การจัดประชุมเสนอผลงานวิจัยระดับบัณฑิตศึกษา มหาวิทยาลัยสุโขทัยธรรมาธิราช ครั้งที่ 4
The 4th STOU Graduate Research Conference

Factors Associated with Systemic Inflammatory Response Syndrome in Severe Traumatic Brain Injury Patients within the First Six Hours After Surgery

Ratchadaporn Laongam* Krongdai Unhasuta** Penchun Sareewiwatthana ***
Thaweesak Aurboonyawat****

Abstract

This study was the descriptive research design, which aimed to study the relationships among severity of injury, preoperative period, physiological changes and systemic inflammatory response syndrome (SIRS) in patients with severe traumatic brain injury (severe TBI) within the first six hours after surgery.

The participants consisted of 88 patients with severe TBI within the first six hours after surgery in ICU of three tertiary hospitals, Bangkok. Standard tools were using to FOUR scale and SAH-PDS, SIRS score.

The results of the study revealed that subjects aged between 18-85 years old, most of the subjects were male (61.4%) with a mean aged of 48.84 years. Falls was of the first leading cause (33%). The most diagnosis from CT scan were intracerebral hemorrhage (45.5%) and the majority of the surgeries involved craniectomy (63.6%). The average score severity of injury were 6.91 points (S.D. = 2.22). Patients with severe TBI within the first six hours after surgery were assessed by the FOUR scale. The average score of preoperative period were 550 minutes (S.D. = 660). The average score of physiological changes were 2.27 points (S.D. = 1.23). The average SIRS score were 1.77 points (mode = 2, S.D = .91), the most frequency of SIRS score was 2 points (40.9%). Analysis of the Spearman correlation coefficient among severity of injury, preoperative period, physiological changes and SIRS. SIRS and physiological changes had a positive correlation with the physiological changes (ρ = .281, $p < .01$) at a statistically significant level, but had no correlation with severity of injury and preoperative period.

Keywords: Severe Traumatic Brain Injury, Severity of injury, Time, Physiological change, SIRS

*Master of Nursing Science Program in Adult Nursing, Faculty of Nursing, Mahidol University
laongam2523@gmail.com
**Assist. Prof.Dr., Department of Surgical Nursing, Factuly of Nursing, Mahidol University
krongdai.unh@mahidol.ac.th
*** Assoc. Prof., Department of Surgical Nursing, Factuly of Nursing, Mahidol University nspsn@mahidol.ac.th
**** MD., Dip Thai Board Neurological Surgery,Siriraj Hospital, Mahidol University

Background and significance of the study

Severe traumatic brain injury (severe TBI) involves injury in the scalp, skull, cerebral tissues and arteries caused by traffic accidents, self-inflicted injuries, assault, falls, electrical shock, heat, mechanical objects and both living and non-living mechanisms. Most traumatic brain injuries are caused by the impact of objects or foreign objects on the head, thereby causing the skull to break as it, compresses the brain, blood vessels, and tissues in addition to cerebovascular rupture. The bleeding causes a blood clot which in turn compresses the brain. Patients suffer severe TBI, become comatose and develop the condition of cushing's reflex, e.g. severe high blood pressure, slow heart rate, and abnormal breathing patterns. Patients with severe TBI have Glasgow Coma Scale (GCS) scores between 3-8 points. Furthermore, according to CT brain scans, traces of brain injury are found with cerebral edema, which is the main cause of death among severe TBI patients within the first six hours after surgery or requiring treatment by surgery in order to remove pressure from the skull and blood clots in the brain.

Following surgery, the bodies of patients with severe TBI respond to inflammation by increased cytokine secretions, which have maximum within the first six hours after surgery. Therefore patients with severe TBI have fevers, rapid heart rates, rapid breathing and high white blood cell counts with the development of postoperative complications and organ failure in various systems in which 89% of postoperative patients with severe TBI who have at least one system failure are at risk for developing organ failure. The organ failures frequently encountered are failures of the respiratory and cardiovascular systems. When the failures of these systems cannot be corrected within 72 hours following surgery, organ failure will follow in multiple systems and the patients will eventually die. Hence, postoperative evaluation of physiological changes in patients with severe TBI is imperative in monitoring of these patients.

Patients with severe TBI who undergo surgery have lower blood circulation to the brain, especially during the first-four hours following surgery when blood circulation to the brain is only 50%, tissue and vessel injury and autoregulation impaired. Blood circulation returns to normal within the next 4-6 hours, but no more than 24 hours after surgery. Under these conditions, the brain tissues of patients with severe TBI have lower oxygen levels during the first six hours after surgery, causing the brain to lack of energy due to deficient oxygen supply. The body adapts physiologically by stimulating the hypothalamic-pituitary axis to dissolve glucose from various sources such as protein, fat and muscle in order to reserve energy for the brain and anaerobic metabolism, thus resulting in lactic acid and acidic conditions in the body. The dissolution of glycogen under stress response conditions due to the surgery, cause the body to experiences stress hyperglycemia with extremely high blood glucose levels and the occurrence of lactic acidosis which leads to oxygen deficiency for the brain. The body's production of free-radicals becomes dysfunctional which results in cerebral edema and eventual death. The dissolution of glycogen as a result of the stress response caused by the surgery leads to stress hyperglycemia with high blood glucose levels and lactic acidosis causing oxygen deficiency to the brain as the body's abnormal production of free-radicals results in pulmonary edema and the patient eventually dies.

Severity of injury in severe TBI patients within the first six hours after surgery can be evaluated by using the GCS and the time elapsed during the preoperative period. Severe TBI patients and long preoperative period affect the body's inflammatory response by increasing cytokine secretion and unbalancing the immune system, causing the body to develop systemic inflammatory response syndrome (SIRS). Furthermore, according to the study of Matis and Birbilis (2008), low GCS scores have been found to indicate high rates of neurological injury due to an abnormality of the blood brain barrier, autonomous control mechanisms in the brain and the endocrine glands and systemic inflammatory response to physiological changes in the injury. Because blood circulation mechanisms cause pulmonary arteries to contract severely due to adrenergic responses caused by to brain injury, the consequence is increased pulmonary hydrostatic pressure and permeability of the pulmonary capillaries with inflammation mechanisms in which the body secretes TNF-α, IL-1β and IL-6 with more macrophages resulting in increased permeability of the pulmonary capillaries and neurogenic pulmonary edema. Thus, severity of injury can be used to predict death in hospitalized postoperative severe TBI patients.

Hence, SIRS is a significant issue affecting the recoveries of postoperative severe TBI patients because inflammatory processes occur as soon as the body is injured, especially within 4-6 hours following surgery, with low blood supply to the brain. When the body cannot efficiently adjust homeostasis, various organs will fail which will affect the recovery times of severe TBI patients within the first six hours after surgery.

In Thailand, little studies have been conducted on the effects of SIRS. Thus, the researcher is interested in studying the factors related to SIRS, including the preoperative period and physiological changes in severe TBI patients within the first six hours after surgery. The research findings can be applied to information of a nursing practice guideline to assess of systemic inflammatory responses and plans for solving/managing the problem of severe TBI patients within the first six postoperative hours can rehabilitate rapidly and safely.

Objective of the Study

1. To study SIRS in severe TBI patients within the first six hours after surgery.
2. To study the correlations among severity of injury, preoperative period, physiological changes and SIRS in severe TBI patients within the first six hours after surgery.

Conceptual Framework

In this research, the conceptual framework is based on the review of literature related to SIRS (Davies & Hagen, 1997) and the one-and two-hit theory (Tzioupis et al, 2005) to study relationships among severity of injury, preoperative period, physiological changes and SIRS in severe TBI within the first six hours after surgery.

Methodology

This study is descriptive research aimed at studying the factors related to SIRS in severe TBI patients within the first six hours after surgery. The population for this study comprised of patients with severe TBI due to external causes as categorized by the International Statistical Classification of Disease and Related Health Problems (ICD 10-TM) with codes from V01-Y34 who received treatment at the intensive care units (ICU) of three tertiary hospitals, Bangkok within the first six hours after surgery. The sample group size was calculated from power analysis by setting the power of the test at .80 and the medium effect size at .30. According to the calculations of Polit & Beck's table, the sample group size came to 88 samples. The instruments are divided into two parts with the following details:

1. Personal characteristic and clinical profile consist of the data on gender, age, cause of trauma, multiple injuries, postoperative diagnosis, type of surgery, preoperative period, GCS and comorbidities

2. The evaluation forms related to the SIRS of severe TBI patients within the first six postoperative hours contained the following:

2.1 Severity of injury evaluation forms for patients within the first six postoperative hours. The researcher used the complete outline of the unresponsiveness scale (FOUR) (Wijdicks, et al., 2005).

2.2 The evaluation form for physiological changes in severe TBI patients within the first six postoperative hours was modified by the researcher from the Subarachnoid Hemorrhage-Physiologic Derangement Score (SAH-PDS) developed by Claassen and colleagues (Claassen, et al., 2004).

2.3 The American College of Chest Physicians and the Society of Critical Care Medicine Consensus Conference. The researcher used the Systemic Inflammatory Response Syndrome (SIRS) scores from the American College of Chest Physicians and the Society of Critical Care Medicine Consensus Conference (Bone, et al., 1992).

Data Collection

In this study, the researcher collected data on the severe TBI patients within the first six hours after surgery in ICU of three tertiary hospitals, Bangkok by the following procedures:

1. The researcher requested a letter of introduction from the Faculty of Graduate Studies, Mahidol University in order to present the research outline to the bangkok metropolitan ethical

committee for research in human subjects in order to request approval to conduct research at three tertiary hospitals, Bangkok.

2. The researcher presented the research outline to the Bangkok Metropolitan Ethical Committee for Research in Human Subjects in order to request approval to conduct research at three tertiary hospitals, Bangkok by collecting data from severe TBI patients within the first six hours after surgery.

3. Once the researcher had received consent from the Ethical Committee of the Bangkok Metropolitan Administration, the researcher used the letter of approval for data collection to contact the nursing department supervisor, the head nurse of the intensive care unit and nurses of the critical care unit at three tertiary hospitals, Bangkok to explained the research objectives, methods of data collection and data collection procedures. The researcher recorded the data in severe TBI patients within the first six hours after surgery by using the research instruments created by the researcher from the time the patients were first received from the operation room for treatment in the intensive care unit and over a period of six hours.

4. The researcher collected data in severe TBI patients within the first six hours after surgery at three tertiary hospitals, Bangkok in the following order:

4.1 The researcher selected the sample severe TBI patients who had received surgical treatment to be monitored for six consecutive hours after surgery at the aforementioned ICU by the inclusion criteria set for the sample group by recording data from medical records according to baseline data record forms such as gender, age, cause of trauma, comorbidity injuries to other systems, postoperative diagnosis of diseases, type of surgery, preoperative period, initial GCS scores from the operation room and comorbidity.

4.2 The researcher continually evaluated and recorded factors related to SIRS in severe TBI patients from the time the patients first received treatment at the ICU until six hours after surgery.

4.3 The researcher met with patients or relatives to explain the details involved in conducting the research and request cooperation in joining the sample group. In cases where patients were conscious and capable of consent, the researcher requested permission from the patients directly. If patients were unconscious, the researcher requested consent from relatives for participation as a member of the sample group in the research. Once the sample group members had acknowledged information concerning the sample group's right to protection and consented to participate in the study, the sample group members were asked to sign informed consent forms for participation in the research.

5. The researcher evaluated and recorded the factors related to SIRS in severe TBI patients within the first six hours after surgery. The first evaluation was carried out when patients were first received from the operation room. The second evaluation took place at six hours after surgery. The data was obtained from medical records and laboratory test results.

6. Once the researcher had gathered all data in line with the number of the sample group (88 patients), the researcher once again cleaning data before processing and statistically analyzing the data.

Protecting the rights of the sample group

In this study, the researcher considered the sample group's right to protection in terms of three aspects, namely, potential risks from the research, benefits of the research and data confidentiality by adhering to procedures for requesting approval to conduct research in human subjects. After the researcher had received approval, the researcher began to conduct the research by introducing herself to patients or relatives to explain the details of the research e.g. research topic, research objectives, expected benefits, sampling, data collection processes and duration, including requesting cooperation from patients or relatives by explaining their right to participate or refuse to participate in the research, depending upon the willingness of the patients or relatives, including the right to withdraw from the study at any time during the course of the research.

Patients received routine care throughout the duration of treatment in hospital. This study holds no risks for the sample group. However, patients spent some time in participation. The findings of the study will have overall benefit for severe TBI patients during the first six postoperative hours in that the findings can be implemented as baseline data in planning more efficient care and treatment for patients. The data obtained from this study was kept confidential. The findings have been presented or published in terms of an aggregate perspective without identifying the participants. The data is only accessible through the codes set by the researcher, thereby making the researcher the only person able to access the data. If patients or relatives had any doubts, they were able to ask the researcher directly at all times. Once the sample group received explanations to help understand and acknowledge the research details, the participants signed the informed consent forms.

Results

Table 1 Personal characteristics and clinical profile (n = 88)

Personal characteristics	Number	Percent
Gender		
Male	54	61.4
Female	34	38.6
Age (years)		
18-35	25	28.4
36-60	35	39.8
61-85	28	31.8
Range = 18-85 years, Mean= 48.84 years, S.D. = 19.41 years		
Glasgow Coma Scale		
2T	7	8.0
3T	3	3.4
4T	5	5.7
5T	13	14.8
6T	29	33.0
7T	31	35.2
Cause of injury		
Fall	28	31.8
Motorcycle accident	18	20.5
Assaults	16	18.2
Fall from a height	14	15.9
Car accident	11	12.5
Solid /wood hammer head drop	1	1.1
Diagnosis		
Single lesion		
Intracerebral hemorrhage	40	45.5
Subdural hemorrhage	15	17
Subarchnoid hemorrhage (traumatic)	4	4.5
Brain contusion	2	2.3
Epidural hemorrhage	2	2.3
Multiple lesions		
Brain contusion with subdural hemorrhage	7	8

Epidural hemorrhage with subdural hemorrhage	4	4.5

Table 1 Personal characteristics and clinical profile (n = 88) (cont.)

Personal characteristics	**Number**	**Percent**
Multiple lesion (cont.)		
Brain contusion with epidural hemorrhage	3	3.4
Brain contusion with intracerebral hemorrhage	2	2.3
Subarchnoid hemorrhage (traumatic) with Intracerebral hemorrhage	2	2.3
Epidural hemorrhage with traumatic subarchnoid hemorrhage	1	1.1
Epidural hemorrhage with intracerebral hemorrhage	1	1.1
Type of brain surgery		
Craniectomy	56	63.6
Craniotomy	24	27.3
Craniotomy and venticulostomy	4	4.5
Venticulostomy	2	2.3
Burr hole	2	2.3
Comorbidity		
None	50	56.8
Yes	38	43.2
Comorbidity 1 disease		
Hypertension	15	39.5
Diabetes mellitus	3	7.9
Coronary artery disease (CAD)	2	5.3
Chronic lung disease	1	2.6
Comorbidities 2 disease		
Diabetes mellitus with hypertension	7	18.5
Hypertension with CAD	2	5.3
Hyperthyroid with CAD	1	2.6
Diabetes mellitus with dyslipidemia	1	2.6
Dyslipidemia with hypertension	1	2.6
Comorbidities 3 disease		
Diabetes mellitus, dyslipidemia with CAD	2	5.3
Dyslipidemia, hypertension with CAD	1	2.6
Diabetes mellitus, hypertension with CAD	1	2.6
Comorbidities 4 disease		

Dyslipidemia, hypertension, CAD with chronic kidney disease	1	2.6

Table 1 demonstrated demographic data of severe TBI patients. The majority of severe TBI patients in this study were male. Subjects aged between 18-85 years old (mean 48.84 years, S.D. = 19.41). The highest amount of subjects was 36-60 years old. For causes of severe TBI, falls was of the first leading cause for twenty-nine subjects (33%). The most diagnosis from CT scan was intracerebral hemorrhage (45.5%) and the majority of the surgeries involved craniectomy (63.6%). An ICU admission GCS ranged from 2T-7T scores with mean of 5.67 (S.D. = 1.49). The most frequently encountered co-morbidity with one disease of hypertension (39.5%), while co-morbidities with two diseases included diabetes mellitus and hypertension (18.5%) and comorbidities with three diseases included diabetes mellitus, dyslipidemia and coronary artery disease (5.3%).

Table 2 Mean, standard deviation, and range of severity of injury, preoperative period, physiological changes and systemic inflammatory response syndrome in severe traumatic brain injury patients within the first six hours after surgery (n = 88).

Data	Range	Mean	S.D.
Severity of injury	1-13	6.91	2.22
Preoperative period (min)	70- 4,947	550	660
Physiological changes	0-7	2.27	1.23
Systemic inflammatory response syndrome	0-4	1.77	.91

Patients with severe TBI within the first six hours after surgery had an average score severity of injury at 6.91 points (S.D. = 2.22). Patients with severe TBI within the first six hours after surgery were assessed by the FOUR scale whereby, all of the samples were found to have total possible severity of injury scoring within a range of 1-13 points. Severe TBI had 45 patients (51.1%) and severity of injury scores ranged from 0-7 points. The most frequency severity of injury was 7 points. As moderate TBI had 43 patients (48.9%), scoring severity of injury was during the 8-13 score. The most frequency severity of injury was 8 points (see in appendix H). The average score of preoperative period had 550 minutes (S.D. = 660), the range of preoperative period ranged from 70 to 4,947 minutes. The average score of physiological changes had 2.27 points (S.D. = 1.23), the range of physiological changes was between scores 0-7 points. Majority subjects had normal PDS (75%) (see in appendix I). The average SIRS score 1.77 points (S.D = .91), the SIRS scoring range was between 0-4 points. The most frequency of SIRS score was 2 points (40.9%). Majority subjects had mild SIRS (39.8%)

Table 3 Spearman rank correlation coefficient among the studied variables (n = 88)

	variable	1	2	3	4
1	Severity of injury	1			
2	Preoperative period	.244*	1		
3	Physiological changes	.243*	.103	1	
4	Systemic inflammatory response syndrome	-.079	-.150	.281**	1

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

Table 3 showed the correlation among severity of injury, preoperative period, physiological changes and systemic inflammatory response syndrome in patients with severe TBI within the first six hours after surgery. It was found that SIRS in patients with severe TBI within the first six hours after surgery had a positive correlation with the physiological changes ($\rho = .281$, $p < .01$) at a statistically significant level. When considering in relation to severity of injury a positive correlation was discovered between the preoperative period ($\rho = .244$, $p < .05$) and physiological changes ($\rho = .243$, $p < .05$) at a statistically significant level.

Discussion and Conclusion

Severity of injury, the findings of the study concurred with the study of Sadakab et al. (2012) explained that the FOUR scale might be able to measure impaired consciousness and overcome some of the shortcomings of the GCS. GCS remained unable to identify subtle changes in alteration of consciousness whereas the FOUR scale was superior to the GCS in that it could account for intubated patients without substituted or guessed scores. Patients are evaluated using the FOUR scale. The severity of TBI was shown by pointing on the basis of the FOUR scale to make a difference on the GCS.

Preoperative period, the results showed that the samples had a preoperative period of 550 minutes (9 hours and 16 minutes), which did not concur with the results from the research for a long time or type of surgery. Thus, 29 patients had preoperative periods of approximately 2-4 hours; 22 patients received craniectomy and 7 patients received craniotomy. Preoperative period had long, increased risk and mortality.

Physiological changes, in severe TBI within the first six hours after surgery include alveolar arterial gradient ((A-a) DO_2), mean arterial pressure (MAP), blood glucose, and bicarbonate. The average score had 2.27 (SD = 1.23) and physiological changes were between scores 0-7 points show that the samples with abnormal physiological changes affected to secondary TBI. Majority subjects had normal PDS (75%) (A-a)DO_2 averaged 24.886 mm. MAP averaged 101.018 mmHg. Blood glucose averaged 170.45 mg/dl, and bicarbonate averaged 22.39 mg/dl

SIRS, The patients averaged SIRS 1.77 points (mode = 2, SD = .91 points), within a range of SIRS scores between 0-4 points showing that the samples did not indicate whole body inflammatory response syndrome. The educational process of Phillips (2006) and King (2007) reported the inflammatory immune response (IIR), which is normally controlled by the complement system, to involve four major components:, namely, vasodilation, increased vascular permeability, cellular activation, and coagulation. Vasodilation increased the availability of oxygen and glucose to the cells and the availability of neutrophils, macrophages, and other mediators to the area of injury to contain and eradicate any bacteria or foreign body. An increase in vascular permeability also facilitates the delivery of oxygen, glucose, neutrophils, and macrophages to the needed area. Cellular activation is the activation of neutrophils and macrophages to the phagocytose of any foreign substances or debris and to begin the process of microdebridement in the area involed. Activation of the clotting cascade facilitates the walling off of the injured area and minimizes any blood loss. The IIR is meant to protect the host, to limit the extent of the injury and to promote wound healing. It is meant to be a controlled response in proportion to the body's needs. Increased IIR results in SIRS.

SIRS in severe TBI patients within the first six hours after surgery has a positive correlation with the physiological changes that were statistically significant ($r = .275$, $p <.01$) which had consistent with the study. Hlatky et al. (2004), and Claassen et al. (2004) reported that postoperative patients underwent physiological changes. CBF in the brain returns to normal within 4-6 hours following brain surgery. The average amount of CBF is 35 ± 16.4 ml per 100 g of brain per minute. In order to obtain sufficient oxygen to the brain for the body, with changes in mean arterial pressure. Glucose levels in the blood bicarbonate or pressure differences of the oxygen in the arterial blood to the pulmonary alveoli were changed.

Sadaka et al. (2012) explained that for every 1-point increase in the total FOUR scale, the odds of in-hospital mortality were reduced by an estimated 36%. Every 1-point increase in the total FOUR scale was associated with a 29% reduction in the odds of a poor functional outcome. Every 1-point increase in the total FOUR scale was associated with a 33% reduction in the odds of a poor neurological outcome. When considered individually, the severity of injury is a positive correlation between preoperative periods ($r = .244$, $p <.05$) and physiological changes ($r = .243$, $p <. .05$) Giannoudis et al. (2006) reported surgical stress response to be part of the systemic reaction to every surgical procedure and encompass a wide range of endocrinological, immunological and haematological effects.

Recommendations

1. Intervention that tailor to SIRS should focus on close monitoring for severity of injury, physiological changes, to prevent decrease cerebral perfusion and SIRS.

2. SIRS should be continuous monitoring to detect inflammatory response, a factor promote recovery.

3. Physiological should be continuous monitoring to prevent a rise intracranial pressure and decrease cerebral perfusion.

4. FOUR had difference GCS, to assess brainstem reflex and respiration pattern, to detect mortality rate.

Limitations

1. The SAH- PDS score was an invasive technique and specific best SAH patients.
2. The pre-operative period was erroneous with uncertain timing; thereby putting the research utilization may be limited to generlized.

References

Akavipat, P. (2009). Endorement of the FOUR score for consciousness assessment in neurosurgical patients. *Neurological Medicine Chir(Tokyo), 49*, 565-571.

American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. (1992). *Critical. Care Medicine. 20* (6): 864–74.

Bone, R. C., Balk, R. A., Cerra, F. B., Dellinger, R. P., Fein, A. M., Knaus, W. A., et al. (1992). Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. *Chest*, *101* (6), 1644-1655.

Claassen, J., Kreiter, K. T., Kowalski, R. G., Du, E. Y., Ostapkovich, N., Fitzsimmons, B.-F. M., et al. (2004). Effect of acute physiologic derangements on outcome after subarachnoid hemorrhage. *Critical Care Medicine*, *32* (3), 832-838.

Dewar, D., Moore, F. A., Moore, E. E., & Balogh, Z. (2009). Postinjury multiple organ failure. *Injury, International Journal of the Care of the Injured*, *40*, 912-918.

Giannoudis, P. V., Dinopoulos, H., Chalidis, B., & Hall, G. M. (2006). Surgical stress response. *Injury, international journal of the care of the injured*, *37s*, s3-s9.

Heegaard, W., & Biros, M. (2007). Traumatic brain injury. *Emergency Medicine Clinics of North Amerca, 25*, 655-678.

Hickey, J. V. (2003). *The clinical practice of neurological and neurosurgical nursing* (5th edition). Courier-Westford: Lippincott Williams & Wilkins.

Hlatky, R., Contant, C. F., Diaz-Marchan, P., Valadka, A. B., & Robertson, C. S. (2004). Significance of a reduced cerebral blood flow during the first 12 hours after traumatic brain injury. *Neurocritical Care, 1*, 69-83.

Jennett, B. (2005). Development glasgow coma and outcome scale. *Nepal Journal of Neuroscience, 2*, 24-28.

Josephson, L. (2004). Management of increades intracranial pressure. *Dimensions of critical care nursing, 23* (5), 194-207.

Keel, M., & Trentz, O. (2005). Pathophysiology of polytrauma. *Injury, International Journal of the Care of the Injured, 36*, 691-709.

King, J. E. (2007). Sepsis in critical care. *Critical Care Nursing Clinics of North America* (16), 77-86.

Lim, H. B., & Smith, M. (2007). Systemic complications after head injury: A clinical review. *Anaesthesia, 62*, 474-482.

Matis, G., & Birbilis, T. (2008). The glasgow coma scale - A brief review past, presenr, future. *Acta neurologica belgica, 108*, 75-89.

Mattar, I. (2011). Using the roper, logan and tierney model in the management of traumatic brain injury in a critical care setting. *Singapore nursing journal, 38* (3), 14-19.

McQuillan, K. A., & Thurman, P. A. (2009). *Trauma Nursing: From Resuscitation Through Rehabilitation(4th ed.).* (K. A. McQuillan, M. B. Makic, & E. Whalen, Eds.) United States of America: Saunders Elsevier.

Moppett, I. K. (2007). Traumatic brain injuruy: assessment, resuscitation and early management. *British Journal of Anaesthesia, 99* (1), 18-31.

Namas, R., Ghuma, A., Hermus, L. Zamora, R., Okonkwo, DO., Billiar, TR., & Vodovotz, Y. (2009). The acute inflammatory response in trauma / hemorrhage and traumatic brain injury: Current state and emerging prospects. *Libyan journal of medical, 4* (3), 136-148.

NeSmith, E. G., Weinrich, S. P., Andrews, J. O., Medeiros, R. S., Hawkin, M. L., & Weinrich, M. (2009). Systemic inflammatory response syndrome score and race as predictors of length of stay in the intensive care unit. *American Journal of Critical Care, 18* (4), 339-347.

Pape, H.-C., Tsukamoto, T., Kobbe, P., Tarkin, I., Katsoulis, S., & Peitzman, A. (2007). Assessment of the clinical course with inflammatory parameters. *Injury: International Journal of the Care of the Injured, 38*, 1358-1364.

Park, S.-K., Chun, H.-J., Kim, D.-W., Im, T.-H., Hong, H.-J., & Yi, H.-L. (2009). Acute physiology and chronic health evaluation II and simplified acute physiology score II in predicting hospital mortality of neurosurgical intensive care unit patients. *Journal Korean Sciences, 24*, 420-426.

Paterson, R., & Webster, N. (2000). Sepsis and the systemic inflammatory syndrome. *J.R.Coll.Surg.Edinb, 45*, 178-182.

Pfister, D., Strebel, S. P., & Steiner, L. A. (2007). Postoperative management of adult central neurosurgical: Systemic and neuro-monitoring. *Best Practice & Research Clinical Anaesthesiology, 21* (4), 449-463.

Phillips, R. A. (2006). Stopping the train. *Nursing mode incredibly easy*, 44-54.

Polit, D. F., & Beck, C. T. (2008). *Nursing research: Generating and assessing evidence for nursing practice (8th ed.).* Philadephia: Lippincott William&Wikins.

Raghavan, M., & Marik, P. E. (2006). Stress hyperglycemia and adrenal insufficiency in the critically ill. *Siminars in Respiratory and Critical Care Medicine, 27* (3), 274-285.

Smrcka, M., Mrlian, A., Karlsson-Valik, J., & Klabusay, M. (2007). The effect of head injury upon the immune system. *Bratisl Lek Listy, 108* (3), 144-148.

Toft, P., & Tonnesen, E. (2008). The systemic inflammatory response to anaesthesia and surgery. *Current Anaesthesia and Critical care, 19*, 349-353.

Visser, T., Pillay, J., Koenderman, L., & Leenen, P. L. (2008). Postinjury immune monitoring: Can multiple organ failure. *Current Opinion in Critical Care, 14* (6), 666-672.

Wijdicks, E. F., Bamlet, W. R., Maramattom, B. V., Manno, E. M., & Mcclelland, R. L. (2005). Validation of a new coma scale: The FOUR score. *Annals of Neurology, 58*, 585-593.

Wolf, C. C., & Nash, S. K. (2011). A head injury teaching module for prehospital assessment. *Military medicine, 2*, 204-208.