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Effects of Two Sensory Stimulation Models on Recovery in Adults with Severe Traumatic Brain Injury

Uraporn Chuaykarn[1] and Chanokporn Jitpanya[2*]

[1]Maharaj Nakhon Sri Thammarat Hospital, Nakhon Si Thammarat, Thailand
[2]Assistant Professor, Faculty of Nursing, Chulalongkorn University, Bangkok, Thailand

**Corresponding e-mail: jchanokp@hotmail.com*

ABSTRACT

Background and Aims: *Literature from medical and health sciences indicated that sensory stimulation had a positive effect on traumatic brain injury patients. The present study was aimed to find out the effectiveness of a specific sensory stimulation (4 modalities) in comparison with another sensory stimulation (5 modalities) on recovery in comatose patients following severe traumatic brain injury.* ***Methods:*** *The study design was experimental, repeated measured with three groups. Two sensory stimulation models were compared with one control group. Forty-five participants with traumatic brain injury were recruited from surgical wards at Maharaj Nakhon Sri Thammarat Hospital, Thailand. The participants were randomly assigned to three groups, each group of 15 participants. Outcomes of the program were recovery determined by the Coma Recovery Scale-Revised (CRS-R). Inter rater agreement of the CRS-R was 0.85. Descriptive statistics, Fisher's exact test, repeated measure analysis of variance, and post hoc comparison were used for data analysis.* ***Results:*** *All the patients were equally comparable regarding their baseline characteristics, and basic recovery determined by CRS-R. Recovery scores of the three groups were improved. However, those who received the sensory stimulation program (4 modalities) had significantly higher CRS-R scores ($P<0.001$) after 5 days when compared to the two other groups.* ***Conclusion:*** *The sensory stimulation therapy had positive effects on traumatic brain injury patients. Application of the program required few stimuli materials which could be stored at the patient's bedside making them accessible to care providers. However, monitoring physiologic parameters should be done before, during and after the stimulation.*

Keywords: Brain injury, Cognitive recovery, Coma, Sensory stimulation, CRS-R

INTRODUCTION

People with traumatic brain injury can survive as a result of technology advances [1]. They are able to have normal life with varying degrees of support. However, some continue in a coma or persistent vegetative state [2]. Recovery from coma or vegetative state depends on many factors such as cause, injury location, severity, and extent of neurological damage [3]. Sensory stimulation program may enhance recovery process [4-6]. It may affect the reticular activating system (RAS), and increase arousal and attention to the level necessary to perceive incoming stimuli. Sensory stimulation prevents environmental or sensory deprivation which has been shown to retard recovery, development of central nervous function, and further impair brain functioning. Lastly, sensory stimulation provides opportunities for patients to respond to the environment in an adaptive way.

Sensory stimulation includes a variety of stimulation techniques such as visual, auditory, tactile, taste, and smell stimulation. Mobility stimulation is included in stable individuals [7]. However, there are some issues need to be concerned. For example, session of stimulation daily, session duration, and period of sensory stimulation programs are varied. Meyer and colleagues [8] conducted a literature review regarding techniques used in sensory stimulation. The authors reported that stimulation strategies varied from a single sense to stimulation of all senses using various stimuli. Another issue was that some studies in the review, especially a multimodal sensory stimulation demonstrated a trend towards greater improvements in outcomes than a single modality sensory stimulation. On the contrary, other studies supported the use of a single modality sensory stimulation. In conclusion, the authors reported that many studies

were characterized by several limitations including small sample size, lack of blinded outcome assessments, lack of follow-up, lack of generalizability and clinical heterogeneity in the baseline characteristics of study participants.

According to the American Occupational Therapy Association guideline for adults with traumatic brain injuries [9], a recommendation for or against sensory stimulation programs could not be made because "evidence that the intervention is effective is lacking, poor quality, or conflicting, and the balance of benefits and harm cannot be determined." More studies are needed with a randomized-control design, sufficient sample size, long-term follow-up and a more broadly generalizable population sample.

In Thailand, sensory stimulation conducted mostly by nurses has been based on Urbenjaphol, Jitpanya, and Khaoropthum's study [10]. This program was multimodal (5 senses including visual, auditory, tactile, taste and smell stimulation; one sense during each session). However, there are some limitations for implementing multimodal stimulation in nursing practice [11]. First, smell stimulation may be limited because the olfactory nerve is the most commonly injured cranial nerve in TBI. Many TBI patients have tracheostomies which eliminate the exchange of air through the nostrils and therefore inhibit the sense of smell. Some patients have nasogastric tubes in place, which block one nostril and therefore decrease the sense of smell. Second, taste stimulation may be harmful if a patient is prone to aspiration. Finally, oral stimulation may cause patient to demonstrate a bite reflex. Chitkara et al. [12] studied the efficacy of a sensory stimulation (4 senses at a time including visual, auditory, tactile, and movement) on patients with traumatic brain injury. Taste and smell stimuli were replaced with movement stimulation or kinetic stimuli. The result showed that patients receiving the early multimodal sensory stimulation displayed a significantly improvement as compared to the control group.

The present study was undertaken to find out the effectiveness of a specific sensory stimulation (4 modalities) in comparison with another sensory stimulation (5 modalities) on recovery in comatose patients following severe traumatic brain injury.

METHODS

Design and participants

This study was an experimental, repeated measured with three groups being performed in surgical wards at Maharaj Nakhon Sri Thammarat Hospital, Thailand during a 4-month period from June to September 2016. It was estimated that a sample size of at least 15 individuals per group was needed to detect an effect size of 0.65, as determined in another study [12] with an alpha risk of 0.05 and power of 0.80 [13].

Eligible patients were approached on their third day of admission if they were in a state of a coma during the first three days of admission; had a Glasgow Coma Score (GCS) of 3 – 8; and stable hemodynamics. Patients who were older than 60 years of age or less than 15 years of age; opium and drug addicts; receiving sedatives; suffering from blindness, deafness and delusional disorders, seizures, brain stem trauma, spinal cord injury and brain death were further excluded from the study. The approval of Maharaj Nakhon Sri Thammarat Hospital, institutional review board (IRB) was achieved (IRB approval number 27/2016).

Data collection and procedure

The selection process for participants began by asking an independent nurse to review lists of individuals that appeared to meet the criteria for participation in the study. Those individuals identified by the nurse as appropriate were chosen as potential participants for this study. To meet the final criteria for participation in the study, a signed Consent to Participate Form was required from the person with the legal authority to provide consent for the participant. All participants' demographic and clinical data were taken. The level of consciousness of participants was taken in terms of Glasgow Coma Score [14]. Forty-five traumatic brain injury (TBI) patients were randomly assigned through to two experimental groups (Group A, and B) and a control group (Group C). Each group consisted of 15 patients.

In Group A, the participants were treated by multimodal stimulation model. The program composed of auditory, visual, tactile, and kinaesthetic stimulation. Each session of stimulation lasted 30 min. The program was carried twice a day, every day for two weeks [12]. Participants in Group B were treated by a sensory stimulation including auditory, visual, olfactory, gustatory, and tactile stimulation. Each session lasted 15-30 min. The program was carried five times a day, every day, for two weeks [4,10]. Participants in Group C received conventional care i.e., turning position by nurses, passive exercise movements, and oral care.

Before starting the treatment, the researcher approached the participant by identifying themselves; talking slowly, and

in a normal tone of voice; keeping sentences short. The researcher oriented participants to date, time, place, and reason for being in the hospital, and explained to the patient what they were going to do. Next, the researcher checked resting vital signs (heart rate, blood pressure, and respiratory rate). If increased intracranial pressure (ICP) and/or cerebral perfusion pressure (CPP) were still issues, monitoring ICP and CPP during and after treatment would be performed. A limited number of people around the participant would be set by the researcher with the TV off and the door closed during treatment. The participant was set in upright position in bed before starting. The stimuli were organized in an orderly manner. During the treatment, the researcher observed overstimulation signs such as flushing of the skin, perspiration, agitation, eye closing, decreased in arousal level, increase in muscle tone, and prolonged increase in respiration rate.

Outcome measures

The Coma Recovery Scale-Revised (CRS-R) [15] was developed to assess cognitive recovery in patients with severe brain injury. The CRS-R consisted of 23 items measuring 6 subscales including auditory function, visual function, motor function, verbal function, communication, and arousal function. The maximum score was 23 and the lowest score was 0. The CRS-R scores were measured on baseline, and 1st day to 14th day during the intervention.

Three independent nurses were blinded to the groups, and recorded recovery over the course of 14 days. Determination of agreement among three nurses was evaluated periodically throughout the baseline and treatment measurement periods. Review of score sheets determined that agreement among three nurses were 85%.

Data analysis

Overall differences regarding their demographic and baseline characteristics among three groups were determined using the Fisher's exact test. Repeated ANOVA were used to determine significant differences regarding patients' recovery between and within groups based on the CRS-R scores. Post-hoc comparison was performed after the F-test was significant. Data were reported as means, SD, or percentage as appropriate. A 2-sided $P<0.05$ was considered statistically significant.

RESULTS

Participant characteristics

All study groups were equally comparable regarding their demographic and baseline characteristics (Table 1).

Effects of Sensory Stimulation on Recovery (CRS-R score).

Table 1 Baseline characteristics of 15 participants in each group

Characteristics	Group A	Group B	Group C	P-value*
Gender				
Male	13	12	11	0.8
Female	2	3	4	
Age (years)				
Under 20 years	3	3	3	0.8
21-40 years	6	7	5	
41-60 years	6	5	6	
Injury location				
Frontal lobe	6	6	6	1
Temporal lobe	3	3	3	
Parietal lobe	1	1	1	
Occipital lobe	1	1	1	
Fronto-parietal lobe	1	1	1	
Fronto-temporal lobe	1	1	1	
Bilateral frontal lobe	1	1	1	
Bilateral Fronto temporal lobe	1	1	1	
Treatment				
No surgery	7	7	7	1
Craniotomy	4	4	4	
Craniectomy	3	3	3	
Burr hole	1	1	1	

GCS (Base line)				
4T-5T	3	2	2	0.9
6T-7T	12	13	13	
*Using Fisher's exact test				

Those who received multisensory stimulation technique had higher CRS-R scores after day 7th through to the 14th day of the intervention than the two other groups (Table 2 and Figure 1).

Table 2 Means of CRS-R scores on baseline, 1st day through to 14th day during the interventions

Time	Group A		Group B		Group C	
	Mean	SD	Mean	SD	Mean	SD
baseline	4.07	1.28	4.53	1.64	4.53	1.5
1st day	4.07	1.28	4.53	1.64	4.53	1.5
2nd day	4.07	1.28	4.67	1.63	4.6	1.59
3rd day	5.6	1.63	5.13	2.06	4.73	1.94
4th day	7.4	2.58	6	2.85	5.07	2.63
5th day	9.33	3.33	7	3.16	5.93	3.05
6th day	10.87	4.22	9	3.48	6.33	3.41
7th day	13.13	4.15	9.07	4.13	5.87	4.17
8th day	14.4	4.73	10.2	3.76	6.4	4.61
9th day	16.07	4.13	11.67	3.51	7.8	5.3
10th day	17.27	4.23	13.2	4.6	8.2	5.04
11th day	18.33	4.25	13.87	4.86	9.13	5.23
12th day	19.07	4.11	15.6	4.62	10.73	5.53
13th day	19.67	3.65	16.8	5.03	11.93	5.68
14th day	19.8	3.61	17.13	5.2	12.33	5.86

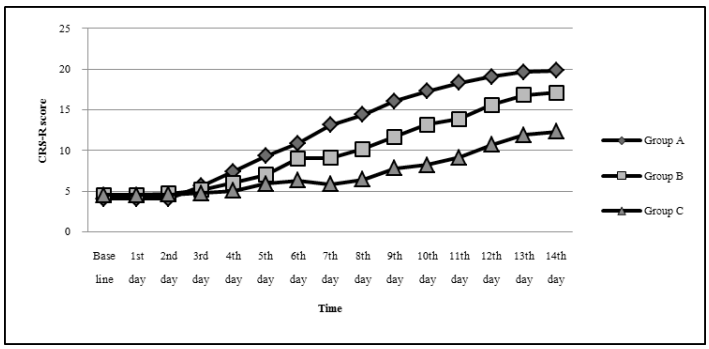

Figure 1 Means of Coma Recovery Scale-Revised (CRS-R) scores on baseline, 1st day through to 14th day during the intervention of three groups

The repeated measured ANOVA were performed testing the effect of stimulation models on CRS-R scores between group A, B, and C. The results showed a significant difference between group A, B, and C ($F=9.74$, $P<0.001$). There was also a significant effect of time on CRS-R scores ($F=177.74$, $P<0.001$). The interaction between group and time had a significant effect on CRS-R scores ($F=11.21$, $P<0.001$). Pairwise comparison using the LSD showed that the CRS-R scores were significant difference among Group A and B, and C as shown in Table 3.

Table 3 Pairwise comparison of Coma Recovery Scale-Revised (CRS-R) using LSD

Time	Group A and C		Group B and C		Group A and B	
	Mean Difference	P-value	Mean Difference	P-value	Mean Difference	P-value
Baseline	0.46	0.394	-0.01	1	-0.46	0.394
1st day	0.46	0.394	-0.01	1	-0.46	0.394
2nd day	0.53	0.339	-0.06	0.904	-0.6	0.283
3rd day	-0.86	0.216	-0.4	0.566	0.46	0.503
4th day	-2.33*	0.022	-0.93	0.348	1.4	0.162

5th day	-3.40*	0.006	-1.06	0.364	2.33	0.051
6th day	-4.53*	0.002	-2.66	0.057	1.86	0.177
7th day	-7.26*	0	-3.20*	0.041	4.06*	0.01
8th day	-8.00*	0	-3.80*	0.022	4.20*	0.012
9th day	-8.26*	0	-3.86*	0.02	4.40*	0.009
10th day	-9.06*	0	-5.00*	0.005	4.06*	0.021
11th day	-9.20*	0	-4.73*	0.01	4.46*	0.015
12th day	-8.33*	0	-4.86*	0.008	3.46	0.054
13th day	-7.73*	0	-4.86*	0.009	2.86	0.114
14th day	-7.46*	0	-4.80*	0.012	2.66	0.15

DISCUSSION

The current study was conducted to study the effect of a multi-modal sensory stimulation (4 senses) and another multi-modal sensory stimulation (5 senses) on recovery of head injury patients. Results showed that the sensory stimulation program (4 senses) is associated with higher levels of recovery measured by the CRS-R when compared to the stimulation program (5 senses) and a control group. Additionally, the recovery of the stimulation program (5 senses) was higher than a control group. Sensory stimulation programs provide the orderly systematic presentation of stimuli at a frequency, intensity, and duration not commonly available in the clinical. The rationale is that a sensory stimulation therapy of sufficient frequency, intensity and duration improves recovery by neuronal organization, increased dendritic branching, and increased numbers of dendritic spines. Scientists demonstrated that although the individual brain cells did not regenerate, the cell processes, axons, and dendrites, were highly responsive to functional demand [16,17].

Sensory stimulation also stimulates the reticular activating system. It also stimulates the limbic system to help generate goal-directed behaviours. Emotion-provoking stimuli enhance amygdaloid activity to facilitate limbic system activation. Benefits from sensory stimulation are boosted if it is delivered by persons familiar to the comatose patient [16,17].

Lastly, sensory stimulation prevents sensory deprivation. Sensory deprivation can easily occur in a hospital environment as the patient lacks familiar surroundings; loses familiar sounds; and experiences the effects of powerful medications (sedatives), interruptions of rapid-eye-movement (REM) sleep, confinement to bed, change in food and fluid, and lack of movement. Excessive sensory deprivation is prevented by stimulating the reticulolimbic system, along with the muscular system, physical movement, familiar voices, music, touch, temperature, lighting variations, and the use of odours prescribed by researchers to help maintain the functional integrity of the nervous system [16,17].

CONCLUSION

In conclusion, the results of the current study indicated that both multi-modal sensory stimulation programs, if 4-senses either 5-senses, could lead to improvements in the level of recovery of comatose patients with severe TBI. Noticeably, sensory stimulation with 4-senses might better shorten the coma duration of these patients. Therefore, nurses should integrate the sensory stimulation in their usual care.

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