

Effectiveness of Direct Auditory Stimulation Program on Coma Arousal among Patients with Traumatic Brain Injury

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Abstract: **Background:** Coma is the main complications after traumatic brain injury. Auditory stimulation is a type of stimulation that can enhance the environment and raise comatose patients' levels of arousal and awareness. **Purpose:** to examine the effects of direct auditory stimulation program on coma arousal among patients with traumatic brain injury. **Design:** A quasi experimental (experimental / control) design. **Setting:** Neurosurgical intensive care units, Menoufia University Hospital, Menoufia. **Sample:** A convenient sample of sixty adult patients. **Instruments:** a) A Semi Structured Demographic Sheet b) Revised Trauma Score c) Bispectral Index Number d) Glasgow Coma Scale. **Result:** After intervention, GCS was significantly improved in the experimental group (13.40 ±1.22) in comparison with the control group (9.90 ±1.47) (P<0.001), Bispectral number was significantly increased in the experimental group (86.26 ±7.29) in comparison with the control group (73.06 ±7.01) (P< 0.001), and ICU length of stay was significantly reduced in the experimental group (9.630 ±2.59) compared to the control group (13.30 ±2.77) (P< 0.001). **Conclusion:** Direct auditory stimulation program affect GCS and Bispectral index number positively. **Recommendation:** Auditory stimulation program should be incorporated as a routine hospital care for comatose patients with TBI to enhance consciousness.

Keywords: Auditory stimulation, Coma arousal, Traumatic Brain Injury.

1. INTRODUCTION

Traumatic Brain Injury (TBI) is the foremost cause of mortality and morbidity in all age groups [1,2]. There were 64,362 TBI-related deaths in 2020 and roughly 223,135 TBI-related hospitalizations in 2019 [3]. In Egypt, TBI is a major public health problem, representing about 17.2% of trauma patients [4]. Traumatic brain injury arises from any external mechanical force that result in a temporary or permanent impairment of physical, cognitive and psychological function along with an altered level of consciousness [5]. The severity of traumatic brain injury can be ranged from mild, moderate to severe as it affects cell structure and function [1]. One effect of TBI is altered levels of consciousness. In general, the longer a patient is in a coma, the slower their rate of recovery will be, which could prolong their stay in the intensive care unit [6]. Disturbed conscious level classified as full consciousness, confusion, stupor, and deep coma. Coma is a severe neurologic status that affected the person, resulting in unresponsive of the surroundings and unable to react to extrinsic stimuli. The ability to respond to both external and internal stimuli is absent or diminished as a result of sensory

deprivation [7,8]. Sensory stimulation is a safe method which enhance the Reticular Activating System (RAS) in the brain and facilitates the reorganization of brain activities through creating new neural connection and allow people to interact with the environment [9]. Sensory stimulation is simple and easy to apply and considered as an attractive intervention for unconscious patients [10]. The sensory stimuli encompasses a variety of stimuli as visual, auditory, tactile, olfactory, gustatory and proprioceptive stimulations. Auditory stimulation is a simple and non-pharmacological intervention. Auditory stimulation is used to stimulate the affected neural network, accelerate brain plasticity and improve arousal in comatose patients [11,12]. Hearing is the last sense to go in comatose patients, in contrast to the other senses, and there are no barriers to inhibit this sensation, hence it has received more attention than other sensory stimuli [13]. There are various types of auditory stimulation, including recognizable music, family voices, music, TV, bells, and/or addressing the patient by name [10]. Generation of consciousness is the result of the joint action of multiple neural networks of the brain. The auditory cortex is an essential part of these networks. The activation of the auditory cortex is compared with the patient's state of consciousness and revealed that the retention of the auditory cortex may be an indicator of the retention of consciousness [11,12]. So, it can be utilized as a straight forward, practical intervention to enhance these patients' recovery and consciousness level [8].

Significance of the Study

Disorders of Consciousness (DOC) following TBI increase patient mortality, limit and delay recovery, and impose a greater economic and physical burden on patients, their families, and the community [14].

Lack of verbal communication with comatose patients may cause deterioration and delay in regaining consciousness. Talking to comatose patients is an essential method for reviving their consciousness and allow the patients to regain their awareness quickly. There is sufficient evidence that support the beneficial effect of auditory stimulation for unconscious patient; however, nurses are not communicating enough to these patients. Critical care nurses can help patients return to consciousness through these simple and non-invasive measures and protect them against isolated lifestyle after TBI [15]. Therefore, the purpose of the present research was to examine the effect of direct auditory stimulation program on coma arousal among patients with traumatic brain injury. Results from this study will enable critical care nurses to help comatose patients to improve their cognitive function and recovery outcomes.

Purpose of the Study

The purpose of the current study was to examine the effect of direct auditory stimulation program on coma arousal among patients with traumatic brain injury.

Research Hypotheses

1. Comatose patients who receive the direct auditory stimulation program are more likely to have higher score of Glasgow Coma Scale compared to patients who do not receive the intervention.
2. Comatose patients who receive the direct auditory stimulation program are more likely to have higher score of the Bispectral Index compared to the control group.
3. Comatose patients who receive the direct auditory stimulation program (experimental group) are more likely to experience less ICU length of stay than the control group.
4. There is a relationship between Glasgow Coma Scale Score and ICU length of stay.

2. METHODOLOGY

Research Design

A quasi experimental (experimental / control) design was utilized.

Setting

The research was carried out in the neurosurgical intensive care units, at Menoufia University Hospital, Shebin El-Kom, Menoufia.

Sample

A convenient sample of 60 participants was approached over 11 months. These patients met the following criteria a) Adults, age 18- 65 years, b) Admitted to neurosurgical intensive care units, c) Patients who had Bispectral index number more than 60. Patients were excluded if they had any of the following conditions: a) history of past neurological illness or disturbance of auditory function because those patients cannot respond to the designed auditory stimuli; b) Non-traumatic coma, c) history of cardiac arrest of longer than four minutes because their brain function may be affected as a result of prolonged hypoxia, d) patients who have brainstem infarction, e) auditory area radiological affection reflected by CT or MRI.

Sample Size calculation:

Sample size was determined using power analysis. A 80% power to reveal a variation in the percentage of cases receiving the direct auditory stimulation program of at least 20% between groups, using a two-sided test and a 5% significance level and large effect size of 0.65. Large effect size was utilized to estimate the sample size in the current study because a greater effect of the direct auditory stimulation program was anticipated based on previous findings [9]. To test the study hypotheses, a sample size of 50 was adequate. Ten cases were added to compensate for the attrition rate. Therefore; the final decided sample was 60 participants.

INSTRUMENTS**I) A Semi Structured Demographic Sheet**

The investigator developed a demographic sheet to gather data, such as patient's age, gender and length of ICU length of stay. This information was obtained from the patient's medical records.

II) The Revised Trauma Score (RTS)

Developed by Champion et al (1989) [16] to assess the absolute survival probability of traumatic patients. The score includes three continuous measurements, Glasgow Coma Scale, Systolic Blood Pressure, and Respiratory Rate. It ranged between 0 and 7.8408, the highest score reflect increased the survival rate. A score of less than 3 indicates that survival is exceedingly unlikely, regardless of intervention. The scores of the GCS ranged from 3 (score 0) to 13-15 (score 4). The systolic blood pressure result varies from 0 mmHg (score 0) to more than 89 mmHg (score 4) and respiratory rate result varies from 0 cycle per minute (score 0) to 10-29 cycle per minute (score 4).

Revised Trauma Score = (0.9368 x GCS Value) + (0.7326 x SBP Value) + (0.2908 x RR Value)

At a fixed sensitivity of 90%, the RTS is shown to be a more reliable predictor of death than the Kampala Trauma Score (KTS), with statistical significance only being obtained for an enhanced specificity (67% vs. 47%; p 0.001) [17].

Pearson Product Moment Correlations used to examine the RTS's validity in the current study. Based on the significant value produced by the internal consistency ($r = 0.864$, $p < 0.001$) and the two-tailed P-value < 0.05

Bispectral Index

A parameter developed by Aspect Medical Systems, Inc in 1994 derived from the electroencephalogram (EEG) parameter that was developed specifically to assess patient response during sedation and anesthesia and to measure depth of sedation and arousal [18]. The bispectral index number ranging from 0 which indicate isoelectric EEG and totally suppressed patient up to 90-100 which indicates awake and responding to verbal stimuli. Each numerical range correlates to a degree of sedation as the follow: Isoelectric EEG (score 0), Deep hypnotic level (score less than 40), Moderate hypnotic level (score from 40 to less than 60) and Awake Sedated (score from 60 to 100) [19].

A correlation was observed between BIS and Richmond Agitation- Sedation Scale (RASS) to evaluate the depth of sedation in ICU patients undergoing Flexible Fibroptic Bronchoscopy (FFB) ($P < 0.05$) [20].

In the current study, the Bispectral index scale (BIS) reliability was tested by test re-test utilizing the internal consistency of Cronbach's Coefficiency Alpha ($\alpha = 0.78$). The validity of this tool was ($r = 0.75$ - p -value = < 0.05).

III) Glasgow Coma Scale:

The Glasgow Coma Scale (GCS) was developed to measure the depth and duration of impaired consciousness and coma. It consists of three aspects of behavior that are independently measured; motor responsiveness, verbal performance, and eye opening [21]. The GCS encompasses visual, verbal and motor responses. The minimum score was 3 and the maximum was 15. A score of 13–15 is high consciousness, 9–12 is moderate, and 8 or less indicates low consciousness in severe brain injuries. The eye response ranges from no eye opening (score 1) to spontaneous opening of eyes (score 4). The verbal response ranges from no verbal response (score 1) to orientated (score 5) and the motor response ranges from no motor response (score 1) to obeying commands (score 6) [10].

The reported inter-rater reliability of the total Glasgow Coma Scale was 0.86 [22]. The validity of GCS was reported to be high when used with TBI ($r^2=0.0233$, $P<.0001$)[23].

In the present study, GCS reliability was assessed by test re-test reliability using the internal consistency and the Cronbach's Coefficient Alpha ($\alpha = 0.98$). The GCS validity was evaluated with Pearson Product Moment Correlations. According to the significant value obtained by 2-tailed P-value <0.05 and the internal consistency ($r=0.72$ - p-value <0.05).

Ethical Consideration

The Research Ethics Committee at the Faculty of Nursing granted written clearance to conduct the study and after the experimental 's purpose was explained to the hospital director, the researcher was given official authorization to proceed. A written/oral consent obtained from the patient's family after informed about the aim, procedure and benefits of the study. The researcher stated that participation in the study was voluntary and they may leave the study at any time without incurring any penalties. Coding the data and keeping it in a locked cabinet helped ensure the confidentiality and anonymity of the patient information.

Pilot Study

Before administering of the questionnaire, it was pre-tested by six patients (10%). Their responses confirmed the clarity and validity of the questions and they did not participate in the study.

Data Collection

Data was collected over a period of 11 months. Subjects were recruited to participate in the study after 24 hours of ICU admission and stabilization of the condition. The subjects were matched against the inclusion and exclusion criteria of the study. The investigator dealt with the control group first who received standard care provided by hospital including patient repositioning, eye care, DVT prophylaxis and fluid and nutritional management to prevent contamination of data. Experimental group received the direct auditory stimulation program five sessions per day for five consecutive days.

Direct Auditory Stimulation Intervention (Experimental Group)

Direct auditory stimulation was developed by Mohammadi et al., (2019)[9] and included the recorded sound of family members, orientation by a nurse, family member and familiar music. For each patient, one family member was trained about how to record a voice message. The first part of this message included the information about place and time (thirty seconds) and the accident which caused the head trauma (thirty seconds). In the second part of the message, that last for about four minutes talk the patient about shared sweet memories. In the last part, they spoke promising and encouraging words about the patient's recovery and future subjects (five minutes).

The message was recorded in the visitation room of the ICU after recruitment the patients to the study in the first 24 hours using a voice recorder. The interval between sessions was one hour, to ensure washout of the accumulation effect of previous stimuli. The investigator collected data all days of the week. The direct auditory stimulation program performed five sessions per day for five consecutive days. Semi structured demographic and clinical data sheet (instrument I) was collected from patient's medical record and assessed Revised trauma score (instrument II) for both experimental and control group in the first session only.

Each session the researcher assessed Glasgow Coma Scale (instrument IV) and recorded BIS (instrument III) 5 minutes before intervention for both experimental and control group. Then the researcher performed direct auditory stimulation program for participants in the experimental group and wait 5 minutes and reassessed Glasgow Coma Scale and recorded BIS for both groups.

3. RESULTS

Table (1): Shows that the mean age of the experimental and control group was (29.33 ± 7.07 and 29.33 ± 7.07) years old respectively. Regard to gender, most of the participants in experimental and control group were males 90.0% and 86.7% respectively. Regarding the GCS, about 66.7% and 63.3% in the studied sample had 3-8 GCS respectively. There was no significant variation between the studied sample regarding their demographics characteristics.

Table (1): Demographic Characteristics of the Studied Sample (N=60)

Items	Experimental Group (n=30)		Control Group (n=30)		X ²	P-value	
	X±SD		X±SD				
Age (X±SD)	29.33 ± 7.07		28.7 ± 5.96		t test 0.335 ^{NS}	0.738	
Gender	No	%	No	%	0.162 ^{NS}	0.688	
	Male	27	90.0%	26			86.7%
	Female	3	10.0%	4			13.3%
Glasgow coma score	Score 3-8	20	66.7%	19	63.3%	0.073 ^{NS}	0.787
	Score 9-12	10	33.3%	11	36.7%		

Ns= not significant (P> 0.05)

Table (2): Shows that Glasgow Coma Scale mean score in the experimental group (13.40 ±1.22) was significantly improved in comparison with control group (9.90 ±1.47) after intervention (P <0 .001).

Table (2): The Effect of Direct Auditory Stimulation Program on Glasgow Coma Scale Mean Score of the Studied Sample (N= 60)

Glasgow Coma Scale	Experimental Group		Control Group		t1 test	t2 test
	Baseline	After intervention	Baseline	After intervention	P1-value	P2-value
	8.70 ±1.17	13.40 ±1.22	8.56 ±.97	9.90 ±1.47	0.478 ^{ns}	10.03*
Paired t test	-26.059 *		-7.919 *			
P-value	0.0001		0.0001			

Data expressed as mean and standard deviation

NB: t1 & p1: between experimental and control groups on baseline .

t2&p2: between experimental and control groups after intervention.

p*= high significant (P≤ 0.001)

Figure (1): This figure clarifies that a highly significant improvement of Glasgow Coma Scale mean score was found in the experimental group (8.70 ± 1.17) of the participants have low Glasgow Coma Scale mean score baseline compared to (13.40 ± 1.22) after intervention ($P < 0.001$).

Figure (1): The Effect of Direct Auditory Stimulation Program on Glasgow Coma Scale Mean Score of the Studied Sample (N= 60)

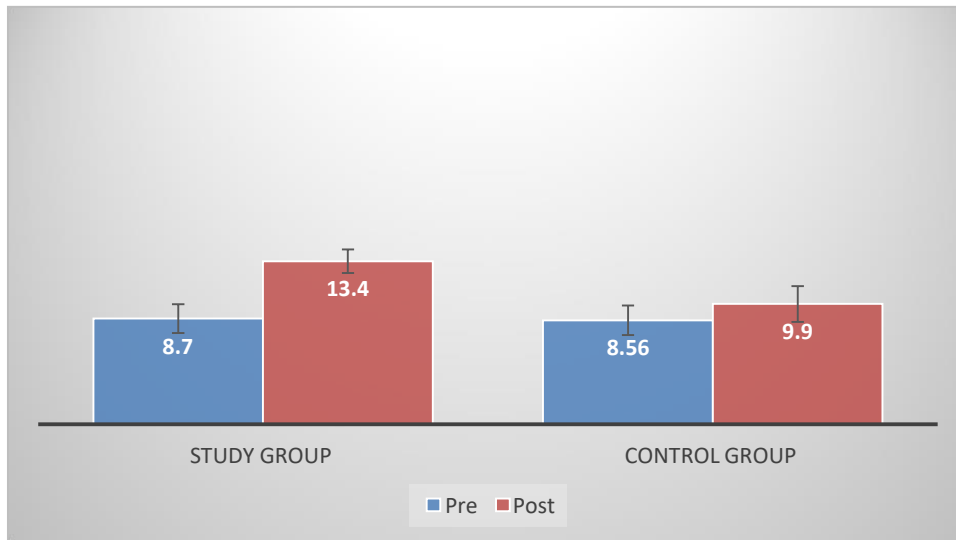


Table (3): Illustrates that the mean score of Bispectral Index Number in the experimental group (86.26 ± 7.29) was significantly improved in comparison with the control group (73.06 ± 7.01) after intervention ($P < 0.001$).

Table (3): The Effect of Direct Auditory Stimulation Program on the Bispectral Index number of the Studied Sample (N= 60)

BSI	Experimental Group		Control Group		t1 test	t2 test
	Baseline	After intervention	Baseline	After intervention	P1-value	P2-value
	67.73 ± 6.90	86.26 ± 7.29	66.0 ± 5.5	73.06 ± 7.01	.1.073 ^{ns}	7.14 *
Paired t test	-17.205 *		-9.142 *		0.288	0.0001
P-value	0.0001		0.0001			

p*= high significant ($P \leq 0.001$)

Table (4): Shows that experimental group had a significantly lower mean ICU length of stay (9.630 ± 2.59) in comparison with the control group (13.30 ± 2.77) following the intervention ($P < 0.001$).

Table (4): Comparison between Experimental and Control Group Regarding ICU Length of Stay (in days)

Items	Experimental Group X±SD	ControlGroup X±SD	t test	P-value
ICU Length of stay (in days)	9.630 ± 2.59	13.30 ± 2.77	-5.34*	0.0001

p*= high significant ($P \leq 0.001$)

Figure (2): Clarifies that The experimental group had significantly reduced mean score of ICU length of stay in comparison with control group after intervention ($P < 0.001$).

Figure (2): Mean Score of ICU Length of Stay (in days) of the Studied Sample (N= 60)

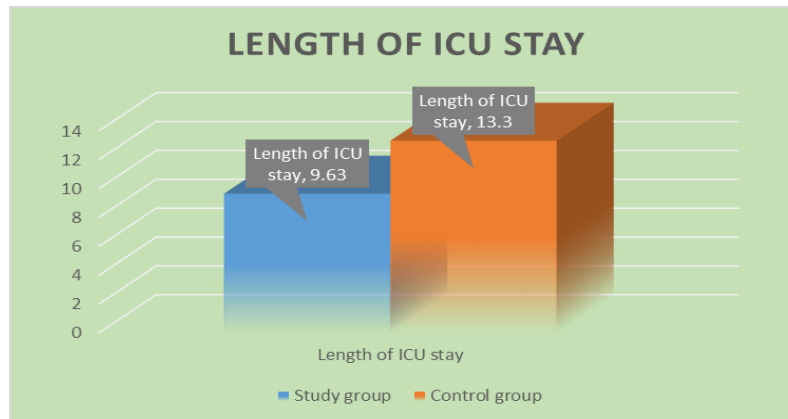


Table (5): Shows a significant negative correlation between GCS score and age between experimental and control group after intervention with $r = -0.372$ ($P < 0.035$) and $r = -0.223$ ($P < 0.236$) respectively. In addition, there is a significant negative correlation between Glasgow Coma Scale score and ICU length of stay between experimental and control group after intervention with $r = 0.179$ ($P < 0.345$) and $r = -0.559$ ($P < 0.001$) respectively.

Table (5): Correlation Between Glasgow Coma Scale, Age and ICU length of Stay for the Studied Sample After Intervention

Items	GCS							
	Experimental Group				Control Group			
	Baseline		After intervention		Baseline		After intervention	
	r	P – Value	R	P – Value	R	P – value	r	P – value
Age	-0.219	0.245	-0.372*	0.035	-0.393*	0.032	-0.223	0.236
ICU length Stay	-0.049	0.799	0.179	0.345	-0.406*	0.026	-0.559	0.001

** . Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed)

Table (6): Illustrates that there is a significant negative correlation between Bispectral index number and age between experimental and control group after intervention with $r = -0.603$ ($P < 0.000$) and $r = -0.277$ ($P < 0.139$) respectively. In addition, there is a significant negative correlation between Bispectral index number and ICU length of stay between experimental and control group after intervention with $r = -0.571$ ($P < 0.001$) and $r = -0.086$ ($P < 0.652$) respectively.

Table (6): Correlation Between Bispectral Index number, Age and ICU length of Stay for the Studied Sample After Intervention

Items	Bispectral index number							
	Experimental Group				Control Group			
	Pre intervention		After intervention		Baseline		After intervention	
	R	P – Value	R	P – value	R	P – value	R	P – Value
Age	-0.291	0.119	-0.603**	0.000	-0.413*	0.023	-0.277	0.139
ICU length of Stay	-0.094	0.620	-0.571**	0.001	-0.418*	0.021	-0.086	0.652

*Correlation is significant at the 0.05 level (2-tailed)

** . Correlation is significant at the 0.01 level (2-tailed).

4. DISCUSSION

Traumatic brain injury (TBI) causes impaired consciousness with different levels of severity. Individuals in a coma are not aware of self or the environment and no response to external stimuli [24]. Auditory stimulations are among the diverse sensory stimulations that has received more consideration than other senses as being considered safe, and effective measures. In addition to being commonly used in various healthcare settings to improve arousal and awareness state in patients with coma [11].

The Effect of Direct Auditory Stimulation on Coma Arousal

The current study hypothesized that the patients who receive direct auditory stimulation program are more likely to have higher score of Glasgow Coma Score and Bispectral Index number than control group. Finding from the current study supported the hypothesis and elucidate that there was a highly statistically significant enhancement in Glasgow Coma Score and Bispectral index number.

The present study result in consistence with Ahmed et al., (2023) [25] who reported that cases in the experimental group had a greater mean level of consciousness, a shorter mean ICU length of stay and a reduced incidence rate of adverse physiological events.

This finding is in agreement with Hoseini et al., (2022) [26] who reported that the cognitive function and level of consciousness of patients in the experimental group at different interval were improved significantly rather than the control group.

Similar finding was reported by (Vanoni et al., (2021), Yekefallah et al., (2021) & Sedghi & Ghaljeh (2020)) [27,8, 28] whom found that after intervention, familiar voice groups and conscious level of the auditory preferences was significantly higher in comparison with the control group.

Additionally, these results were in line with those of Varghese et al., (2021) & Mohammadi et al., (2019) [15&9] who reported that the experimental group who received the auditory stimulation showed a statistically significant rise in consciousness compared to the control group.

Moreover, this finding is in congruence with Rahimi et al., (2019) [29] who reported that auditory stimulation in the experimental group significantly improves the consciousness in comparison with the control group.

The Effect of Direct Auditory Stimulation on ICU Length of Stay

The direct auditory stimulation program had a significant improvement in the patient outcomes which include ICU length of stay. The present study hypothesized that the patients who receive the direct auditory stimulation program are more likely to experience less ICU length of stay than control group.

Similarly, Yekefallah et al., (2021) & Gorji et al., (2014) [8,30] revealed that musical stimulation can significantly improve the level of consciousness and reduce the length of ICU stay among hospitalized patients with TBI.

The Relationship between Glasgow Coma Scale Score and ICU length of Stay

The current study hypothesized that there was a correlation between Glasgow Coma scale and selected patient outcomes such as ICU length of stay after implementation of direct auditory stimulation program. The finding of the study supported the hypothesis and found a relationship between the total Glasgow Coma Scale mean score and ICU length of stay. Patients with improved GCS had significantly less ICU length of stay. This is in the same line with Patel et al., (2020) [31] who found that GCS score is statistically significant in predicting ICU length of stay in TBIs adult patients and there is a negative correlation between GCS score and ICU length of stay.

The findings are in concurrence with Tesfay et al., (2019) [32] results which revealed that mild and moderate GCS was positively associated with less time of recovery and less ICU length of stay.

The Relationship between Glasgow Coma Score and Age

The study hypothesized that there is a relationship between Glasgow Coma scale Score and patient age. Finding of the present study supported the hypothesis and revealed a statistically significant increase in the mean score of Glasgow

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Coma Score with decrease patient age. Also Skaansar et al., (2020) [33] revealed that aging is associated with worse outcome after traumatic brain injury (TBI) and the management intensity of hospitalized patients with TBI decreased with advanced age and that advanced age associated with less GCS, prolonged ICU length of stay and increased risk of 30-day mortality.

The finding was different from what was reported by Salottolo et al., (2014) [34] who revealed that elderly TBI patients have better GCS scores than younger TBI patients with similar TBI severity. A possible explanation for the study findings may be due to small sample size in addition to using different research design.

Limitation of the Study

The study results cannot be generalized because lack of randomization.

5. CONCLUSION

Direct auditory stimulation program has a positive effect on Glasgow Coma Scale Score and Bispectral index number among patients with traumatic brain injury.

6. RECOMMENDATIONS

Design clinical practice guidelines for nurses working in the ICU to use auditory stimulation program as a routine care for comatose patients. Additionally, findings of the current study will enable critical care nurses to be aware of the prototype and variation in traumatic brain injury patients' responses and thus nurses can develop individualized interventions.

Implications of Nursing Practice

Organize regular in-service education courses to educate critical care nurses about the practice of auditory stimulation program as part of their daily routine care for TBI.

Implication for Future Research

Using Sensory Stimulation Assessment Measure (SSAM) scale to assess arousal in the future studies instead of Glasgow Coma Scale (GCS) whereas SSAM better detects slight neurological improvements after auditory stimulation than the GCS.

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