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Multiple organ dysfunction syndrome (MODS) prediction score in multi-trauma patients

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ABSTRACT

Background: Multiple organ dysfunction syndrome (MODS) in patients with major trauma remains a frequent and devastating complication in emergency departments and intensive care units. Easily and accurately identifying patients at risk for MODS post-injury, especially in multi-trauma cases, is important. The aim of this study was to develop an instrument to predict the development of MODS in adult multi-trauma patients using clinical and laboratory data available in the first 24 h after trauma.
Methods: We prospectively enrolled adult multi-trauma patients with Injury Severity Score (ISS) ≥16, between 16 and 65 years old, admitted to four academic Level-I trauma centers for 1 year between September 2014 and 2015. Sequential organ failure assessment score was used to determine MODS during hospitalization. A risk score was created from the final regression model consisting of significant variables as MODS predictors.
Result: During the period of the study, 98 multi-trauma patients were included. The mean age was 35.2 years, and most were male (85.71%). The mean ISS was 23.6, mostly (76.53%) caused by blunt injury mechanism. MODS occurred in 43 patients (43.87%). The prediction risk score consists of Revised Trauma Score (<7.25) and lactate level ≥2.75 mmol/L. This study also verified several independent risk factors for post-multi-trauma MODS such as ISS >25, presence of systemic inflammatory response syndrome, shock grade 2 or more, and white blood cells >12,000.
Conclusion: We derived a novel simple and applicable instrument to predict MODS in adults following multi-trauma. The use of this scoring system may allow early identification of trauma patients who are at risk for MODS and result in more aggressive targeted resuscitation and damage control surgery.
Trial registration: ISCRTN ISRCTN16661943. 09/11/2016 retrospectively registered.

1. Background

Multi-trauma is defined as injury to at least two body regions with total injury severity score (ISS) < 16, usually with the presence of systemic inflammatory response syndrome (SIRS) on at least one day during the first 72 h [1–3]. Severe trauma may promote physiological disarray and a hyper-inflammatory state leading to multi-organ dysfunction syndrome (MODS) with multi-organ failure (MOF) at the end of its spectrum [4].

Incidence of post-trauma MODS-MOF is about 29% [5]. Mortality among major trauma patients with failure of two organs is 67%, and approaches 100% if more than three organs have failed [6]. Historically, a several trauma scoring system was developed to stratify trauma patients into mortality risk groups. This paradigm proved beneficial for triage, better resuscitation and overall patient management.

Pathophysiology of MODS-MOF after trauma involves injury severity with ISS ≥25, the presence of SIRS, and sepsis [7,8]. Previous studies found several factors correlated with the development of MODS after trauma such as older age, high trauma scoring (as “first hit”), the presence of shock, base deficit <8 mEq/L, hyperlactatemia>2.5 mmol/L in the first 24 h after trauma, massive

List of abbreviations: MODS, Multiple organ dysfunction syndrome; MOF, Multiple organ failure; SIRS, Systemic inflammation response syndrome; ATLS, Advanced trauma life support; DSTC, Definitive surgical treatment care; ISS, Injury severity score; RTS, revised trauma score; SOFA, Sequential organ failure assessment; GCS, Glasgow coma scale; TOF, Trauma organ failure.

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Table 1
Demographics and characteristics of the study sample.

Data	Result
Total, *n*	98
Age	35.2[a]
Sex; male:female	84 (85.71%): 14(14.28%)
Cause	72 (73.47%)
• Traffic accident	12 (12.24%)
• Criminal violence	7 (8.11%)
• Fall from height	2 (1.35%)
• Animal attack	2 (1.35%)
• Thermal/electric	
Mechanism	74 (75.51%)
• Blunt	12 (12.24%)
• Penetrating	12 (12.24%)
• Combination	
Pre-hospital duration (hours)	6.33[a]
• Referral from other hospital	54 (55.10%)
• Direct to our trauma center	44 (44.90%)

[a] Mean.

blood transfusion (>6 bag of packed red blood cells), elevated IL-6 level, and emergency definitive airway in the pre-hospital setting or resuscitation at the emergency department [9,10]. Rapid and earlier recognition of risk for MODS would be beneficial for improving trauma center referral systems, meaning aggressive resuscitation could begun much earlier before the lethal post-trauma systemic cascade had evolved into its endpoint (MOF) with associated high mortality rate and higher health cost. This study attempted to validate these risk factors and develop a scoring instrument to predict MODS after injury using variables in the pre-hospital and emergency department settings.

2. Methods

This 1-year prospective cohort study was held at four academic level-1 trauma centers in Indonesia:Kandou Hospital, Manado; Kariadi Hospital, Semarang; Sanglah General Hospital, Bali; and Universitas Hasanudin Hospital, Makassar. The inclusion criteria were as follows: multi-trauma patients with ISS $\geq$16, age between 16 and 65 years, no chronic co-morbid illnesses, and no previous major trauma with or without surgery. The study had ethical clearance approved by ethics review board of each hospital involved.

Demographic data collected included age and sex, pre-hospital transport time, vital signs on arrival, definitive airway (performed during pre-hospital transfer or at the emergency department before surgery), Abbreviated Injury Scale for each body region to generate the ISS, final diagnosis, and major intervention or surgery performed. Laboratory data obtained were routine blood cell count and lactate at admission followed by renal function test, liver function test, blood gas analysis, and others as indicated by each patient's clinical course.

The main outcome of MODS-MOF was assessed using the Sequential Organ Failure Assessment (SOFA) Score [11]. SOFA identifies organ dysfunction or failure across six organ systems, and consists of measures of PaO_2/FIO_2 ratio (respiratory system), platelet count (hematology), Glasgow Coma Scale (central nervous system), mean arterial pressure and inotropics (cardiovascular system), urine output and creatinine level (renal system), and total bilirubin (liver-digestive system). The occurrence of MODS is defined as a SOFA score of $\geq$1 in >1 system, and MOF as a SOFA score of $\geq$3 in $\geq$2 organ systems. Other outcomes collected included intensive care unit and hospital length of stay, and in-hospital mortality.

3. Results

During the 1-year study period 98 multi-trauma patients met the criteria for inclusion, and comprised the study population. The average age was 35.2 years, most patients were male (85.71%, 84 vs 14), most had trauma caused by traffic accidents (73.47%), and most had blunt trauma (75.51%) (see Table 1). Age and sex were insignificant predictors for MODS so were excluded from the prediction model.

Of all multi-trauma samples, 43 developed MODS (43.87%). Of patients who developed MODS, 12 progressed to MOF (12.24%). In-hospital death occurred in 13 (11 MOF, 2 MODS) (13.26%). Table 2 shows study outcomes and Fig. 1 shows MODS distribution. Average hospital length of stay for all samples was 11.06 days.

The mean of trauma severity as measured by ISS was 23.59 and by RTS was 7.345. Most samples showed SIRS (88.89%), had high white blood cell count (mean 19,455 cells/μL), high lactate level (mean 3.14 mmol/L), normal average platelet count (229,000 cells/μL), and 12 patients had emergency definitive airway (12.2%). Of 98 samples, 43 were from patients in varying degrees of shock (mean grade 2.05). There were five significant variables predictive of MODS from the univariate analysis (see Table 3) and these were included in the predictor model.

3.1. Post-multi-trauma MODS prediction score model

After univariate analysis for each independent factor, all variables were further analyzed using logistic regression analysis. When the model consisted of all nine variables, statistic analysis showed no significance. The next step was to construct a prediction model that included independent variables one by one without

Table 2
Outcomes for the study sample.

Independent variable	Mean	Significance	Cut off point	Sensitivity	Specificity
ISS	23.59	<0.0001*	25.8	51.2%	80%
Emergency definitive airway		0.99	–	–	–
RTS	7.354	<0.001*	7.25	65.1%	78.2%
SIRS	88 (88.89%)	0.02*			
Shock	2.05	<0.001*	1.86	74.4%	70.9%
Hemoglobin	12.29	0.078	–	–	
White blood cells count (cells/μL)	19,455	0.048*	11,980	90.7%	25.5%
Platelet count (cells/μL)	229,000	0.128	–	–	–
Lactate level (mmol/L)	3.14	<0.001*	3.44	48.8%	85.5%

* = p<0.05.