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Discuss the Value of PICCO and Echocardiography in Terms of Hemodynamic Monitoring

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ABSTRACT

Objective: To compare the measurements of cardiac output between PiCCO and color Doppler echocardiography and evaluate the consistency in patients with septic shock. Methods: 25 septic shock in-patients treated in the department of Intensive Critical Carewere chosen from Dec,2013 to Sep, 2014. Heart rate, invasive mean arterial pressure and systematic circulatory vascular resistant index at different times were measured by continuous PiCCO monitoring. The cardiac output at the same time was measured by the PiCCO thermodilution technology, pulse contour technology and color Doppler echocardiography. Results: There were no significant differences of the measurements of cardiac output between the PiCCO thermodilution technology and echocardiography atdifferent times($p > 0.05$); The cardiac output measured by pulse contour technology was significantly lower than that by echocardiography at 2ndh ($p < 0.05$), there were no significant differences at other times. Conclusion: When the peripheral vascular resistance changes rapidly, the consistency of PiCCO thermodilution technology and echocardiography is better than that of pulse contour technology and echocardiography in the measurements of cardiac output. When patients have the similar hemodynamic changes like septic shock, we'd better use the PiCCO thermodilution technology to measure the cardiac output.

Keywords: *PiCCO; color Doppler echocardiography; septic shock; CO*

INTRODUCTION

Septic shock mainly defined as that it still can not improve the state of sepsis-induced hypotension, accompanied by clinical manifestations such as reduced peripheral vascular resistance and cardiac output increased under sufficient fluid resuscitation situation. Its essence is the result of systemic inflammatory response syndrome continued proliferation. Early septic shock, peripheral circulatory disorders, and inadequate tissue perfusion, which usually presents refractory hypotension, oliguria, blood lactate higher. The severity of Sepsis can be monitored by clinical trials. At the same time it can be estimated by the SOFA and APACHEII score, as evidenced by the research SOFA and APACHEII score is higher related to severity of sepsis [1].

The early goal of treatment for patients with septic shock is currently recognized internationally important treatment. The

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measures of resuscitation of early goal recognized by current international is as follows. After the clinical diagnosis of severe infection or septic shock, early recovery needs to meet the following criteria: central venous pressure (CVP) reaches 8-12 mmHg; mean arterial pressure is 65 mmHg; urine is 0.5 ml/kg/h; ScvO2 or SvO2 is 70%; Required transfusion of packed red blood cells make Hct is more than 30%; or infusion of vasoactive drugs to achieve recovery goals [2, 3]. But for patients with septic shock, due to the action of inflammatory mediators result in vascular endothelial vascular permeability changes, a lot of liquid can seep into the gap between the interstitial lung tissue, resulting in the possibility of acute pulmonary edema and acute heart failure, and suffering even aggravate respiratory and cardiac function. So hemodynamic monitoring and effective treatment of septic shock is an integral part [4, 5].

Changes of previous clinical hemodynamic mainly represent patients with circulation and heart function through the volume of urine, CO and CVP binding the clinical experience of doctors, lack of objectivity and accuracy. Therefore, clinicians eager to get more data-aided clinical diagnosis and treatment through more comprehensive monitoring technology. At the same time people pay more and more attention to hemodynamic monitoring and water index of extravascular lung during fluid resuscitation, and PiCCO as a premium high-tech product in recent years bring more and more severe physician's attention and it is widely used in blood dynamics monitoring for clinical in patients with septic shock.

The heart of color Doppler ultrasound Doppler principle, measure each chamber of the heart through several major plane. Use the Simpson method – A geometric approach to calculate the correlation of hemodynamic parameters, and can determine blood flow properties of the beam. It is a non-invasive, convenient and cost-effective secondary examination. It is widely accepted and researched by clinicians. In this study, the implementation of the hospital has a strong heart ultrasound specialist team, which provide a good basis for the operation in the study.

The system of puise indicator continuous cardiac output (PiCCO) as a combination of thermodilution technique and pulse wave contour analysis, measure CO value instantly by thermal dilution technique, and continuous CO value measured by pulse contour analysis techniques. Meanwhile PiCCO system calculate intrathoracic blood volume (ITBV) and extravascular lung water (EVLW), compared to CVP, PAOP, RVEDV, and ITBV, it is more accurately to reflect cardiac preload extent, which has been confirmed now.

Catheters of past Swan-Ganz cost more expensive, more complications, and higher requirements for its invasive operation. The operator is difficult, and limited in extensive clinical. But PiCCO technology with a combination of thermodilution and pulse contour technology, because no pulmonary artery catheter, low-risk, low price than the former, it is easy to carry out in clinical, and recognized by the majority of physicians. Furthermore, the date of PCCO, CI, ITBVI, EVLWI, CFI, SVV, heart rate, stroke volume, mean arterial pressure, GEDV, and SVRI monitored through PiCCO can be read directly by PiCCO monitor. Wherein ITBVI as indicators of cardiac preload has high accuracy, EVLW can react lung water situation. Moreover, other data monitored through PiCCO are contribute to an accurate dose for patients with severe physician grasp capacity of resuscitation, and vascular drugs, providing a more objective indicator of vasoactive drugs to reduce patient time and duration of treatment for patients, physicians improve clinical judgment and severe treatment capacity. Overall, PiCCO with less invasive; placement process is simple,

no X-ray to determine the position of the catheter; cheaper, PiCCO catheter can be placed for a long time, it also can reduce patient costs. PiCCO system obtain hemodynamic parameters through two different technical principles, and assisted clinicians determine the outer periphery of a more comprehensive water and cardiac function in patients.

Currently, cardiac color Doppler ultrasound often through several major section measurements, calculated related hemodynamic parameters with the use of Simpson method after measuring.

The formula is:

the volume of left ventricular = Am × L/3 + (Am + Ap) × L/(2 × 3) + Ap × L/(3 × 3)

Am is the mitral valve area of left ventricular short in the level of axis view

Ap is the mitral valve area of left ventricular papillary muscle in short axis view

L is the length of the long axis of the left ventricular apical in two-chamber or four-chamber plane

Monitoring HR, MAP, SVRI of all patients with septic shock at 0 h, 2 h, 6 h, 12 h, 24 h, 48 h by PiCCO in the study. Prompted hemodynamic characteristics of high-ranked low resistance of 25 patients with septic shock; after the early goal of resuscitation, the patient gradually returned to normal peripheral vascular resistance, and cardiac output is decreased.

Cardiac color Doppler examination is highly dependent on the operator's personal factors. It has a larger variability in different operators. the three-dimensional spatial structure of the heart must operate from more speculative aspect, and experimental variability CO value is large.

In the study, taking into account the kind of factors, it is unified by a physician at the situation of unknown of the patient's condition, take each successive measured three times, get the averaged value, to avoid human error factors.

MATERIALS AND METHODS

General Information

The experimental data collect from December 2013 to September 2014, a total of 25 patients diagnosed as septic shock and incorporate ICU patients, which meet to the inclusion criteria of the study. The maximum age is 85 years old, the youngest is 17 years old, and the average age is (56.32 ± 12.99) years old in 25 patients. The main diseases are as follows: severe intraperitoneal infection in 5 people, two people with severe pancreatitis, 4 people with chronic obstructive pulmonary emphysema pulmonary infection, 2 people was purulent cholecystitis, two people with peptic ulcer, gastrointestinal bleeding in 2 people, two people with gastrointestinal perforation, 4 people with multiple body injuries, and two people with multiple fractures of the body.

Inclusion criteria

Transferred to ICU or ICU patients with septic shock, the diagnostic criteria septic shock are as follows: (1) General indicators: chills, breathing rate, and blood pressure decreased were appear; (2) laboratory tests: white blood cell count was significantly increased or decreased, and serum C reactive protein or PCG original increased; (3) there are clear localized foci in clinically; (4) hemodynamic parameters: cardiac output, reduced peripheral vascular resistance; (5) microcirculation: cold distal extremities, oliguria; (6) organ dysfunction: urea and creatinine increased, blood clotting abnormalities, hyperlipidemia and other high pink; (7) metabolism: Insulin requirements increase; (8) need vasoactive drugs to maintain blood pressure; MAP<65mmHg (9) the presence of SIRS, meet not more than two or two of. index: T> 38 or < 36 ; R> 90 beats/

min; RR> 20 beats/min or PaCO2 <32 mmHg or mechanical ventilation; WBC was significant changed: 12 × 109/L or < 4 × 109/L, or immature white blood cells > 0.01; (10). After the early goal resuscitation, it has continued hypotension, MAP < 65mmHg.

Exclusion criteria

(1) All non-septic shock patients: because of systemic disease such as infection, heart disease, mediastinal infection, patients with rheumatoid arthritis classes; (2) heartbeat, respiratory arrest patients, such as resuscitation of cardiopulmonary, patients with acute myocardial infarction; (3) there are IABP (Intra-aortic balloon Pump, IABP) patients; (4) patients with malignant arrhythmias, such as ventricular fibrillation, ventricular tachycardia. (5) patients with femoral artery puncture site migration and severe burns; (6) rhythm is atrial fibrillation; (7) vein or femoral artery catheter in patients with septic shock and could not do under the collarbone. (8) The patient who do not want to do PiCCO monitoring technology or cardiac color Doppler ultrasound reluctant row.

METHODS

After do subclavian vein and femoral artery catheterization in patients with the specialist in our department, connecting PiCCO, monitoring the MAP, SVR, instantly CO, and PCCO of the patient at different times. Record the above data monitored by PiCCO while measured immediate CO value of patient which operated by a specialist in cardiac ultrasound. Two physicians were trained PiCCO invasive hemodynamic monitoring techniques and cardiac color Doppler ultrasound measurements CO value specialized training, and two severe cardiac ultrasound diagnostics specialist assist the study of the whole process until it is completed.

The measurements of hemodynamic index by PiCCO

The arterial temperature pressure catheter of PiCCO was used in the experiments (4F, PV2014L16, Pulsion, Germany) to monitor arterial pressure and depicted arterial pressure waveform on this basis, using a computer to calculate the continuous PCCO. PV2014L16 arterial pressure catheter with a special temperature probe, the temperature of the ice brine change can be feel.

15 ml ice brine (5) was injected through the subclavian vein, saline ice went through the superior vena cava upon and arrive in atrium; Then went through the ventricle and reach to the lungs. After thermodilution pumped

Table 1: 22 the comparison of the datas with 22 cases of patients with septic shock

TIME	MAP (mmHg)	HR (times per minute)	SVRI(dyn•s•m2/cm5)	CO(cardiac color Doppler ultrasonic measurements ,L/min)	CO(PiCCO thermodilution measurements,L/min)	CO(PiCCO pulse contour measurement L/min)
0h	59.64±9.67	119.68±13.46	1271.50±195.14	7.43±2.21	7.40±2.18	__
2h	66.36±5.65	113.05±8.36	1339.27±168.02	7.30±2.22	7.29±1.53	6.49±1.91▲
6h	70.82±2.97	106.95±9.89	1394.77±175.42	6.40±1.70	6.37±1.69	6.37±1.75
12h	68.82±5.48	100.68±7.95	2086.64±243.61	5.74±1.38	5.70±1.40	5.69±1.36
24h	83.64±12.23	96.18±5.93	1884.82±236.78	5.26±1.19	5.27±1.18	5.18±1.15
48h	89.73±8.05	89.55±4.52	1924.23±285.90	4.83±1.04	4.82±1.04	4.83±0.95

It represents a significant difference compared with cardiac color Doppler ultrasonic measurements P<0.05)

back to the heart, then get to femoral artery. Got through the shares again arterial catheter temperature probe, and draw the entire thermal dilution curve. The detector automatically calculated the CO value immediately. Based on the curve, the calculated values of continuous PCCO and cardiac output/cardiac index (CO/CI), the total amount of end diastolic volume (GEDV), total intrathoracic blood volume (ITBV), extravascular lung water (EVLW) as well as blood pressure, heart rate and systemic vascular resistance. (Table 1).

After connecting the various conduits and monitors, pulse contour method respectively use continuous monitoring PCCO (read directly by the PiCCO system) and thermal dilution measure instantly CO (by a central venous injection of cold saline, the value obtained by the thermodilution technique). Measurement procedure is as follows: (1) Ready for injection of cold saline (temperature < 5) 250ml. (2) Under subclavian vein catheterization. Patient supine after pillow was taken away, Trendelenburg.

Clavicle in the next 1/3 Outbound Wang pointed to the puncture site after local anesthetic lidocaine, the right hand of an operator holding the needle, the needle and the amount leaving it level, our department specialist puncture. Upon the needle puncture point, slightly above the collarbone and backward against the needle inward, needle 4-5 cm after Withdrawing to see dark red blood, blood can be inserted into clear after the guide wire from the side of the needle hole exit needle, guide wire extension insert intravenous catheters (7.5FR, double-lumen catheter, Shenzhen Yixin, China), catheter insert depth of 15 centimeters. Confirm catheter patency back to the blood, connect monitor (IntelliVue MP60, Philips, Germany) pressure measurement system, covering topical gauze or transparent film.

Femoral artery catheter insert PiCCO arterial pressure temperature (4F, PV2014L16, Pulsion, Germany). Patient supine, the strongest in the femoral pulse at the bottom of two centimeters is the puncture site. After the local anesthetic lidocaine, touch left femoral pulse maxima positioned and needle between the two finger touch arterial by our department physician. After Withdrawing blood, the blood is bright red, later identified as arterial blood into the guide wire, pull out the needle. PiCCO the arterial temperature and pressure catheter go through guide wire. Inserted into the femoral artery under the guidance of the guide wire. After the expansion of the skin with arterial dilatation catheter, the temperature and pressure femoral artery catheterization. After get proper catheter position, pull out the guide wire. Attach a transducer means. Butterflies with sheets fixed on the skin, disinfection dressing.

Open the IntelliVue MP60 Monitor (Philips, Germany) cardiac output monitoring system to calculate the patient's basic input page information, including height, weight, CVP and other basic items.

When get a stable baseline, inject a solution for 15 ml projectile as quickly as possible (<7 seconds).

Repeat three times after the thermodilution measurement, calculate PiCCO monitoring value (the measured value is the thermodilution measurement instantly CO, after which the monitor displays the CO value named PCCO).

Cardiac color Doppler ultrasound

Cardiac color Doppler is a noninvasive heart examination techniques, obtain the majority of physicians in the clinical recognition. In this study, MylabTwice color Doppler diagnostic (Esaote, Italy) was used, and the probe frequency is 3.5MHz. Left lateral position of the patient, the specialist cardiac ultrasound diagnosis using biplane Simpson method to measure the left ventricular apex Shu, reduced

end-diastolic volume and stroke volume, combined with real-time heart rate (HR) to measure CO. Each successive measured three times, and got averaged record. In the study, 25 patients had the same cardiac color Doppler ultrasound specialist to measure CO values.

Monitoring indicators

Record heart rate (HR), invasive mean arterial pressure (MAP), systemic vascular resistance index (SVRI) of each patient, line two PiCCO measurements and a heart color Doppler ultrasound measuring cardiac output (CO) at 0 h, 2 h, 6 h, 12 h, 24 h, 48 h. Measure and record the CO value displayed by PiCCO system in the first use of the pulse contour method. In the second time, measure and record CO value displayed by PiCCO system by thermal dilution method. PiCCO calibrated once every four hours, cardiac color Doppler ultrasound exam each successive measured three times and got averaged record.

Statistical Methods

Analyzed data using SPSS 19.0 software and Med Calc9.2.1.0 software. Measurement data were recorded as mean ± standard deviation (x ± s), mean date were compared using paired t test. Brand consistency between using bivariate - Analysis Altman difference plot (ABland-Altman plot). p <0.05 was considered statistically significant.

Technology Roadmap

Technology Roadmap is shown in Figure 1.

RESULTS

In the experiment, 25 patients were included in the diagnosis of septic shock patients, 2 patients with severe pancreatitis patients and one case of death in patients with COPD and lung infection during treatment. The data is incomplete, and it is excluded. Since PiCCO during the initial measurement only use thermal dilution technique, so it was without PiCCO pulse contour CO measurement value at 0h. Measurement results are shown in Table 1 from Different methods at 0 h, 2 h, 6 h, 12 h, 24 h, 48 h.

Patients with low blood pressure, rapid heart rate, low peripheral vascular resistance, high cardiac output before treatment, after given conventional treatment, blood pressure gradually increased, and heart rate decreased, peripheral vascular resistance gradually returned to normal, cardiac output decreased. SVRI is lower than normal (1200-2000 dyn•s•m2/cm5) at 0 h, 2 h and 6 h. There is no significant difference (P > 0.05) of CO value and cardiac color Doppler ultrasonic measurements through PiCCO thermodilution measurements at 0 h; CO value of PiCCO pulse contour measurement is lower than that of the cardiac color Doppler ultrasonic measurements (P < 0.05), and there is no significant difference (P > 0.05) between CO value of thermodilution measurements and that of cardiac color Doppler ultrasonic measurements at 2 h; PiCCO use the thermodilution technique and pulse contour technique to measure the value of CO, respectively. Which is relatively good with CO value measured by cardiac color Doppler ultrasound, and there is no significant difference (P> 0.05) at 6 h, 12 h, 24 h, 48 h.

Table above are the Bland-Altman difference plot (A Bland-Altman plot), x-axis represents the average CO value of the two groups, y-axis represents two methods to measure the difference between the CO values, the solid line indicates the average of the difference value (bia), and the dotted line represent the difference between the average value ± 1.96 × standard deviation (bia ± 1.96SD). PiCCO thermodilution cardiac color Doppler ultrasound consistency of CO values shown in Fig.2(a,b,c,d,e,f) at 0h, 2h, 6h, 12h, 24h, 48h. Each figure dot substantially uniformly distributed in a straight line on both sides of the mean difference value representing PiCCO thermodilution cardiac color Doppler ultrasound consistency at 0 h, 2 h, 6 h, 24 h, 48 h.

Consistency CO values in PiCCO pulse contour method and cardiac color Doppler ultrasound were shown in Fig. 3(a,b,c,d,e), Each figure dot substantially uniformly distributed in a straight line on both sides of the mean difference value representing PiCCO thermodilution cardiac color Doppler ultrasound consistency at 0 h, 2 h, 6 h, 24 h, 48 h. The figure was significantly bias the average difference between each dot value straight side at 2 h, showing PiCCO pulse contour method and cardiac color Doppler ultrasound has poor consistency at 2 h.

Table 2 and Table 3 is further elaborated Bland-Altman difference plot (ABland-Altman plot). The average value of the difference in CO value is (-0.01, 0.03) through PiCCO thermodilution and cardiac color Doppler ultrasound measurements at 0 h, 2 h, 6 h, 12 h, 24 h, 48 h in Table 2. 95% confidence intervals in CO value were (-0.46, 0.53), (-0.27, 0.23), (-0.12, 0.18), (-0.12, 0.18), (-0.09, 0.10) through PiCCO thermodilution and cardiac color Doppler ultrasound measurements at 0 h, 2 h, 6 h, 12 h, 24 h, 48 h. The average value of the difference in CO value is (0.00, 0.08) through PiCCO thermodilution and cardiac color Doppler ultrasound measurements at 6 h, 12 h, 24 h, 48 h in Table 3. The average value of the difference in CO value is 0.79 through PiCCO thermodilution and cardiac color Doppler ultrasound measurements at 2 h which is significantly exceed this range. 95% confidence intervals in CO value were (-0.12, 0.29), (-0.17, 0.26), (-0.12, 0.28), (-0.82, 0.82), (-0.09, 0.10) through PiCCO thermodilution and cardiac color Doppler ultrasound measurements at 2 h, 6 h, 12 h, 24 h, 48 h.

The results of this study showed that Bland - Altman difference plot (A Bland-Altman plot) is displayed each dot figure substantially uniformly distributed in a straight line on both sides of the mean value of the difference in 0 h, 2 h, 6 h, 12 h, 24 h, 48 h, prompted by thermal dilution technique measuring 0 h, 6 h, 12 h, 24 h, CO value and cardiac color Doppler ultrasonic measurements 48h time consistency, consistent with previous findings. The use of pulse wave measuring profiling technology 2h when Bland - Altman difference plot (ABland-Altman plot) figure the average difference between the value of each dot somewhat straight side, indicating the pulse wave-shaped profile analysis CO measurement values and cardiac color Doppler ultrasound measurement

Table 2: Mean Difference(Bias)Between CO by the thermodilution of PiCCO and CO by the UCG,Lower Limits of Agreement (Bias±1.96SD),Upper Limits of Agreement (Bias±1.96SD)

	0h	2h	6h	12h	24h	48h
The average difference value(L/min)	0.03	0.02	0.03	0.02	-0.01	0.01
1.96SD(L/min)	0.495	0.25	0.15	0.15	0.3	0.095
Consistency limit(L/min)	0.53	0.23	0.18	0.18	0.29	0.10
Consistency limit(L/min)	-0.46	-0.27	-0.12	-0.12	-0.31	-0.09

Table 3: Mean Difference(Bias)Between CO by the Pulse contour method of PiCCO and CO by the UCG,Lower Limits of Agreement (Bias±1.96SD),Upper Limits of Agreement (Bias±1.96SD)

	2h	6h	12h	24h	48h
The average difference value (L/min)	0.79	0.08	0.05	0.08	0.00
1.96SD(L/min)	0.66	0.205	0.215	0.20	0.41
Consistency limit (L/min)	1.45	0.29	0.26	0.28	0.82
Consistency limit (L/min)	0.13	-0.12	-0.17	-0.12	-0.82

consistency is poor at 2 h, but significantly lower than the absolute value of cardiac color Doppler ultrasound. Because patients with septic shock microcirculation, a large number of inflammatory mediators released into the blood, all kinds of inflammatory mediators acting on endothelial cells, endothelial cells by stimulating the release of inflammatory mediators endothelin, NO and other media, changing the vascular endothelium, vascular pass permeability and intravascular blood flow, leading to stasis and vascular changes in the body's microcirculation blood tension, thus affecting the peripheral vascular resistance. In the study, CO value measured by occurs pulse contour technology is below the value of CO measured by cardiac color Doppler ultrasound at 2 h, which is considered telated to the rapid changes in arterial vascular resistance [6-8].

PCCO calculated is as follows:

$$PCCO = cal \bullet HR \bullet \int systole (P(t)/SVR + C(p) \bullet dp/dt)\, dt$$

cal represents the correction factor; HR represents the heart rate; P (t) represents arterial pressure; P(t)/SVR represents the pressure area under the curve; C(p) indicates arterial compliance; dp/dt curve indicates arterial pressure waveform.

Wherein the correction factor, SVR, arterial compliance is determined at the time of correction. When the actual SVR decreased and arterial compliance increased, since P (t)/SVR and C(p) becomes smaller, CO value may be lower than the true value. In addition, mechanical ventilation PEEP value and valvular disease may affect PiCCO monitoring [9]. For affected in varying degrees of changes in SVR PiCCO monitoring, Irlbeck et al [10] noted the slow change in peripheral vascular resistance when PiCCO calibrated once every four hours, avoiding PiCCO measurement accuracy is affected. But when the rapid changes in peripheral vascular resistance, PiCCO correction time interval is not clear.

Based on Irlbeck [9] studies, PiCCO calibrated once every four hours in the present study, avoiding generated CO measurement error since hemodynamic instability. but there are still differences of CO values at 2 h between the two groups through pulse contour technology group and cardiac color Doppler ultrasound measurement. Probably due to rapid changes in peripheral vascular resistance, arterial compliance is high, impact PCCO formula, resulting in PCCO formula appear errors, resulting in CO value measured by pulse contour techniques is lower than its calculated value, and CO value measured by thermal dilution technique is unaffected. After given conventional treatment, SVRI of the patient is still low at 6 h. But it has increased peripheral vascular resistance than before, and did not change significantly. Compared the CO value of cardiac color Doppler ultrasonic measurements with that of PiCCO pulse contour measurement, there is no significant difference, while Bland-Altman difference plot (ABland-Altman plot) diagram showed each dot was substantially uniformly distributed in a straight line on both sides of the mean difference value, indicating that it is consistency of CO value measured by PiCCO through pulse profile measurements and cardiac color Doppler ultrasonic measurements at that time.

CONCLUSIONS

When peripheral vascular resistance changes slowly, regular use of thermodilution technique can correct PCCO and guarantee the accuracy of PiCCO pulse contour techniques to measure. When rapid changes in peripheral vascular resistance and decreases, the results of the study prompted PiCCO thermodilution measurement of CO value and technology cardiac color Doppler ultrasonic measurements still maintain good consistency, but poor consistency is between PiCCO pulse

contour technique and cardiac color Doppler ultrasonic measurements, and significantly underestimated CO value.

When peripheral vascular resistance changed rapidly, consistency of PiCCO thermodilution measurement technology measure CO value and cardiac color Doppler ultrasound measurements may be better than the pulse contour techniques measured. For patients with similar clinical septic shock, hemodynamic changes, the use of PiCCO monitoring in CO value preferably thermal dilution technique to measure values prevail.

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