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# Application and Nursing of Pulse Index Continuous Cardiac Output (PiCCO) Volume Monitoring in Early Fluid Resuscitation in Patients with Septic Shock

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## Abstract

**Background:** Septic shock is a rapidly changing and fatal syndrome that can cause comprehensive deterioration of cardiopulmonary and renal function and multiple organ failure. At the same time, septic shock has the complex clinical manifestations and hemodynamics. PiCCO can accurately monitor blood flow, physical and volume indicators, and active and effective fluid resuscitation are important measures to reduce the fatality rate of septic shock and improve the prognosis of patients. **Objectives:** To explore the application and nursing of PiCCO in early fluid resuscitation in patients with septic shock. **Methods:** This was a retrospective observational study. The observation group and the control group each had 30 cases. The observation group used PiCCO to guide fluid resuscitation; the control group used conventional methods to guide fluid resuscitation. The changes in CVP, HR, MAP, and urine volume per hour were observed in the two groups. The changes of various indicators before and after fluid resuscitation, the length of stay in ICU and the mortality rate were compared between the two groups. All the outcomes were collected from the electronic medical case system after patients' discharge from the hospital. **Results:** APACHE II, CVP, HR, MAP were compared between the observation group and the control group, and the differences were statistically significant ($P < 0.05$). The blood volume of patients in the observation group was significantly improved after fluid supplementation ($P < 0.05$). Compared with the control group, the length of stay in ICU in the observation group was significantly shorter, and the mortality rate was also signifi-

cantly reduced ($P < 0.05$). **Conclusion:** PiCCO can be better used in early fluid resuscitation of patients with septic shock.

## Keywords

Septic Shock, Pulse Index Continuous Cardiac Output (PiCCO), Nursing

## 1. Introduction

Sepsis is life-threatening organ dysfunction caused by a dysregulated host response to infection. Septic shock is a subset of sepsis with circulatory and cellular/metabolic dysfunction associated with a higher risk of mortality and it has always been a problem that plagues the world's medical community [1] [2]. For such patients, a large amount of fluid resuscitation is very important in early treatment. However, excessive fluid resuscitation may lead to pulmonary edema or circulatory overload. Therefore, it is important to understand the patient's blood volume status. Through effective fluid resuscitation, the lack of blood volume in the blood vessels is corrected, and the tissue perfusion is ensured, thereby reducing the fatality rate of septic shock [3] [4]. PiCCO can monitor cardiac output (CO), cardiac index (CI) and volume indicators such as intrathoracic blood volume index (ITBVI), global end-diastolic volume index (GEDVI), stroke volume variation (SVV) and vascular resistance, etc. PiCCO is simple and easy to operate [5] [6]. This study explores the application and nursing of PiCCO volume monitoring in early fluid resuscitation in patients with septic shock, and the report is as follows.

## 2. Objects and Methods

### 2.1. Objects

Sixty patients with septic shock who were admitted to the surgical ICU from July 2014 to July 2020 were selected. Inclusion criteria: patients aged 18 - 60 years old, with diagnosis of septic shock, and with fluid resuscitation treatment. Exclusion criteria: patients during pregnancy, patients with previous arteriovenous fistulas, patients who give up active treatment, and patients with other types of shock such as cardiogenic shock or hemorrhagic shock. In this group of patients, there were 38 males and 22 females; they were 18 - 60 years old, with an average age of 34 years. Thirty patients with septic shock who used routine monitoring to guide fluid management were set as the control group, and 30 patients with septic shock who used PiCCO monitoring to guide fluid management were set as the observation group. The age and gender of the two groups were not statistically significant ($P > 0.05$), and they were comparable. This study was performed by referring to the medical records, and there was almost no risk to the objects. So the written informed consent was exempted. We have obtained permission from the hospital's ethics committee.

## 2.2. Methods

### 2.2.1. Control Group

Routine monitoring methods was used to guide fluid management: continuous electrocardiogram (ECG) monitoring, hourly monitoring of heart rate (HR), percutaneous oxygen saturation, arterial blood pressure, central venous pressure (CVP), hourly urine volume and intake, and dynamic mastering of hourly and total intake and output. The level of CVP was maintained at 8 - 12 mmHg to guide fluid rehydration, active fluid rehydration at < 8 mmHg, and fluid rehydration at > 12 mmHg. Resuscitation 6 hours target was achieved by using vasoactive drugs to maintain the mean arterial pressure ≥ 65 mmHg, CVP 8 - 12 mmHg, and urine volume ≥ 0.5 ml/kg·h.

### 2.2.2. Observation Group

PiCCO monitoring was used to guide fluid management based on guiding fluid replenishment according to conventional methods. PiCCO module was connected to the monitor for hemodynamic monitoring through the central venous catheter's main passage in the neck or clavicle and the femoral artery thermodilution catheter. Generally, 0.9% sodium chloride solution was injected every six-hour at 2˚C ~ 5˚C, 10 ml/time. The injection was completed at a uniform rate within four seconds, and the average value was taken for three consecutive measurements. When the patient has changed in circulatory kinetics, the measurement is carried out at any time. PiCCO Active fluids was given when EVLWI < 7 ml/kg and ITBVI < 850 ml/m$^2$; limit fluid replacement when EVLWI < 10 ml/kg and ≥ 7 ml/kg, ITBVI > 1000 ml/m$^2$; limit fluid rehydration and use diuretics when EVLWI≥ 10ml/kg; adjust vasoactive drugs according to the results of CI and systolic function; and adjust norepinephrine dosage according to system vascular resistance index. Resuscitation six-hour goal was: SVV ≤ 10%, CI > 3.0 L/min·m$^2$, EVLWI < 10 ml/kg, MAP ≥ 65 mmHg, and urine volume ≥ 0.5 ml/kg·h.

## 2.3. Observation Indicators

APACHE II score [7] was calculated before treatment and 72 hours after treatment. The HR, CVP, MAP, GEDVI, the length of ICU stay, and mortality of the two groups were collected at two time points, namely before treatment and 72 hours after treatment. All the above indicators were collected from the electronic medical case system after patients' discharge from the hospital.

## 2.4. Statistical Methods

Statistical analysis was performed using SPSS23.0. Express the measurement data as X ± S, and use the independent sample t test. Express the count data as a ratio (n%) and use the $\chi^2$ test. The Chi-square test was used to test the differences between the observation group and the control group. $P < 0.05$, the difference was statistically significant.

## 3. Results

The comparison of APACHE II score, HR, CVP, MAP between the two groups of patients showed that the difference in APACHE II score, HR, CVP, MAP in the observation group was statistically significant ($P < 0.01$), and the HR and MAP of the control group were statistically significant ($P < 0.05$) (Table 1).

The comparison results of the changes of various indexes before and after fluid management of patients in the observation group showed that the differences in CO, CI, GEDVI, EVLWI indexes in the observation group were statistically significant ($P < 0.05$) (Table 2).

The comparison of the length of stay in ICU and the mortality of the two groups. The difference was statistically significant ($P < 0.05$) (Table 3).

## 4. Discussion

The reduction of useful circulating blood volume is one of the features of septic shock. Effective fluid resuscitation is the key to treatment. PiCCO assisting clinical acquisition of accurate, dynamic, and continuous hemodynamic monitoring data, to be earlier, provide treatment guidance more accurately [8]. Compared with the traditional CVP monitoring method, this continuous cardiac output monitoring method based on arterial waveform has its unique advantages [9] [10].

From Table 1 that the observation group has significantly improved APACHE II score, HR, CVP, MAP compared with the control group, indicating that PiCCO monitoring can help patients with septic shock. The safe and effective implementation of early resuscitation programs.

From Table 2, the indicators of CO, CI, GEDVI, and ELVWI of the observation group were significantly stable after the implementation of PiCCO monitoring and guiding fluid management. The possible reason is that PiCCO monitoring enables medical staff to visually observe various hemodynamic indicators of the patient from the monitor. Through the analysis of monitoring indicators,

**Table 1.** Comparison of APACHE II score, HR, MAP, CVP before and after treatment between the two groups.

| Group | Age | Observation time | APACHE II | HR | MAP | CVP |
|---|---|---|---|---|---|---|
| Control group | 35.1 ± 8.6 | Before treatment | 24.4 ± 6.8 | 143.5 ± 32.2 | 64.4 ± 16.8 | 4.5 ± 2.8 |
| | | 72 h after treatment | 22.3 ± 5.4 | 134.1 ± 28.6 | 74.1 ± 14.2 | 6.5 ± 3.2 |
| *t* | | | 3.97 | 3.46 | 18.70 | 15.83 |
| *P* | | | 0.75 | 0.03* | 0.04* | 0.08 |
| Observation Group | 34.0 ± 8.7 | Before treatment | 23.8 ± 5.3 | 142.9 ± 31.5 | 63.4 ± 17.8 | 4.4 ± 3.2 |
| | | 72 h after treatment | 18.6 ± 5.0 | 122.3 ± 22.9 | 84.4 ± 15.9 | 8.5 ± 2.2 |
| *t* | 0.51 | | 13.76 | 22.05 | 32.06 | 29.55 |
| *P* | 0.61 | | <0.01** | <0.01** | <0.01** | <0.01** |

Note: **means $P < 0.01$; *means $P < 0.05$; APACHE II: Acute Physiology And Chronic Health Evaluation II; HR: Heart Rate; MAP: Mean Arterial Pressure; CVP: Central Venous Pressure.

medical staff can more accurately assess the cardiopulmonary function and volume status of patients with septic shock, thereby adjusting the type of fluid, input sequence and time at any time. The feasibility and accuracy of the total end-diastolic volume index and the thoracic volume index in measuring the blood volume of patients have been confirmed. EVLWI can directly reflect the severity of pulmonary edema, including lung water caused by high permeability and high hydrostatic pressure. Therefore, the blood flow in the thoracic cavity and extravascular lung water monitoring guidance can avoid excessive fluid load from the second blow to the heart and circulatory system, protect or even improve the heart function to the greatest extent, thereby accelerating the stabilization of hemodynamics [11] [12]. But oneprevious study showed that in the early phase of severe sepsis among patients receiving mechanical ventilation, there was no constant relationship between GEDI and fluid reserve responsiveness [13]. Further, another recent study showed that echocardiography measurements of CO and CI were comparable to PiCCO measurements, which was non-invasive compared with PiCCO. This result indicated the limitation of PiCCO, and thus echocardiography measurement could be used to guide fluid and vasoactive-inotropic management of critically ill pediatric patients [14].

From **Table 3**, it was found that the observation group patients effectively shortened the length of stay in the ICU and reduced the mortality rate. Fluid resuscitation management is considered to be the key to the treatment of patients with septic shock. In the past, conventional fluid management often failed to provide an accurate and intuitive basis for patient safety. If the fluid resuscitation period cannot be passed smoothly, it may aggravate the patient's condition, even life-threatening. PiCCO monitoring can better guide the cardiopulmonary management of critically ill patients, and early circulatory stability in critically ill patients has important clinical significance for the protection of tissue perfusion and organ function [15]. It can be seen the condition of septic shock patients who use PiCCO monitoring to guide fluid body management can be stabilized earlier than patients who use conventional monitoring methods to guide infusion, which provide an excellent platform for disease treatment, and enable patients to pass the critical period safely [16].

**Table 2.** Changes in various indicators of PiCCO volume monitoring before and after fluid management in the observation group (n = 30).

| | CO (L/min) | CI (L/min/m$^2$) | GEDVI (mL/m$^2$) | ELVWI (ml/kg) |
|---|---|---|---|---|
| Before treatment | 2.9 ± 0.3 | 2.6 ± 0.5 | 415.0 ± 95.4 | 10.7 ± 4.5 |
| 72 h after treatment | 4.6 ± 0.5 | 4.5 ± 0.3 | 703.0 ± 112.4 | 9.2 ± 3.3 |
| *t* | 251.10 | 159.40 | 58.39 | 7.55 |
| *P* | <0.01* | <0.01* | <0.01* | <0.01* |

Note: *means $P < 0.05$. CO: cardiac output; CI: cardiac index; GEDVI: global end-diastolic volume index; EVLWI: extra vascular lung water index.

**Table 3.** Comparison of the length of stay in ICU and the number of deaths (rate) between the two groups.

| Group | n | Length of stay in ICU | Number of deaths (rate) |
|---|---|---|---|
| Control group | 30 | 25.3 ± 4.9 | 7 (23) |
| Observation Group | 30 | 20.1 ± 3.5 | 1 (3) |
| Statistics | | t = 18.25 | $\chi^2 = 5.19$ |
| *P* | | 0.04* | 0.03* |

Note: *means $P < 0.05$.

In summary, the application of the PiCCO volume index can accurately and reliably assess the patient's volume status, can accurately indicate the patient's cardiopulmonary function, provide the most direct basis for the patient's fluid management, and facilitate timely adjustment of the fluid management plan, so that can help patients who with septic shock through the dangerous period successfully. At the same time, the monitoring method is simple, safe, and accurate. It can meet the requirements of rapid fluid resuscitation. It has essential value for fluid resuscitation of patients with septic shock and is beneficial to the observation and the care of patients with septic shock.

## 5. Limitations

This study was limited in several ways. First, this study's observation period was limited to the period of patients staying in the ICU, which was relatively short. The treatment effect of patients after leaving the ICU needs to be tracked. Secondly, the study subjects were limited to a tertiary university hospital in China and therefore were more likely to have more severe diseases, which may hinder the generalization of the results among patients in the general hospital.

## Authors' Contributions

All authors contributed in study conception, design and critically revised the article. Miss Li and Liang have equally contributed as first authors to the article and drafted the article and in acquisition of data.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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