Hemodynamic Profile of Pediatric Patients Admitted to Pediatric Intensive Care Unit Dr. Soetomo General Hospital

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Abstract

Background: Shock is one of the most commonly found conditions and causes high mortality rates in PICU. Macro-circulation and microcirculation hemodynamic monitoring is performed to know the degree of severity of the shock, to determine the treatment to be given, and to evaluate the previous treatments given. **Objective**: This study aims to determine the hemodynamic disturbances profile of pediatric patients in PICU of Dr. Soetomo General Hospital Surabaya in the period of 1st September 2021-31st May 2022. **Methods**: This study was an observational cross-sectional study. The data obtained were processed and analyzed using Microsoft Excel. **Results**: A total of 32 samples met the inclusion and exclusion criteria. The majority of the patients in this study (84,38%) suffered from septic shock. The macro-circulation hemodynamic measurements, the majority of the patients had normal blood pressure (53,13%), inadequate stroke volume (75%), tachycardia (78,13%), normal cardiac output (59,38%), normal SVR (68,75%), and inadequate DO_2 (53,13%). In the microcirculation hemodynamic measurement, the majority of the patients had alactatemia (65,63%). **Conclusion**: The measurements of several hemodynamic parameters in majority of the pediatric shock patients showed the abnormality related to the shock condition, whereas the other parameters were in their normal ranges as the result of the early resuscitations given before the PICU administrations.

Keywords : shock; hemodynamic disturbances; hemodynamic monitoring; PICU

1. Introduction

Shock is one of the most commonly found cases in PICU that causes high mortality (1). A research conducted in the US reported 37% of the overall pediatric patients were found with the condition of shock. The mortality of pediatric patients with shock was reported to be higher (11,4%) compared to non-shock pediatric patients (2). Shock is characterized mainly by the decline of oxygen delivery, causing hypoxia in tissues and cells. Therefore, the restoration of oxygen delivery becomes the main goal of resuscitation in shock cases (3).

Hemodynamic monitoring is commonly performed to know a patient’s hemodynamic components, both macro-circulation and microcirculation. The macro-circulation parameters are used to know the hemodynamic flow. However, normal macro-circulation parameters are not enough to indicate adequate perfusion. Therefore, microcirculation parameters are also used to know the body's perfusion. The two components are related and together could represent the body's oxygen delivery (4).

Several macro-circulation parameters are used to assess the condition of shock, some of which are the blood pressure, stroke volume, heart rate, cardiac output, and systemic vascular resistance (5). The increase of lactate levels, which shows the occurrence of anaerobic metabolism as a result of inadequate oxygen delivery, is commonly used as a microcirculation parameter (6).

2. Method

This study used the observational cross-sectional design and has already been approved by Dr. Soetomo General Hospital Ethical Committee. The samples of the study were collected with purposive non-probability sampling with the method of total sampling. The population of the study is Pediatric Intensive Care Unit (PICU) patients with shock in Dr. Soetomo General Hospital in 1st September 2021 – 31st May 2022. Patients with complete hemodynamic monitoring procedures in the first 48 hours of intensive care are included as subjects, whereas patients with incomplete hemodynamic monitoring are excluded. The data were obtained according to the variables, which later were coded, processed, and analyzed descriptively.

3. Results

In this study, 32 patients met the inclusion and exclusion criteria. The majority of the patients were male (62,5%). The patients were also classified into different pediatric age groups and mostly were in School Age (5-12 years old) (34,38%).

Table 1 Demographic Distribution

Demographic Characteristics	n	%
Age Group		
Infants (0-1 years old)	7	21,88%
Toddler (1-3 years old)	6	18,75%
Preschool (3-5 years old)	3	9,38%
School Age (5-12 years old)	11	34,38%
Adolescent (12-18 years old)	5	15,63%
Sex		
Male	20	62,50%
Female	12	37,50%

Several macro-circulation parameters were obtained in the study, which were blood pressure, stroke volume, heart rate, cardiac output, systemic vascular resistance, and oxygen delivery. Blood lactate levels were also obtained as the microcirculation parameter.

Table 2 Characteristics of Pediatric Shock Patients

Characteristics	n	%
Type of Shock		
Cardiogenic	2	6,25%

Hypovolemic	3	9,38%
Obstructive	0	0,00%
Septic	27	84,38%
Macro-circulation Parameter		
Blood Pressure		
Hypertension	0	0,00%
Normotension	17	53,13%
Hypotension	15	46,88%
Stroke Volume (SV)		
Inadequate SV	24	75,00%
Adequate SV	8	25,00%
Heart Rate (HR)		
Tachycardia	25	78,13%
Normal	4	12,50%
Bradycardia	3	9,38%
Cardiac Output (CO)		
High CO	1	3,13%
Normal CO	19	59,38%
Low CO	12	37,50%
Systemic Vascular Resistance (SVR)		
High SVR	8	18,75%
Normal SVR	22	53,13%
Low SVR	2	28,13%
Oxygen Delivery (DO_2)		
Adequate DO_2	15	46,88%
Inadequate DO_2	17	53,13%
Microcirculation Parameter		
Blood Lactate Levels		
Hyperlactatemia	11	34,38%
Alactatemia	21	65,63%

The most common type of shock found was septic shock (84,38%). Through the macro-circulation parameters, it was shown that the majority of the patients had normotension (53,13%), inadequate SV (75%), tachycardia (78,11%), normal CO (59,38%), normal SVR (53,13%), and inadequate DO_2 (53,13%). Blood lactate levels as the microcirculation parameter showed the most common condition to be alactatemia (65,63%).

4. Discussion

The demographic findings in this study showed dominations by the male and School Age (5-12 years old) age group. These findings are supported by several research which show that in adults or post-pubescent children, males are more likely to fall into the state of shock compared to females, whereas in prepubescent children there is no significant risk differences between the two sexes (7).

The majority of patients in this study suffered from septic shock. A similar study conducted in Jakarta also shows the domination of patients with septic shock (8). This is supported by the result of a randomized clinical trial which showed that septic shock is the most common type of shock, followed by hypovolemic shock, cardiogenic shock, and obstructive shock (9).

The first macro-circulation parameter to be discussed in this study is blood pressure, with most of the patients having normal blood pressure (53,13%). Blood pressure normally falls as a result of the body's circulation failure. However in the early phase of shock which is often referred as the warm shock, the body tries to compensate in the hope of maintaining its vital organ function. In this state, blood pressure would still be in its normal range although other signs of shock would be visible (10).

This study showed that most of the patients had inadequate stroke volume (SV). Together with the heart rate (HR), SV forms the cardiac output (CO). Therefore, a change in the SV affects on the CO, which is one of the main parameters of oxygen delivery (11). SV, especially in the early phases of different types of shock, commonly falls under its normal range through different mechanisms (11,12).

The majority of patients in this study experienced tachycardia. This could be explained by the body's stress response to diseases. The human body activates the central and sympathetic nervous system which leads to the secretion of different hormones such as the ACTH, cortisol, epinephrine, and norepinephrine. These hormones increase different hemodynamic components, one of them being the heart rate (HR) (13).

Most of the patients in this study showed normal cardiac output (CO). Together with blood pressure, CO determines the prognosis of some critical illnesses and becomes a significant component in the diagnosis of cardiogenic shock (14). As mentioned in the previous parts, CO is the product of SV and HR. The two components also continuously alter according to each other component and the body's condition. In this study most of the patients had low SV and high HR (tachycardia). These two components compensate one another, resulting in normal CO. Other mechanisms, some of which are the autonomic nervous system and the endocrine system, also regulate the CO (15).

This study showed that the majority of the patients in this had normal systemic vascular resistance (SVR). The decrease of SVR is commonly found in septic shock due to the activation of systemic inflammation cascade, whereas SVR is more commonly found to be higher in other types of shock as an effort to maintain adequate perfusions (16,17). The different result found in this might have been caused by the administration of vasopressors or inotropes before the intensive care started.

The oxygen delivery (DO_2) of most of the patients in this study were inadequate. This finding matches the definition of shock, which is the pathological condition of inadequate tissue oxygenation. In the state of shock, the oxygen delivered is not sufficient to meet the body's oxygen consumption, therefore not able to maintain the aerobic metabolism. The DO_2 is a product of the CO and arterial oxygen content (CaO_2) (18). In the previous part it has been mentioned that the patients in this study mostly had normal CO, therefore the pathological conditions of low DO_2 were predicted to be caused by the low CaO_2.

The microcirculation parameter discussed in this study is the blood lactate levels. This study was dominated by patients with alactatemia (blood lactate level being under the pathological range). A study conducted in a general hospital in Jakarta shows a similar result, where in a group of pediatric shock patients most of the lactate blood levels were recorded as normal to low (8). The condition of hyperlactatemia (blood lactate level being above the normal range) has been known as a marker of tissue hypoxia. This is because the rise of blood lactate levels are mainly caused by the anaerobic glycolysis which happens in the condition of hypoperfusion (19). It is predicted that the unmatched result of the study was caused by the lactate level testing being done in the early stage of shock when the oxygen delivery has not declined far under the normal range since the anaerobic metabolism has not occurred massively.

5. Conclusion

This study concluded that among the Pediatric Intensive Care Unit (PICU) patients with shock in Dr. Soetomo General Hospital in 1st September 2021 – 31st May 2022, most of them being males, coming from the School Age (5-12 years old) age group, and experiencing the septic shock. The parameters of blood pressure, CO, and SVR in most of the patients were recorded normal, showing that there had been previous resuscitations that improved these parameters. The parameters of inadequate SV and high HR (tachycardia) found in most patients matched the mechanism of compensation in shock. The parameter of DO_2 which were mostly found inadequate was predicted to be caused more by the low CaO_2. The blood lactate levels in most patients were found alactatemia, showing that most of the patients had not fallen far into the condition of anaerobic metabolism.

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