant to outcome using both univariate and multivariate analysis in AA Azian[17]. Kido et al[18] also showed a significant relationship existed between lesion size and GCS which the larger lesion enabled prediction of lower GCS scores (p = 0.02).

The multivariate analysis showed statistically significant variables to outcome included ICH, EDH, SDH, IVH, SAH as well as midline shift (Table 7). CT undoubtedly allows rapid diagnosis of hematomas and classification of intracranial pathology. The number and distribution of CT findings was associated with differential outcome. Different methods of classification of intracranial injury as seen on CT have been utilized by different researchers in their study to predict prognosticate outcome following head injury. Some of the classifications were according to the anatomical site of the hematomas[17]. The present study used the midline shift, which was also demonstrated in Athiappan et al[25] and Toutant et al[19], which found that 16 of 37 cases (43.2%) died, 17 cases improve in patients brain injury with midline shift greater than 10 mm, 16 cases of 59 cases died (27%) 39 cases improved

Table 6. Association between sex, ages, degree of midline shift, CT scan finding, GCS score and outcome in patients with head injury

Variables	Results					
	Good		Death		χ^2	p-value
	n (166)	%	n (50)	%		
Age (years)						
< 60	148	78.3	41	21.7	1.502	NS
≥ 60	19	67.9	9	32.1		
Sex						
Male	136	77.0	41	23.0	<0.001	NS
Female	30	76.9	9	23.0		
Midline shift						
No shift	101	60.8	18	36.0	13.01	0.001
Shift up to 10 mm	44	26.5	16	32.0		
Shift greater than 10 mm	21	12.7	16	32.0		
CT scan finding						
Normal & other	49	98.0	1	2.0		
SDH	19	82.6	4	17.4		
EDH	17	85.0	3	15.0	13.01	0.001
ICH	24	92.3	2	7.7		
SDH with Midline shift	37	61.7	23	38.3		
EDH with Midline shift	19	82.6	4	17.4		
Severe head injury or DAI	1	7.2	13	92.8		
GCS score						
Mild injury	47	95.9	2	4.1	24.56	<0.001
Moderate injury	31	93.9	2	6.1		
Severe injury	88	65.7	46	34.3		

NS = non significant (p-value < 0.05)
SDH = subdural heamatoma, EDH = epidural heamatoma, ICH = intracerebral heamatoma, DAI = diffuse axonal injury

Table 7. Univariate analysis showed the relationship between independent variables by logistic regression with p-value, Odds ratios (OR) and 95% confidence intervals (95% CI) for predicting outcome of patients with head injury

Variables	p-value	Death (%)	Crude odds ratio (OR)	95% CI
Age (years)	0.224			
< 60		21.7	1	-
≥ 60		32.1	1.71	(0.72-4.1)
Sex	0.268			
Male		23.0	1	-
Female		23.0	1.94	(0.59-6.28)
Midline shift	0.001			
No shift		14.9	1	-
Shift up to 10 mm		27.6	2.33	(1.08-5.03)
Shift greater than 10 mm		42.1	4.45	(1.95-10.13)
CT scan finding	<0.001			
Normal & other		2.0	1	-
SDH		17.4	10.30	(1.08-98.07)
EDH		15.0	8.63	(0.84-88.62)
ICH		7.7	4.07	(0.35-47.19)
SDH with Midline shift		38.3	30.42	(3.93-235.07)
EDH with Midline shift		17.4	10.30	(1.08-98.07)
Severe head injury or DAI		86.7	318.09	(26.74-3783)
GCS score	0.001			
Mild injury		4.1	1	-
Moderate injury		6.1	1.51	(0.20-11.33)
Severe injury		34.1	12.14	(2.82-52.25)

Table 8. Multivariate analysis for outcome correlation between CT scan finding, brain with midline shift, GCS score and outcome in patients with head injury. Adjusted Odd ratio by Logistic Regression analysis

Variables		95% CI			
		OR	Lower	Upper	p-value
CT scan finding <0.001	SDH	13.588	1.241	148.806	
	EDH	14.326	1.302	157.681	
	ICH	3.887	0.328	46.011	
	SDH with MS	30.942	3.910	244.862	
	EDH with MS	11.232	1.136	111.014	
	SHI or DAI	201.513	16.77	2421.23	
GCS score	Mild	1			0.001
	Moderate	1.71	0.217	13.587	
	Severe	10.42	2.244	48.435	
Midline shift	No shift	1			0.731
	Shift up to 10 mm	2.18	0.299	15.84	
	Shift greater tha10 mm	2.34	0.265	20.68	
	Moderate* Shift up to 10 mm	0.446	0.008	25.83	
GCS * Midline shift	Moderate* Shift greater than 10mm	0.545	0.000	7.439	0.988
	Severe * Shift up to 10mm	0.564	0.028	11.30	
	Severe * Shift greater than 10mm	140.95	0.000	1.367	

SDH = subdural heamatoma, EDH = epidural heamatoma, ICH = intracerebral heamatoma, SDH with MS = subdural heamatoma with midline shift, EDH with MS = epidural heamatoma with midline shift, SHI or DAI = severe head injury or diffuse axonal injury

in patients brain injury with midline shift up to 10 mm while 17 of 121 cases died (14%) 84 cases improved in patients brain injury without midline shift. The present study showed the degree of midline shift in patients brain injury was statistically significant as a determinant of outcome (p= 0.011). It appeared that probability of poor outcome was higher when there is combination of midline shift with other type of intracranial hemorrhage, clinical factor such as sex, age GCS score and associated injury. The similar results were also demonstrated by Gennarelli et al[20] and Lobato et al[21] which pointed out that the type of lesion is an important factor in determining the outcome as the severity of injury assessed by GCS. The degree of Midline shift was found to be not significant in relation to GCS score in the present study (p = 0.061). This meant that a larger midline shift tends to be not associated with a lower GCS score.

The present study found that the presence of midline shift especially with SDH was significant. This meant that the outcome would be poorest if the midline shift with SDH compared to other lesion in patients with brain injury. Reviews by V Juran et al showed that SDH with Midline shift treatment was possible in certain cases. It could be successful in smaller hematomas in patients in a good clinical condition but also in smaller in those comatose patients where the Midline shift is most likely caused by brain edema and contribution of brain compression is small. Significant correlation was observed between CT findings of lesion, EDH, SDH with Midline shift with the GCS score. This is similar to other study in which CT scan finding of SDH as well as GCS score was found to be the most important prognostic variable to predict outcome. Although, E.Gaitur pointed out that outcome depended not only on the combination of clinical and CT feature, but on application of accurate criteria for conservative or surgical treatment, diagnostic possibilities, intensive therapy methods and surgical management optimization as well.

However, in the present study the mortality rate was found to be significantly greater in patients with SDH with midline shift (p = 0.001). Yamaura et al noted a higher mortality when SDH was associated with the presence of parenchyma lesion[23]. A poorer outcome was observed in the present study when SDH were associated with midline shift (38.33%) than without Midline shift (13.04%), while poorer outcome when EDH was associated with Midline shift (17.39%) than without midline shift (7.69%). 24(92.3%) out of 26 patients with hemorrhagic contusion had a good outcome, which is quite similar with the analysis by Kunishio where 66.7% of their patients with contusion had a good outcome[24].

Out of 216 cases in the present study, 96 cases showed evidence of midline shift. Out of the 96 cases, 32 patients (33.3%) died while the remaining 64 patients (66.6%) had a good outcome (Table 6). The present study showed in contrast to other studies[21,22], which revealed that midline shift was a significant predictor of mortality. Mass effect, a factor closely related to hematoma size, which can be measured simply as midline shift has been known to correlate closely with outcome. The present study showed a similar result to a study by Narayan[22], the extent of midline shift did not add significantly to the prognostic capability of their model. Selladurai also noticed that the degree of midline shift did not prove to be of a predictive significance[15]. Of all the patients with midline shift, 29 patients (30.2%) had a GCS score of 12-15 while 68 patients (70.8%) fell into the GCS score < 12 which is the unfavorable group. The present study analysis found that the GCS score was a predictive factor as well as midline shift (p = 0.001) in patients traumatic brain injury on the combination of clinical and CT features.

Conclusion

The increased degree of midline shift in patients with head injuries by CT scan was related to the severity of head injury (GCS = 3-12) and was significantly related to poor final clinical outcome.

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ระดับของการเคลื่อนจากกึ่งกลางของถ่ายภาพรังสีส่วนตัดกะโหลกอาศัยคอมพิวเตอร์ ในผู้ป่วยที่ได้รับบาดเจ็บที่ศีรษะ สอดคล้องกับค่าระดับความรู้สึกตัวแบบกลาสโกลว์สามารถทำนายผลภายหลังการรักษาได้

พิพัฒน์ เชี่ยววิทย์, สิริอร ตริตระการ, ศรัณย์ นันทอารี, สุทธิศักดิ์ สุทธิพงษ์ชัย

วัตถุประสงค์: *เพื่อศึกษาความสัมพันธ์ระหว่างระดับของการเคลื่อนจากกึ่งกลางของภาพถ่ายรังสีส่วนตัดกะโหลกอาศัยคอมพิวเตอร์และค่าระดับความรู้สึกตัวแบบ กลาสโกลว์ในผู้ป่วยที่ได้รับบาดเจ็บที่ศีรษะ*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาย้อนหลังในผู้ป่วยจำนวน 216 ราย ที่เข้ามารับการรักษาภาวะบาดเจ็บที่ศีรษะ ณ โรงพยาบาลศิริราชในช่วงปี พ.ศ. 2542 ถึง ปี พ.ศ. 2547 ผลการรักษาถูกแบ่งเป็น 2 กลุ่ม ระหว่างกลุ่มที่ผลการรักษาดี และผลการรักษาไม่ดี การศึกษานี้ได้ทำการศึกษาเปรียบเทียบการเคลื่อนจากกึ่งกลางของภาพถ่ายรังสีส่วนตัดกะโหลกอาศัยคอมพิวเตอร์และค่าระดับความรู้สึกตัวแบบกลาสโกลว์และผลของการรักษา*

ผลการศึกษา: *จากจำนวนผู้ป่วยทั้งสิ้น 216 ราย พบว่าสาเหตุที่พบบ่อยที่สุดสามอันดับแรก ของภาวะบาดเจ็บที่ศีรษะ ได้แก่ อุบัติเหตุจากรถมอเตอร์ไซด์ ผู้ป่วยล้มศีรษะกระแทกรวมทั้งถูกทำร้ายและผู้ป่วยอุบัติเหตุจากรถยนต์ มีผู้ป่วยจำนวนถึง 96 ราย ที่มีการเคลื่อนจากกึ่งกลางของภาพถ่ายรังสีส่วนตัดกะโหลกอาศัยคอมพิวเตอร์ ในจำนวนนี้มีผู้ป่วย 60 ราย ที่มีการเคลื่อนจากกึ่งกลางของภาพถ่ายรังสีส่วนตัดกะโหลกอาศัยคอมพิวเตอร์น้อยกว่า 10 มิลลิเมตร และมีผู้ป่วยอีก 37 ราย ที่มีการเคลื่อนจากกึ่งกลางของภาพถ่ายรังสี ส่วนตัดกะโหลก อาศัยคอมพิวเตอร์ มากกว่า 10 มิลลิเมตร จากการศึกษาพบว่า 63% ของผู้ป่วยที่มีการเคลื่อนจากกึ่งกลาง ของภาพถ่ายรังสีส่วนตัดกะโหลกอาศัยคอมพิวเตอร์น้อยกว่า10 มิลลิเมตรที่มีอาการบาดเจ็บที่ศีรษะชนิดรุนแรง และมีมากถึง 81% ของผู้ป่วยที่มีการเคลื่อนจากกึ่งกลางของภาพถ่ายรังสีส่วนตัดกะโหลกอาศัยคอมพิวเตอร์มากกว่า 10 มิลลิเมตร ที่มีอาการบาดเจ็บที่ศีรษะชนิดรุนแรง และพบว่ารายที่มีการเคลื่อนจากกึ่งกลางของภาพถ่ายรังสีส่วนตัดกะโหลก อาศัยคอมพิวเตอร์มากกว่า 10 มิลลิเมตรจะมีผลการรักษาที่ไม่ดี*

สรุป: *ระดับของการเคลื่อนจากกึ่งกลางของภาพถ่ายรังสีส่วนตัดกะโหลกอาศัยคอมพิวเตอร์ที่มากเกิน 10 มิลลิเมตร ในผู้ป่วยที่ได้รับบาดเจ็บที่ศีรษะมีความสัมพันธ์กับความรุนแรง ของความบาดเจ็บที่ประเมินด้วยค่าระดับความรู้สึกตัวแบบกลาสโกลว์ และยังมีความสัมพันธ์กับผลการรักษาด้วย*