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Retrospective Study

Prognostic value of hemodynamic indices in patients with sepsis after fluid resuscitation

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Abstract

BACKGROUND

Sepsis usually causes hemodynamic abnormalities. Hemodynamic index is one of the factors to identify the severity of sepsis and an important parameter to guide the procedure of fluid resuscitation. The present study investigated whether the assessment of hemodynamic indices can predict the outcomes of septic patients undergoing resuscitation therapy.

AIM

To evaluate the prognostic value of hemodynamic indices in patients with sepsis after fluid resuscitation.

METHODS

A retrospective study was conducted in 120 patients with sepsis at Hainan General Hospital/Hainan Affiliated Hospital of Hainan Medical University between October 2016 and October 2019. All patients were treated with sodium chloride combined with dextran glucose injection for fluid resuscitation. Patients' hemodynamic parameters were monitored, including heart rate (HR), cardiac index (CI), systemic vascular resistance index (SVRI), mean arterial pressure (MAP), central venous pressure (CVP), and central venous oxygen saturation. The prognostic value of hemodynamic indices was determined based on the prognosis status.

RESULTS

During fluid resuscitation, 86 patients developed septic shock and 34 did not. Ninety-nine patients survived and 21 patients died at 28 d after the treatment. Heart rate, CI, mean arterial pressure, SVRI, and CVP were higher in patients with septic shock and patients who died from septic shock than in non-shock patients and patients who survived, and central venous oxygen saturation was lower in

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patients with shock and patients who died than in non-shock patients and the survivors ($P < 0.05$). When prognosis was considered as a dependent variable and hemodynamic parameters was considered as independent variables, the results of a logistic regression analysis showed that CI, SVRI, and CVP were independent risk factors for septic shock, and CI was an independent risk factor for 28-d mortality ($P < 0.05$).

CONCLUSION

Hemodynamic indices can be used to evaluate the prognosis of septic patients after fluid resuscitation.

Key Words: Sepsis; Fluid resuscitation; Cardiac index; Systemic vascular resistance index; Mean arterial pressure

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Core Tip: Sepsis is usually associated with hemodynamic changes. Hemodynamic monitoring is commonly used to guide resuscitation therapy. This study explored the role of hemodynamic indices for the prediction of outcomes in patients with sepsis undergoing fluid resuscitation. The findings suggested that cardiac index, systemic vascular resistance index, and central venous pressure were independent risk factors for the occurrence of septic shock, and cardiac index was an independent risk factor for the occurrence of death at 28 d after the treatment.

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INTRODUCTION

Sepsis is a series of reactions that occur when an organism is in the state of being infected. Severe sepsis is usually complicated with organ dysfunction and even shock with a high fatality rate^[1,2]. Clinical studies^[3,4] showed that treatment initiated as early as possible can effectively reduce the fatality rate. Currently, the most commonly used therapy for the treatment of sepsis is fluid resuscitation, which aims to maintain hemodynamic stability and slow progression of the disease^[5]. During fluid administration, large amounts of fluids entering the body may increase the work load of cardiopulmonary function^[6]. Hemodynamic monitoring helps to observe the heart's pumping function and analyze patient outcomes^[7]. The most frequently monitored hemodynamic indices probably include heart rate (HR), cardiac index (CI), mean arterial pressure (MAP), systemic vascular resistance index (SVRI), central venous pressure (CVP), and central venous oxygen saturation (ScvO₂)^[8,9]. The present study tried to discuss the prognostic value of hemodynamic indices in patients with sepsis after fluid resuscitation to provide data to promote the treatment for sepsis.

MATERIALS AND METHODS

General information

A retrospective analysis was conducted in 120 patients with sepsis treated at Hainan General Hospital/Hainan Affiliated Hospital of Hainan Medical University between October 2016 and October 2019. Sodium chloride combined with dextran glucose injection was administrated for fluid resuscitation in all the patients. Patients enrolled in the study included 40 with respiratory system infection, 30 with urinary system infection, 16 with digestive system infection, 15 with nervous system infection, and 19 with other infection. Patients were eligible for the study if they were diagnosed with

sepsis at the age of 18 to 70 years old and was informed and signed the consent form^[10]. Non-sepsis patients with poor basic state and unable to cooperate in the study, patients with circulation system disease and unavailability of medical records, and patients unable to complete the treatment because of themselves or their families were excluded from the study.

Among the 120 patients, 76 were male and 44 were female with an average age of 63.23 ± 12.32 (range, 18-69) years old. Acute physiology and chronic health evaluation II score was 9 to 24 (mean, 14.23 ± 5.64).

Methods

Septic patients were monitored for hemodynamic changes. Central venous catheters were inserted into the internal jugular or subclavian vein under the guidance of CVP test. Fiber optic catheters were then inserted into the central venous catheters to continuously monitor ScvO₂. Catheters indwelled in the radial artery were connected with an Edwards Vigileo Monitor (produced by Edwards Lifesciences) to continuously monitor HR, CI, MAP, and SVRI by pulse contour analysis of waveform^[11].

Measures

Observation measures included: (1) Outcomes of patients with sepsis; (2) Analysis of relationship between hemodynamic indices and the outcomes in patients with sepsis after the treatment; and (3) Analysis of prognosis in septic patients after the treatment.

Statistical methods

SPSS22.0 was used to process the data. Measurement data with a normal distribution are expressed as the mean \pm SD and inter-group difference was compared using Student's *t* test. Enumeration data are expressed with percentages and inter-group difference was compared using χ^2 tests or Fisher's exact test. Logistic analysis was used to estimate the prognosis. $P < 0.05$ represented that there was a significant difference.

RESULTS

In terms of outcomes in the 120 patients undergoing fluid resuscitation, septic shock occurred in 86 patients and at 28 d after the treatment, 99 patients survived.

After analyzing the relationship between hemodynamic indices and the outcomes in patients with sepsis after the treatment, it was found that HR, CI, MAP, SVRI, and CVP were higher in septic shock patients and patients who died than non-shock patients and patients who survived. However, ScvO₂ was lower in septic shock patients and patients who died than non-shock patients and patients who survived ($P < 0.05$; Table 1).

Hemodynamic parameters were used as the independent variables to analyze the prognosis using Logistic analysis. The results showed that CI, SVRI, and CVP were independent risk factors for the occurrence of septic shock and CI was an independent risk factor for 28 d mortality ($P < 0.05$; Table 2). Analysis of the relationship between hemodynamic indices and death at 28 d after the treatment revealed a B value of 0.314 and an SE value of 0.043 (odds ratio = 0.751, 95% confidence interval: 0.751-0.872, $P = 0.01$).

DISCUSSION

Sepsis is one of the most common causes of death in patients admitted in the intensive care unit. Clinical features of sepsis often include systemic inflammatory response and even damage to multiple organs. Severe cases of sepsis may develop into septic shock, which may further lead to multiple organ dysfunction with a fatality rate up to 35% to 70%^[12-14]. Sepsis occurs when the body have a probable or confirmed infection or trauma. The development of infection and trauma will cause systemic inflammatory response, which in turn causes secretion of inflammatory mediators followed by cardiovascular dysfunction with the presence of decreased effective circulating volume, hemodynamic changes including fall of blood pressure, and septic shock^[15]. Hemodynamic monitoring, which is usually used in the diagnosis and treatment of cardiovascular dysfunction, could also be used in sepsis patients with septic shock whose hemodynamic stability is vulnerable to the influence of trauma and infection. Hemodynamic changes vary in different periods of development in patients with

Table 1 Relationship between hemodynamic indices and outcomes in patients with sepsis after the treatment (mean \pm SD)

Prognosis	n	HR (bpm)	CI (L/min/m ²)	MAP (mm Hg)	SVRI (dyn/s/cm ⁵ /m ²)	CVP (mm Hg)	ScvO ₂ (%)
Short-term prognosis							
Shock	86	109.12 \pm 9.53	4.48 \pm 0.87	54.21 \pm 20.12	1479 \pm 297	4.46 \pm 1.22	67.37 \pm 19.35
Non-shock	34	102.16 \pm 7.34 ^a	4.17 \pm 0.83 ^a	49.32 \pm 19.59 ^a	1421 \pm 243 ^a	4.12 \pm 1.09 ^a	71.56 \pm 21.22 ^a
28-d							
Death	21	132.26 \pm 11.23	4.85 \pm 0.94	55.60 \pm 22.16	1493 \pm 276	4.82 \pm 1.03	61.28 \pm 17.75
Survival	99	95.11 \pm 9.14 ^b	4.28 \pm 0.65 ^b	50.92 \pm 19.33 ^b	1435 \pm 239 ^b	4.23 \pm 1.39 ^b	67.84 \pm 25.56 ^b

^a*P* < 0.05 compared with shock patients.^b*P* < 0.05 compared with patients who died. HR: Heart rate; CI: Cardiac index; MAP: Mean arterial pressure; SVRI: Systemic vascular resistance index; CVP: Central venous pressure; ScvO₂: Central venous oxygen saturation.**Table 2 Relationship between hemodynamic indices and shock**

Variable	B value	SE value	P value	OR value	95%CI
CI	0.234	0.032	0.01	0.812	0.875-0.912
SVRI	0.345	0.043	0.01	0.823	0.889-0.992
CVP	0.145	0.023	0.01	0.762	0.712-0.896

CI: Cardiac index; SVRI: Systemic vascular resistance index; CVP: Central venous pressure.

acute sepsis^[16]. In the early phase of sepsis, it is normally characterized by high output-normal resistance and increased cardiac output and CI, and normal or decreased SVRI specifically. As the disease progresses, it is characterized with high output-low resistance and accelerated heart rate, obviously increased cardiac output, and decreased SVRI. In view of this, hemodynamic indices could become one of the factors for prediction of disease state and prognosis in patients with severe sepsis^[17]. Studies^[18] found that fluid resuscitation under the guidance of hemodynamic monitoring helps to improve the treatment efficacy and outcomes in septic patients with myocardial injury. Stimulated by endotoxin, the release of myocardial-depressant-factor increased and then causes unbalanced mechanisms of local blood flow regulation that finally may lead to myocardial ischemia and anoxia and decrease in SVRI, and a series of changes in hemodynamic indices^[19,20].

In the present study, crystalloid and colloid solutions were added to sodium chloride injection and dextran glucose injection administered for fluid resuscitation to maintain plasma colloid osmotic pressure and increase blood volume and improve microcirculation. In addition, hemodynamic monitoring can prevent the occurrence of heart failure due to circulatory overload caused by a large quantity of liquid entering the body. The results of the present study suggested that HR, CI, MAP, SVRI, and CVP were higher and ScvO₂ was lower in the early phase of shock and patients who died than in patients without shock and patients who survived. Logistic regression analysis showed that CI, SVRI, and CVP were independent risk factors for the occurrence of septic shock and CI was an independent risk factor for the occurrence of death at 28 d after the treatment. This hinted that clinical manifestations such as hemodynamic abnormalities, decrease in ScvO₂, and microcirculatory hypoperfusion were frequent in patients with severe sepsis. The prognosis can be predicted through the use of hemodynamic monitoring.

CONCLUSION

Hemodynamic indices are associated with the prognosis in patients with sepsis and they can be used as the factors for the prediction of changes in patients' conditions and prognosis. Moreover, hemodynamic indices can be used to guide the procedure of fluid resuscitation. Further studies are needed to compare the changes in hemody-

namic indices in the later phase of sepsis to provide strong evidence for the clinical treatment of sepsis.

ARTICLE HIGHLIGHTS

Research background

Sepsis is always associated with high mortality. Early diagnosis and appropriate treatment help to improve outcomes. Like markers such as body temperature, leukocyte count, C-reactive protein, and procalcitonin as well as tumor necrosis factor- α , interleukin (IL)-6, IL-8, IL-10, and HLA-DR expression, hemodynamic indices guide clinicians to make a reasonable decision. However, no specific markers for sepsis have been identified.

Research motivation

Hemodynamic monitoring is essential to the care of septic patients. By assessing the hemodynamic indices, patient condition is determined so that timely subsequent interventions will be given accordingly. Whether its role is as important as the above-mentioned markers or factors in the management of sepsis? The present study reported the performance of hemodynamic indices for predicting the outcomes including risk of shock and mortality in septic patients.

Research objectives

To discuss the potential predictive and prognostic value of hemodynamic indices for relevant clinical outcomes in patients with sepsis.

Research methods

Hemodynamic indices were monitored in patients with sepsis, including heart rate (HR), cardiac index (CI), mean arterial pressure (MAP), systemic vascular resistance index (SVRI), central venous pressure (CVP), and central venous oxygen saturation (ScvO₂). The differences in hemodynamic indices were compared between patients with shock and patients without shock and between non-survivors and survivors.

Research results

The results revealed that HR, CI, MAP, SVRI, and CVP were higher in septic shock patients and non-survivors than in non-shock patients and survivors. However, ScvO₂ was lower in septic shock patients and non-survivors than in non-shock patients and survivors.

Research conclusions

Patients with high HR, CI, MAP, SVRI, and CVP levels and low ScvO₂ level probably develop severe disease or experience worsening disease. Hemodynamic indices may have predictive value for the outcomes and prognosis in patients with sepsis.

Research perspectives

Recently, studies showed that static measures were replaced by dynamic measures for the prediction of fluid responsiveness and cardiac performance. In view of this, studies in the future should take the dynamic markers into consideration.

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