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Original Article

Comparison of the accuracy of transpulmonary thermodilution measurement using indicators of different temperatures

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Abstract: Transpulmonary thermodilution measurement is a convenient method for hemodynamic monitoring. However, the previously reported indicator temperature was not consistent. This study aimed to compare the accuracy of Pulse index Continuous Cardiac Output (PiCCO) monitoring using indicators of different temperatures. A total of 104 critically ill patients received PiCCO monitoring using indicators of either 0°C or 8°C. The PiCCO measurements, including general ejection fraction, global end-diastolic index, and cardiac index, were compared between the two temperatures, and were also correlated with that of transesophageal echocardiography (TEE). The two indicator temperatures differed significantly in hemodynamic measurements ($P<0.01$). PiCCO measurements with either indicator temperatures showed positive correlation with TEE results ($P<0.05$). The 0°C indicator had universally higher correlation coefficients than the 8°C indicator. So, PiCCO monitoring with the 0°C indicator might have better accuracy than the 8°C indicator.

Keywords: Indicator, PiCCO, temperature, hemodynamics, thermodilution

Introduction

Close monitoring of hemodynamic status is essential during the treatment of critically ill patients. Pulmonary artery catheter was previously the standard method for hemodynamic monitoring. However, its use has been declining due to the invasiveness and high rate of complications [1, 2]. Transpulmonary thermodilution measurement, such as Pulse index Continuous Cardiac Output (PiCCO), is a novel technique that measures and integrates several hemodynamic variables through intra-arterial and central venous catheterization alone [3, 4]. Therefore, PiCCO is less invasive compared with the pulmonary artery catheter.

After catheterization and setting up the PiCCO monitor with a mandatory data set, calibration is needed before data acquisition. The injective solution should ideally be 0.9% saline as dextrose can damage the sensor's housing. The recommended volume for injection is between 15 and 30 ml. The optimal fluid temperature is below 8°C although room temperature solutions are acceptable [5]. However, it is not clear whether indicator of different temperatures will cause variation in the PiCCO measurements.

In this study, we performed PiCCO with indicators of two temperatures and correlated the results with that of transesophageal echocardiography (TEE).

Materials and methods

Patients

A total of 104 critically ill patients were treated at the ICU in our hospital from November 2008 to October 2013. These patients included 78 males and 26 females with a mean age of 40±8.1 years (range 16-72 years). The primary diseases included traumatic shock in 16 cases, septic shock in 48 cases, hypovolemic shock in 30 cases, multiple organ dysfunction syndrome in 6 cases, and acute renal failure in 4 cases. The hemodynamic monitoring was performed

Table 1. Comparison PiCCO measurements between the 0°C and 8°C indicators

	0°C	8°C	*P*-value	95% confidence interval
GEF	26.96±7.48	17.23±4.79	<0.01	7.33-12.13
GEDI	707.50±80.26	508.23±121.15	<0.01	162.72-235.82
CI	5.23±1.81	3.64±1.32	<0.01	1.15-2.03

GEF: general ejection fraction; GEDI: global end-diastolic index; CI: cardiac index.

with sedation and mechanical ventilation with the patients at the supine position. Informed consent was obtained from the patients. This study was approved by the Ethics Committee of our hospital.

Hemodynamic monitoring

For TEE examination, a 5-MHz transducer was orally inserted into the esophagus with a distance of 35 cm from the incisor. General ejection fraction (GEF), global end-diastolic index (GEDI), and cardiac index (CI) were measured with TEE.

For PiCCO monitoring, central venous and femoral artery catheterization was performed. A PiCCO monitor was set up (Pulsion, Germany). Two temperatures, 0°C and 8°C, were used for the indicator. An injectate of 15 ml was infused within 4 s into the central vein. Measurements were repeated with each temperature for three times. The mean values of each variable were calculated. PiCCO measurements with the 8°C indicator were performed 5 min later after the 0°C indicator.

Statistical analysis

All data were presented as mean ± standard deviation. Dada analysis was performed with SPSS software (SPSS 19.0, SPSS, USA). Comparison between the two temperatures was made with paired *t*-test. The correlation between PiCCO and TEE measurements was analyzed with Pearson test. A *P*-value less than 0.05 was considered statistically significant.

Results

Comparison between the two temperatures

PiCCO measurements with the two indicator temperatures differed significantly (**Table 1**).

Correlation between PiCCO and TEE measurements

PiCCO measurements showed positive correlation with TEE results either using the 0°C or 8°C indicator (**Figure 1**). However, the correlation coefficients (*r*) were universally higher for the 0°C indicator than the 8°C indicator.

Discussion

In this study, we performed PiCCO monitoring with indicators at two different temperatures of 0°C and 8°C. The two temperatures differed significantly in PiCCO measurements, although both showed positive correlation with TEE-measured hemodynamics. However, the 0°C indicator had universally higher correlation coefficients than the 8°C indicator, suggesting a better accuracy of PiCCO measurements with 0°C indicator.

PiCCO has been used for two decades in hemodynamic monitoring for critically ill patients, such as heart failure, renal failure, and severe shock. The accuracy and precision of PiCCO in measuring GEF, GEDI, and CI have been verified [6-12]. Pulmonary artery catheter was the previous reference method for monitoring hemodynamic status. However, this method is affected by myocardial compliance and intrathoracic pressure, and therefore is inaccurate in measuring the end-diastolic volume. In addition, pulmonary artery catheter can cause severe complications such as heart damage, ventricular arrhythmia, pulmonary embolism, and pulmonary artery rupture [13]. In comparison, PiCCO monitoring is less invasive and is more accurate in measuring GEF, GEDI, and CI [14-17]. PiCCO can also measure cardiac preload and afterload, heart contractibility, and extravascular lung water [18-20].

Iced saline is usually used as indicator during PiCCO measurement, although it has been shown that indicator at room temperature and ice-water temperature produced similar results [21]. Most previous studies used an indicator temperature between 0°C and 10°C. In this study, we found that PiCCO measurements dif-

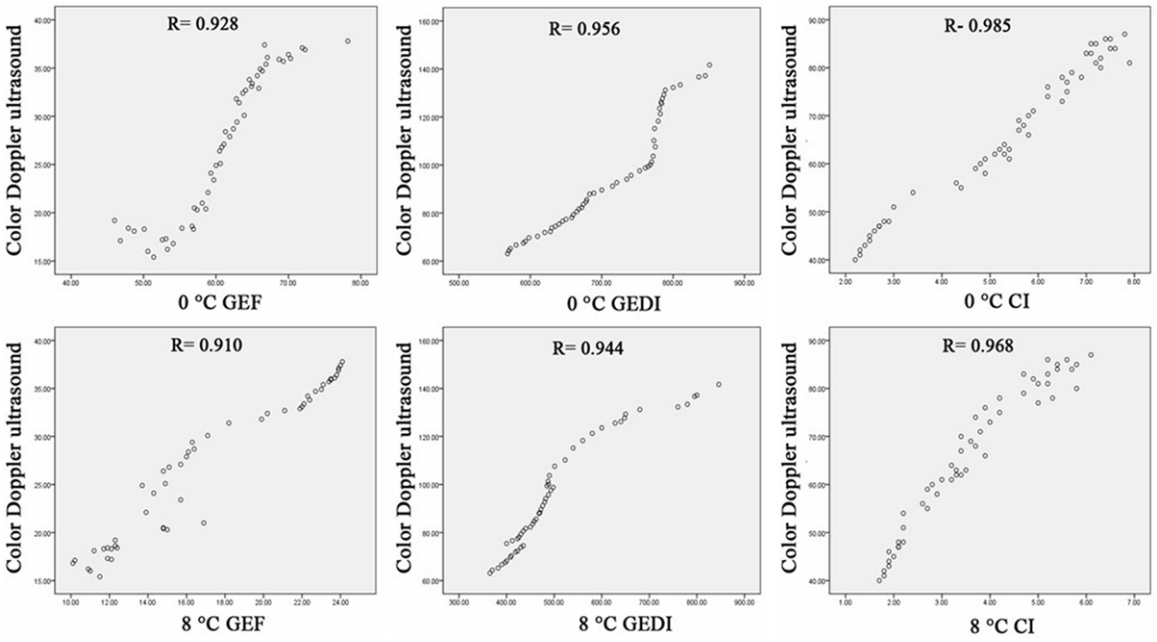

Figure 1. Positive correlation was found between the PiCCO and TEE results either using the 0°C or 8°C indicator. The correlation coefficients (r) were universally higher for the 0°C indicator than the 8°C indicator.

fered significantly between the 0°C and 8°C indicators. Indicator at 0°C showed higher correlation coefficients than the 8°C indicator with the TEE-measured hemodynamic results. These results suggest a possibly better accuracy in PiCCO monitoring with the 0°C indicator than the 8°C indicator. Using additional methods to verify the PiCCO results may give us more confidence in choosing the temperature of indicators. The specific reason for the differences in PiCCO measurements between the indicators of two different temperatures is not clear. We observed that the thermodilution curve appeared earlier with higher amplitude in PiCCO monitoring with the 0°C indicator than the 8°C indicator. These results were consistent with that of Schmidt S. [22].

In conclusion, PiCCO monitoring with the 0°C indicator might have better accuracy than the 8°C indicator. The specific mechanisms underlying this discrepancy need further investigation.

Disclosure of conflict of interest

None.

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