Predictors of Multiple Organ Dysfunction Syndrome in Patients with Major Trauma

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ABSTRACT

Objective: To study the predictive power of systemic inflammatory response syndrome (SIRS) scores, platelet count, and blood glucose level for multiple organ dysfunction syndrome (MODS) in patients with major trauma.
Methods: The sample was 87 patients with major trauma, hospitalized within 24 hours after injury. SIRS score, platelet count and maximum blood glucose level were measured within the first 24 hours after injury, while MODS was measured by the Denver post-injury multiple organ failure (MOF) score at the 3rd day after injury. Multiple regression analysis, using the enter method, was employed to analyze the data with a significance level of .05.
Results: The majority of the samples were male (85.1%) with an average age of 40.39 years. Most of them sustained multiple organ injuries and received surgical treatment within the first 24 hours. It was found that 25.3% of these patients developed organ dysfunction on the 3rd day after injury while 9.2% experienced MODS. SIRS score, platelet count and blood glucose level could predict MODS in patients with major trauma, with 41.7% of the variance explained (R^2= .417, p < .001).
Conclusion: Patients with major trauma should receive close monitoring on their SIRS score, platelet count and blood glucose level within 24 hours after injury. Moreover, Denver post-injury MOF score should be routinely used for detection of organ dysfunction so that preventative measures can be appropriately implemented.

Keywords: Major trauma, systemic inflammation response syndrome, platelet count, blood glucose, multiple organ dysfunction syndrome

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INTRODUCTION

Multiple organ dysfunction syndrome (MODS) is a complication frequently found in critical patients. Approximately, 15% of patients in intensive care unit experience MODS and 20-50% of MODS occurred in patients with multiple injury.[1] The incidence of MODS in adult patients with major trauma ranges from 25 to 47%. Among these, 59% have MODS at the 3rd day after injury leading to infection, disability and mortality.[2,3,4] Ciesla and the others conducted a literature review and summarized that infection, especially for lung infection, abdominal infection, and wound infection, consequently occurred during 48-72 hours after MODS.[4,5] MODS resulted in longer hospital stay.[6] In addition, patients with major trauma having MODS during 48-72 hours post-injury were reported to have higher heart failure and mortality rates than those having MODS after 72 hours post-injury.[4] Ciesla and the others and Lausevic and the others studied the effect of post-injury MODS on mortality rate. It was found that the mortality rate of patients with post-injury MODS was 26-36% significantly higher than patients without post-injury MODS.[2,7,8]

When a person gets injured, multiple physiological response of their human body system takes place, such as circulatory, neuro-hormonal-endocrine, and immune systems. Tremendous inflammatory response (pro-inflammatory response) leads to SIRS which finally causes MODS at the 3rd day post-injury.[9] A study on patients with major trauma having fracture of lower extremities showed that patients who developed pro-inflammatory response with highest SIRS scores in the first day of treatment can be a predictor of MODS with AuROC = 0.720 (p = .0015, 95% CI 0.575- 0.865).[10]

Coagulopathy can cause a threat to life in patients with major trauma. From the literature, patients with

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platelet counts lower than 100,000 cells per deciliters were at high risk of MODS and the mortality rate was significantly higher than the patients with normal platelet counts.[11] Patients after 13 to 48 hours of major trauma with platelet counts lower than 80,000 cells per deciliter were at 3 times higher risk than patients with platelet counts higher than 100,000 cells per deciliter.[12]

The physiological response to injury affects metabolism and interrupts the neuro-endocrine system which impairs the ability to maintain blood glucose level.[13] A study on severe blunt injury patients indicated that patients with blood glucose level higher than 200 mg per deciliter within 24 hours post-injury were at 1.3 higher risk of MODS than the patients with normal blood glucose level.[14] The level of blood glucose had a direct impact on the severity of organ dysfunction. Patients with major trauma having blood glucose level higher than 145 mg per deciliter had a significantly higher risk of cardiac, respiratory, renal, and circulation systems dysfunction than patients with normal blood glucose level at a significance level of 0.05.[15]

According to current clinical and research evidences, there is no specific intervention for MODS.[16] Early detection and prevention from MODS is therefore vital.[1] Dewar et al., (2011) summarized an intensive literature review and proposed that the best prevention for MODS was rapidly identifying patients risk factors which allowed for the performance of early intervention in order to prevent the occurrence of MODS.[16] Over responses of SIRS, platelet count, and blood glucose level as physiological outcomes to injury can lead to MODS. Consequently, other complications such as infection, sepsis, organ failure, and mortality may follow.[4] According to a literature review among clinical researches in Thailand, there was no previous study in major traumatic injury patients. This investigator, who was a registered nurse on duty in the trauma intensive care unit, was therefore interested in studying the predictor of MODS in patients with major trauma. The results from this study may provide vital information on early detection of factors which effect the occurrence of MODS. Accordingly, appropriate preventative measures can be implemented in patients with severe injury with high quality care.

The objective of this study was to study the predictive power of SIRS scores, platelet counts, and blood glucose levels for MODS in patients with major trauma.

MATERIALS AND METHODS

The sample comprised major trauma patients aged equal to and more than 18 years old both male and female who were admitted in Siriraj Hospital and Bhumipol Adulyadej hospital. The inclusion criteria were receiving mechanical ventilation or urgent surgery for intracranial, intrathoracic, or intraabdominal injury or for fixation of pelvic or spinal fractures[17] within 24 hours post-injury. The exclusion criteria was patients with underlying diseases of diabetes mellitus, chronic pulmonary obstruction disease, cerebrovascular disease, cardiovascular disease, chronic renal failure, cancer, hematologic disease, or immune system disease such as AIDs.

Research instruments

The research instruments comprised a demographic data recording form, including injury and treatment data. Platelet count records from complete blood count at 24 hours post-injury and blood glucose level from a glucometer measured the blood sample taken from finger tips within 24 hours post-injury. SIRS was assessed by assessing 4 clinical signs according to the definition of the American College of Chest Physician/Society of Critical Care of Medicine 1992 as follows, 1) body temperature greater than 38°C or less than 36°C, 2) heart rate greater than 90 beats per minute, 3) respiratory rate greater than 20 beats per minute or carbon dioxide partial pressure ($PaCO_2$) less than 32 mm\Hg, and/or 4) white blood cell count greater than 12,000 cells per square millimeter or less than 4,000 cells per square millimeter.[18] MODS was measured by the Denver post-injury MOF score (Table 1) at the 3rd day after injury.[19] The research instruments aforementioned were used to collect data from patients' documents.

Data collection

After receiving ethical approval from the Siriraj Institutional Review Board (Si.134/2012) and Bhumipol

TABLE 1. Denver Post injury Multiple Organ Failure (MOF) Score.

Dysfunction	Grade 0	Grade 1	Grade 2	Grade 3
Pulmonary: PaO_2/FiO_2 ratio†	x > 250	250 ≤ x > 200	200 ≤ x > 100	x ≤ 100
Renal creatinine level, mg/dL	x ≤ 1.8	2.5 ≤ x > 1.8	5.0 ≤ x > 2.5	x > 5.0
Hepatic total bilirubin level, mg/dL	x ≤ 2.0	4.0 ≤ x > 2.0	8.0 ≤ x > 4.0	x > 8.0
Cardiac score ‡	No Inotropes	Minimal Inotropes	Moderate Inotrope	High Inotropes

Abbreviations: FIO_2, fraction of inspired oxygen.

SI conversion: To convert renal creatinine to micromoles per liter, multiply by 88.4; total bilirubin to micromoles per liter, multiply by 17.1.

Denver Post injury MOF Score equals 1 + 2 + 3 + 4 not due to chronic disease. An Denver score greater than 3 indicates MOF.

† Values adjusted for altitude.

‡ Cardiac score: minimal inotrope levels, dopamine or dobutamine level less than 5 µg/kg per minute; high inotrope levels, dopamine or dobutamine level greater than 15 µg/kg per minute; moderate inotrope levels, dopamine or dobutamine 5 to 15 µg/kg per minute.

Adulyadej hospital Ethics Committee, the researcher collected data between March 2012 - July 2012 by asking for cooperation from staff nurses at each site to screen patients matching the inclusion criteria and introduced herself to patients or patients' representatives to explain the research project and asked for the voluntary informed written consent to participate in the research. In the 3rd day after injury, the researcher collected data on injuries, treatment, SIRS score, platelet count, and maximum blood glucose level at 24 hours post-injury, while MODS was assessed at the 3rd day after injury from patient documentation. Descriptive statistics were employed to analyze demographic data and data related to injury and treatment, while multiple regression analysis was utilized to analyze the predictive power of SIRS score, platelet count, and blood glucose level to MODS.

RESULTS

The sample comprised 87 patients with major trauma (Table 2). Most of them were male (85.1%) with an average age of 40.39 (SD±20.18) years. The major cause of injury was traffic accident (56.3%), 75.9% had blunt trauma and 80.5% underwent an emergency operation within 24 hours after injury.

At the 24 hour point most samples had SIRS (63.2%) with an average SIRS score of 2.01 (SD±1.14) points. The samples had an average platelet count of 177,448 cells/dL (SD±84,142) (Table 3). Almost half of the sample had a platelet count less than 150,000 cells/dL (48.2%), and among these 5.7% had a platelet count less than 80,000 cells/dL (Table 3). The maximum blood glucose level within 24 hours post injury averaged 185.40 mg/dL (SD±71.12) of which 29.9% of samples had blood glucose levels higher than 200 mg/dL. At the 3rd day post-injury, their Denver post-injury MOF score averaged 1.05 (SD±1.96) points with 25.3% who developed organ dysfunction and 9.2% who developed MODS (Table 3). Within this group of samples, almost all samples (27 samples) developed respiratory system dysfunction. When categorized by the number of organ dysfunctions, 12 samples developed 1 organ dysfunction, 9 samples developed 2 organ dysfunctions, 8 samples developed 3 organ dysfunctions and 1 sample developed all 4 organ dysfunctions (Table 3).

The correlation between SIRS score, platelet count, blood glucose level, and MODS among major trauma patients has been demonstrated in table 4. SIRS score and blood glucose level had a significant positive correlation with MODS at r = 0.526 and r = 0.385, respectively while platelet count had a significant negative correlation with MODS at r = - 0.386.

The result from Multiple regression analysis showed that SIRS score, platelet count, and blood glucose level, can concurrently predict MODS in patients with major trauma with 41.7% of the variance explained (R^2= .417, p < .001). Moreover, the SIRS score was the best predictor followed with blood glucose level and platelet count (β = .374, .291, -.185, p < .05).

DISCUSSION

After major trauma, the severe injury of tissue and the damaged blood vessels activate blood coagulation. The body uses a huge amount of platelet and blood clotting factors. Therefore, less platelets circulate into peripheral organs resulting in microvascular bleeding which causes

TABLE 2. Demographic characteristics of major trauma patients (n= 87).

Characteristic	n	%
Gender		
Male	74	85.1
Female	13	14.9
Age (yr)		
8-21	18	20.7
22-40	34	39.1
41-60	20	23.0
> 60	15	17.2
Mechanism of injury		
Blunt	66	75.9
Penetrating	16	18.4
Other (Electrical injury / Near drowning)	5	5.7
Type of injury		
Traffic accident	49	56.3
Assault	16	18.4
Workplace	12	13.8
Household	8	9.2
Drowning	2	2.3
Urgent surgery within 24 hours post-injury		
Non-Surgery	17	19.5
Surgery	70	80.5
Intracranial	32	36.8
Intraabdominal	20	23.0
Intrathoracic	10	11.5
Other (Fixation for pelvic/spine fracture)	8	9.2

TABLE 3. SIRS score, platelet count, blood glucose level, and Denver post injury MOF score in patients with major trauma (n= 87).

Variables	n	%
SIRS score		
0-1 (Non-SIRS)	32	36.8
2: (Mild-SIRS)	32	36.8
3: (Moderate-SIRS)	17	19.5
4: (Severe-SIRS)	6	6.9
Platelet count (cell/deciliters)		
< 80,000	5	5.7
80,000 - < 150,000	37	42.5
≥ 150,000	45	51.8
Blood glucose level (mg/deciliters)		
70- 110	7	8.0
111- 200	54	62.1
> 200	26	29.9
Denver post injury MOF score		
0	57	65.5
1- 3	22	25.3
> 3	8	9.2

TABLE 4. Pearson Product Moment Correlation between SIRS score, platelet count, blood glucose level, and MODS in patients with major trauma (n= 87).

Variables	SIRS score	Platelet count	Blood glucose level	MODS
	r	r	r	r
SIRS score	1			
Platelet count	- .218*	1		
Blood glucose level	.385*	- .411*	1	
MODS	.526*	- .386*	. 511*	1

* ($p < .05$)

cell injuries.[12,20] In addition, since the systemic inflammatory response exerts in a high level for a long period of time causing a large amount mediator and cytokines released into blood circulation leading to SIRS. This causes damage of vascular endothelial cells causing ischemia in the corresponding organ.[9,21] In addition, SIRS adversely affects blood coagulation and disturbs metabolism.[1] Accompanied with higher blood glucose level post-injury due to neurological-hormonal-endocrine system response, insulin resistance can cause elevation of blood glucose level.[13,22,23] All of this response promotes cellular hypoxia and metabolic failure which activate anaerobic metabolism leading to acidosis and cellular dysfunction and consecutively cause MODS.[24]

In the present study, the highest level of systemic response to injury occurs within the 24 hour post injury period by which time pathophysiological and metabolism changes have drastically occurred. The more severe injury is, the higher level of systemic response occurs until reaching SIRS, while a patient's blood glucose level increases leading to cellular dysfunction, which is accompanied by lower platelet count and together these can predict MODS in patients with major trauma.

CONCLUSION

The patients with major trauma should receive close monitoring on their SIRS scores, platelet counts and blood glucose levels within 24 hours after injury. Moreover, Denver post-injury MOF score should be routinely used for detection of organ dysfunction so that preventative measures can be appropriately implemented.

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