



Deep coma does not always predict poor outcomes among patients with polytrauma

Jen-Fu Huang¹ · Chun-Hsiang Ou Yang¹ · Chih-Yuan Fu¹ · Yu-Tung Wu¹

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Abstract

Purposes This study aimed to clarify the prognosis of polytrauma patients presenting to the emergency department (ED) with a Glasgow Coma Scale score (GCS) of 3.

Methods A trauma registry system has been established at our institution since 2009. The current study reviewed patients in the registry who presented to the ED with a GCS of 3 from January 2011 to December 2015. Surviving and non-surviving patients were compared to identify the prognostic factors of patient survival. The study also aimed to determine the factors contributing to patients who survived with a GCS > 13 at discharge.

Results During the study period, 145 patients were enrolled in the study, 119 of whom (82.1%) did not survive the traumatic insult. Of the 26 survivors, 13 (9.0%) had a GCS of 14 or 15 at discharge. The multiple logistic regression revealed that a lack of bilateral dilated and fixed pupils (BFDP) (OR 5.967, 95% CI 1.780–19.997, $p = 0.004$) and a GCS > 3 after resuscitation (OR 6.875, 95% CI 2.135–22.138, $p = 0.001$) were independent prognostic factors of survival. Based on the multiple logistic regression, an age under 40 years (OR 16.405, 95% CI 1.520–177.066, $p = 0.021$) and a GCS > 3 after resuscitation (OR 12.100, 95% CI 1.058–138.352, $p = 0.045$) were independent prognostic factors of a GCS > 13 at discharge.

Conclusion Aggressive resuscitation still provided benefit to polytrauma patients presenting with a GCS of 3, especially those with a rapid response to the resuscitation. Young patients with a deep coma on arrival had a higher probability of functional recovery after resuscitation in the ED.

Keywords Multiple trauma · Traumatic brain injuries · Coma · Glasgow Coma Scale · Mortality · Recovery of function

Background

Deep coma in multiple trauma patients suggests severe injury and a grave prognosis. Managing patients who present with a Glasgow Coma Scale score (GCS) of 3 can be highly challenging for trauma surgeons. These patients have a mortality rate that is higher than 80% [1, 2], and even those who survive the traumatic insults experience unsatisfactory functional outcomes and quality of life. Less than 10% of these patients are able to independently manage their own life [3, 4]. Therefore, this type of severe trauma can pose a great burden on both emergency medical services and long-term care systems [5].

Previous reports regarding the prognosis of multiple trauma patients with deep coma have been controversial. Some authors have found no reasonable chance of functional recovery [1, 2], whereas others have identified survivors with good functional recovery among multiple trauma patients with a GCS of 3 [6, 7]. Most of these studies have focused on patients with head injury. However, the level of consciousness (LOC) of trauma patients may be related to factors other than head injury. It is difficult to determine whether a head injury was the cause of a patient's deep coma status during primary evaluations in the emergency department (ED). Additionally, the decision to withdraw aggressive treatment early without further treatment effort solely because of the poor survival rate may be arbitrary. In practice, all patients with a GCS of 3 should be considered to initially respond to aggressive treatment. Every effort should be made when treating these patients.

Therefore, understanding the clinical results of severe trauma patients with deep coma would be highly beneficial.

✉ Chih-Yuan Fu
drfu5564@gmail.com

¹ Division of Trauma and Emergency Surgery, Chang Gung Memorial Hospital, 5 Fu-Xing Street, Guishan District, Taoyuan City, Taiwan, Republic of China

We conducted a retrospective study in our level I trauma center to review the clinical course of patients with a GCS of 3 in the ED. The prognostic factors for survival were identified and delineated, and the characteristics of patients who survived with good function were analyzed and discussed.

Methods

A trauma registry system was established at our institution in 2009. Patients in the trauma registry who presented to the ED with a GCS of 3 from January 2011 to December 2015 were reviewed in the current study. Patients' GCS on arrival was evaluated by the trauma surgeons immediately after they were admitted to the trauma bay, prior to any interventions. If the patients were referred from other hospitals, a GCS of 3 when presenting to the first hospital had to be confirmed on the referral sheet. Patients were then managed according to the principles of Advanced Trauma Life Support (ATLS). The exclusion criteria were as follows: (1) Age under 18 years; (2) Mechanism of trauma of penetration, burn, electric injury or hanging; (3) Cardiac arrest upon arrival to hospital; (4) Blood alcohol level over 30 mg/dl or not available; (5) Any substance use; and (6) An incomplete medical record.

Demographic data, the mechanism of trauma, conditions on arrival (vital signs, LOC), the primary evaluation results, response to resuscitation, the results of imaging studies, subsequent treatment (surgical or radiologic interventions), hospital course and clinical outcome were collected routinely. The Abbreviated Injury Scale (AIS) and the Injury Severity Score (ISS) were calculated and recorded. Surviving and non-surviving patients were compared to identify the prognostic factors of patient survival. To understand the impact of severe head injuries on deep coma patients, these patients (head AIS = 5) were analyzed in detail. Furthermore, the survivors were divided into two groups based on their LOC at discharge to determine the characteristics of patients with a good functional outcome at discharge.

In the current study, bilateral dilated and fixed pupils (BFDP) referred to a pupil diameter of more than 4 mm with no reflex to light bilaterally. Computed tomography (CT) findings of the brain were documented and included types of intracranial hemorrhage, presence of midline shift and degree of basal cistern compression. The Rotterdam CT score, which included the degree of basal cistern compression, the degree of midline shift, epidural hematomas and intraventricular and/or subarachnoid hemorrhage, was also used to evaluate the degree of brain damage [8]. Rotterdam CT scores over 4 were considered to indicate anatomically severe brain injury.

Pearson's X^2 test and Fisher's exact test were applied to compare categorical variables. Quantitative variables were compared using Student's t test or the Mann–Whitney U test.

The odds ratio (OR) and 95% confidence interval (CI) were calculated by logistic regression for qualitative variables and linear regression for quantitative variables. Statistical analyses were performed with SPSS v 21.0 for Windows (SPSS Inc., Chicago, IL, USA). A value of $p < 0.05$ was considered statistically significant.

Results

During the 60-month study period, 127,018 trauma patients were admitted to the ED of our institution. In total, 455 of these patients presented with GCS = 3 on arrival. After applying the exclusion criteria, 145 patients were enrolled in the current study.

The mean age of the study group was 50.7 years old. There were 98 males (67.6%) and 47 females. On arrival, 49 patients had a systolic blood pressure (SBP) lower than 90 mmHg. BFDP was noted in 94 patients. The associated injuries were delineated in Table 1. After receiving primary resuscitation in the ED, 32 patients reached a GCS > 3. There were 119 patients (82.1%) who did not survive the traumatic insults. Of the 26 survivors, 13 (50.0%) had a GCS of 14 or 15 at discharge. The mean hospital stay of the survivors was 44.2 days.

The surviving and non-surviving groups showed statistically significant differences in the presence of BFDP ($p < 0.001$), episodes of cardiac arrest ($p = 0.015$), a GCS > 3 after resuscitation ($p < 0.001$), ISS scores ≥ 16 ($p = 0.005$) and head AIS = 5 ($p = 0.001$) (Table 2). However, the condition on arrival (body temperature, pulse rate and SBP) did not significantly differ between the survivors and non-survivors. Furthermore, multiple logistic regression revealed that the absence of BFDP (OR 5.967, 95% CI 1.780–19.997, $p = 0.004$) and a GCS > 3 after resuscitation (OR 6.875, 95% CI 2.135–22.138, $p = 0.001$) were independent prognostic factors of survival (Table 5).

There were 101 patients with a head AIS = 5, suggesting severe head injury. Of these patients, there were statistically significant differences between the survivors and non-survivors in BFDP ($p = 0.001$) and GCS > 3 after resuscitation ($p = 0.001$) (Table 3). However, there was no significant difference in the results of the CT scans of the

Table 1 The associated injuries of the study group ($N = 145$)

	All grades (%)	AIS ≥ 3 (%)
Head (N)	130 (89.7)	126 (86.9)
Chest (N)	65 (44.8)	61 (42.1)
Abdomen (N)	24 (16.6)	11 (7.6)
Extremities (N)	52 (35.9)	17 (11.7)

AIS abbreviated injury scale

Table 2 The characteristics of trauma patients with a GCS of 3 on arrival and comparisons between surviving and non-surviving patients

	Survivors (<i>n</i> = 26)	Non-survivors (<i>N</i> = 119)	<i>p</i> value
General demographics			
Age (years)	44.46 ± 18.7	52.12 ± 21.6	0.096 [†]
Gender (<i>N</i>)			0.262 [‡]
Female	6 (23.1%)	41 (34.5%)	
Male	20 (76.9%)	78 (65.5%)	
Condition on arrival			
Body temperature (°C)	35.85 ± 1.4	35.29 ± 1.8	0.142 [†]
Pulse rate (bpm)	99.96 ± 29.1	100.71 ± 31.9	0.913 [†]
SBP (mmHg)	126.19 ± 40.8	106.74 ± 51.7	0.096 [†]
Primary evaluation and resuscitation			
BFDP (<i>N</i>)	6 (23.1%)	88 (73.9%)	< 0.001 [‡]
Episodes of cardiac arrest (<i>N</i>)	3 (11.5%)	43 (36.1%)	0.015 [‡]
GCS > 3 after resuscitation (<i>N</i>)	16 (61.5%)	16 (13.4%)	< 0.001 [‡]
Severity of injuries			
ISS ≥ 16 (<i>N</i>)	23 (88.5%)	119 (100.0%)	0.005*
Head AIS = 5 (<i>N</i>)	11 (42.3%)	90 (75.6%)	0.001 [‡]

SBP systolic blood pressure, BFDP bilateral fixed and dilated pupils, GCS Glasgow Coma Scale, ISS Injury Severity Score, AIS abbreviated injury scale

[†]Independent samples t-test

[‡]Chi square test

*Fisher's exact test

Table 3 Comparisons between surviving and non-surviving patients with severe head injury (head AIS of 5)

	Survivors (<i>n</i> = 11)	Non-survivors (<i>N</i> = 90)	<i>p</i> value
General demographics			
Age (years)	48.09 ± 19.9	52.40 ± 21.5	0.528 [†]
Gender (<i>N</i>)			0.326 [‡]
Female	2 (18.2%)	32 (35.6%)	
Male	9 (81.8%)	58 (64.4%)	
Condition on arrival			
Body temperature (°C)	35.86 ± 1.74	35.34 ± 1.79	0.362 [†]
Pulse rate (bpm)	92.72 ± 24.75	101.64 ± 31.91	0.374 [†]
SBP (mmHg)	126.27 ± 49.99	114.97 ± 50.15	0.482 [†]
Primary evaluation and resuscitation			
BFDP (<i>N</i>)	3 (27.3%)	72 (80.0%)	0.001 [‡]
Episodes of cardiac arrest (<i>N</i>)	1 (9.1%)	26 (28.9%)	0.280 [‡]
GCS > 3 after resuscitation (<i>N</i>)	7 (63.6%)	13 (14.4%)	0.001 [‡]
Results of CT brain scans			
Rotterdam CT scale ≥ 4 (<i>N</i>)	8 (72.7%)	81 (90.0%)	0.122 [‡]
Subdural hematoma (<i>N</i>)	7 (63.6%)	71 (78.9%)	0.266 [‡]
Intracerebral hematoma (<i>N</i>)	4 (36.4%)	33 (36.7%)	1.000 [‡]
Epidural hematoma (<i>M</i>)	2 (18.2%)	5 (5.6%)	0.167 [‡]
Subarachnoid hemorrhage (<i>N</i>)	9 (81.8%)	70 (77.8%)	1.000 [‡]
Midline shift (<i>N</i>)	4 (36.4%)	56 (62.2%)	0.115 [‡]
Intraventricular hemorrhage (<i>N</i>)	4 (36.4%)	16 (17.8%)	0.221 [‡]
Basal cistern compression (<i>N</i>)	9 (81.8%)	86 (95.6%)	0.127 [‡]

AIS abbreviated injury, scale, SBP systolic blood pressure, BFDP bilateral fixed and dilated pupils, GCS Glasgow Coma Scale

[†]Independent samples t-test

[‡]Fisher's exact test

brain (Rotterdam CT scale and findings of CT scan). The same prognostic factors for survival were found in the multiple regression analysis of patients with a head AIS = 5, namely, absence of BFDP (OR 6.621, 95% CI 1.459–30.048, $p=0.014$) and GCS > 3 after resuscitation (OR 6.100, 95% CI 1.412–26.352, $p=0.015$) (Table 5).

Regarding the evaluation of patients with good functional outcomes, comparisons between the survivors with and without a GCS > 13 at discharge are shown in Table 4. Patients under 40 years of age ($p=0.005$) or with a GCS > 3 after resuscitation ($p=0.016$) had a significantly higher probability of a GCS > 13 at discharge. After the multiple logistic regression, an age under 40 years (OR 16.405, 95% CI 1.520–177.066, $p=0.021$) and GCS > 3 after resuscitation (OR 12.100, 95% CI 1.058–138.352, $p=0.045$) were independent prognostic factors of a GCS > 13 at discharge (Table 5).

Discussion

Most patients with a GCS of 3 at the ED are likely to die or have poor functional recovery, especially those with irreversible head injuries. Previous studies have indicated a high mortality rate of 80–90% among these patients, and only 5% of patients presenting with a GCS of 3 have been shown to attain good functional outcomes [4]. The current study also

Table 5 Multiple logistic regression analysis of the independent prognostic factors of survival/consciousness in different groups

	Odds ratio	95% CI	p value
Independent prognostic factors of survival in all patients ($N=145$)			
No BFDP	5.967	1.780–19.997	0.004 [†]
GCS > 3 after resuscitation	6.875	2.135–22.138	0.001 [†]
Independent prognostic factors of survival in severe head injury patients ($N=101$)			
No BFDP	6.621	1.459–30.048	0.014 [†]
GCS > 3 after resuscitation	6.100	1.412–26.352	0.015 [†]
Independent prognostic factors of GCS > 13 at discharge in survivors ($N=26$)			
Age over 40 years	16.405	1.520–177.066	0.021 [†]
GCS > 3 after resuscitation	12.100	1.058–138.352	0.045 [†]

BFDP bilateral dilated and fixed pupils, GCS Glasgow Coma Scale

[†]Logistic regression

reported a high mortality rate of 82.1% and good functional recovery of 9.0% among trauma patients with a GCS of 3 at the ED. ED physicians and trauma surgeons face a dilemma between aggressive treatment and early withdrawal of treatment due to these poor outcomes. Therefore, clinicians must be able to precisely predict a patient's clinical outcome for appropriate use of medical resources.

Trauma patients' LOC can be influenced by various factors, including oxygenation status, hemodynamics, central

Table 4 The characteristics of surviving patients and comparisons between patients with and without consciousness at discharge (GCS > 13)

	GCS ≤ 13 ($n=13$)	GCS > 13 ($n=13$)	p value
General demographics			
Age (years)	55.31 ± 18.22	33.62 ± 11.96	0.001 [†]
Age > 40 (N)	9 (84.6%)	4 (30.8%)	0.005 [‡]
Gender (N)			0.645*
Female	4 (30.8%)	2 (15.4%)	
Male	9 (69.2%)	11 (84.6%)	
Condition on arrival			
Body temperature (°C)	35.74 ± 1.19	35.96 ± 1.62	0.692 [†]
Pulse rate (bpm)	91.92 ± 19.99	108.00 ± 35.03	0.164 [†]
SBP (mmHg)	138.62 ± 33.65	113.77 ± 44.80	0.123 [†]
Primary evaluation and resuscitation			
BFDP (N)	2 (15.4%)	4 (30.8%)	0.645*
Episodes of cardiac arrest (N)	2 (15.4%)	1 (7.7%)	1.000*
GCS > 3 after resuscitation (N)	5 (38.5%)	11 (84.6%)	0.016 [‡]
Severity of head injuries			
Rotterdam CT scale ≥ 4 (N)	4 (30.8%)	5 (38.5%)	1.000*
Head AIS ≥ 5 (N)	7 (53.8%)	4 (30.8%)	0.234 [‡]

SBP systolic blood pressure, BFDP bilateral fixed and dilated pupils, GCS Glasgow Coma Scale, AIS abbreviated injury scale

[†]Mann–Whitney U test

[‡]Chi-square test

*Fisher's exact test

nervous system damage and substance use. Therefore, the current ATLS guidelines state that the primary evaluation should emphasize the assessment and management of the patients' "airway", "breathing" and "circulation" prior to their "disability". In other words, as deep comas may not only result from head injury, patients should benefit from prompt airway management, adequate ventilation and stabilization of hemodynamics. Patients may regain consciousness after any affected conditions have been corrected. In the current study, although severe head injury (head AIS = 5) was the major cause of mortality (89.1%), patients who died also had a significantly higher percentage of ISS scores ≥ 16 , which indicated more severe associated injuries (100.0 vs 88.5% in survivors, $p = 0.005$).

In this study, a GCS > 3 after resuscitation was an independent prognostic factor of survival (61.5% in survivors vs 13.4% in non-survivors, $p < 0.001$, odds ratio = 6.875). This finding indicated that patients in deep coma with a GCS > 3 after basic resuscitation had a better chance of survival. In 1991, Waxman et al. noted a poor correlation between GCS at admission and clinical outcome, with 10 of 117 patients with a GCS of 3 on presentation exhibiting a good recovery [9]. Pal et al. suggested that a patient's GCS score 6 h after injury could be a more accurate assessment of multiple injury trauma patients with head injury [10]. Chadhuri et al. analyzed paramedics' records of patients' GCS at the scene and after basic resuscitation and found that all survivors had at least 1 pre-hospital GCS score greater than 3 [11]. Another study on intensive care unit (ICU) patients by Jain et al. concluded that patient outcomes were significantly affected by an increase in GCS of at least 2 points 24 h after admission, adequate spontaneous respiration and brisk pupillary light reactivity on admission. The survival rate increased from 6.1 to 57.1% when all three factors were present [12]. Moreover, a GCS > 3 after resuscitation was also a significant prognostic factor of survival of patients with severe head injury in this study (head AIS = 5) ($N = 101$) (63.6% vs 14.4%, $p = 0.001$, odds ratio = 6.100). In other words, timely resuscitation was beneficial even for patients with severe head injury. Multiple trauma patients with compromised consciousness may recover after receiving adequate ventilation and perfusion, and thus, early withdrawal of treatment would be inappropriate for these patients during their primary evaluation in the ED.

Several studies on managing trauma patients with deep coma on arrival have sought to identify the characteristics of patients who suffered from irreversible injuries and had no reasonable chance of survival. Pupillary status was an easily accessed and frequently used parameter for identifying patients who were beyond salvation. Lieberman et al. found that none of their patients with a GCS of 3 and BFDSP survived [1]. Tien et al. reported the same findings [2]. Additionally, Choi et al. demonstrated that no patients

with an abnormal pupillary response and a GCS motor score lower than 2 had a functional recovery after surviving [13]. On the other hand, Chaumon et al. found an even lower mortality rate of 79.7% and a good outcome rate of 1.5% in these patients. They proposed that the lower mortality might be due to the aggressive surgical strategy applied [7]. In the Trauma Registry of the German Society for Trauma Surgery, patients presenting with a GCS of 3 as well as fixed and dilated pupils from 1993 to 2009 had a mortality rate of 87.0% and a good outcome rate of 8.0% [14]. In the current study, although BFDSP was an indicator of mortality due to severe and irreversible brain damage, there were still six surviving patients with a GCS of 3 and BFDSP, three of whom had good functional outcomes. Therefore, it appears that pupillary abnormalities do not always indicate irreversible brain damage and should thus not be used as a single predictor of patient outcomes. Aggressive resuscitation without any delay played a key role in patient survival.

In modern medicine, prolonged life is not the only objective pursued; the importance of quality of life and functional recovery cannot be overemphasized. Younger patients were found to have a better chance of survival and functional recovery. Quigley et al. reported that of the 248 patients with a GCS of 3 at admission and pupillary abnormalities, 5 survived, 3 of whom were younger than 20 years [15]. Chaudhuri et al. also found that the survivors in their study were all younger than 28 years, and the four youngest survivors achieved a good outcome [11]. Regarding functional recovery, patients with a GCS > 13 at discharge were significantly younger than patients with a GCS ≤ 13 at discharge (33.62 ± 11.96 years old vs 55.31 ± 18.22 years old, $p = 0.001$). Furthermore, patients under 40 years old had better functional outcomes (69.2 vs 30.8% of patients older than 40 years, $p = 0.005$). On the other hand, the results of the current study revealed that there was no significant difference in the severity of head injury between patients with good and bad functional outcomes. Therefore, aggressive resuscitation and treatment should be recommended in young patients with a GCS of 3 at ED admission, regardless of the severity of their head injury.

The limitations of this study include its retrospective nature and the limited sample size of patients from a single trauma center. Thus, selection bias may have limited our conclusions. In addition, the aggressiveness of treatment might have differed between clinicians. Furthermore, information on the long-term follow-up of patients was not available. Further studies with larger sample sizes and prospective designs are needed to clarify the clinical outcomes of the study group and to establish an appropriate management approach for trauma patients with deep coma on arrival.

Conclusion

Aggressive resuscitation still provided benefit to polytrauma patients presenting with a GCS of 3, especially those with a rapid response to resuscitation. Young patients with deep coma on arrival had a higher probability of functional recovery after resuscitation in the ED.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethics approval and consent to participate The current study was approved by Chang Gung Medical Foundation Institutional Review Board with the reference No. 201700733B0.

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