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ORIGINAL ARTICLE

The accuracy of PiCCO® in measuring cardiac output in patients under therapeutic hypothermia: Comparison with transthoracic echocardiography

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KEYWORDS
PiCCO monitor;
Cardiac output;
Hypothermia;
Doppler echocardiography;
Hemodynamic monitoring

Abstract
Background: Invasive cardiac monitoring using thermodilution methods such as PiCCO® is widely used in critically ill patients and provides a wide range of hemodynamic variables, including cardiac output (CO). However, in post-cardiac arrest patients subjected to therapeutic hypothermia, the low body temperature possibly could interfere with the technique. Transthoracic Doppler echocardiography (ECHO) has long proved its accuracy in estimating CO, and is not influenced by temperature changes.
Objective: To assess the accuracy of PiCCO® in measuring CO in patients under therapeutic hypothermia, compared with ECHO.
Design and patients: Thirty paired COECHO/COPiCCO measurements were analyzed in 15 patients subjected to hypothermia after cardiac arrest. Eighteen paired measurements were obtained at under 36 °C and 12 at ≥36 °C. A value of 0.5 l/min was considered the maximum accepted difference between the COECHO and COPiCCO values.
Results: Under conditions of normothermia (≥36 °C), the mean difference between COECHO and COPiCCO was 0.030 l/min, with limits of agreement (−0.22, 0.28) – all of the measurements differing by less than 0.5 l/min. In situations of hypothermia (<36 °C), the mean difference in CO measurements was −0.426 l/min, with limits of agreement (−1.60, 0.75), and only 44% (8/18) of the paired measurements fell within the interval (−0.5, 0.5). The calculated temperature cut-off point maximizing specificity was 35.95 °C: above this temperature, specificity was 100%, with a false-positive rate of 0%.

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Conclusions: The results clearly show clinically relevant discordance between COECHO and COPiCCO at temperatures of <36 °C, demonstrating the inaccuracy of PiCCO® for cardiac output measurements in hypothermic patients.

PALABRAS CLAVE
Monitor PiCCO;
Gasto cardiaco;
Hipotermia;
Ecocardiografía doppler;
Monitorización hemodinámica

La exactitud de PiCCO ® para medir el gasto cardíaco en pacientes bajo hipotermia terapéutica: comparación con ecocardiografía transtorácica

Resumen
Introducción: La monitorización invasiva cardiaca mediante métodos de termodilución, como PiCCO®, es ampliamente utilizada en pacientes críticamente enfermos y proporciona una gran variedad de variables hemodinámicas, como el gasto cardiaco (GC). No obstante, en los pacientes post-paro cardíaco bajo hipotermia terapéutica, la baja temperatura corporal podría interferir con la técnica. La ecocardiografía doppler transtorácica (ECHO) ha demostrado su exactitud en la estimación del GC y no está influenciada por los cambios de temperatura.
Objetivo: El objetivo del presente estudio fue evaluar la exactitud de PiCCO® para medir el GC en pacientes bajo hipotermia terapéutica, en comparación con ECHO.
Diseño y pacientes: Se analizaron 30 pares de mediciones GC_ECHO/GC_PiCCO en 15 pacientes sometidos a hipotermia después de un paro cardíaco. La máxima diferencia aceptada entre los valores de GC_ECHO y GC_PiCCO se consideró 18 mediciones pareadas se realizaron a menos de 36 °C y 12 a ≥36 °C. 0,5 L/min.
Resultados: En la normotermia (≥36 °C), la diferencia media entre GC_ECHO y GC_PiCCO fue de 0,030 L/min, con límites de concordancia (−0,22; 0,28), todas las medidas difieren menos de 0,5 L/min. En la hipotermia (<36 °C), la diferencia media de las mediciones fue −0,426 L/min con límites de concordancia (−1,60; 0,75) y solo el 44% de las mediciones cayeron en el intervalo (−0,5; 0,5). El límite de temperatura calculado que maximiza la especificidad fue 35,95 °C, por encima del cual la especificidad fue del 100% y la tasa de falsos positivos del 0%.
Conclusiones: Los resultados muestran claramente una discordancia clínicamente relevante entre GC_ECHO y GC_PiCCO en temperatura <36 °C, lo que revela la inexactitud de PiCCO® para las mediciones del gasto cardíaco en pacientes hipotérmicos.

Introduction

In post-cardiac arrest patients, mild induced hypothermia has proven to be neuroprotective and to improve the global outcome after the initial period of cerebral hypoxia-ischemia.[1,2] This probably occurs because hypothermia reduces cerebral oxygen demand, decreases intracranial pressure and also limits the production of oxygen free radicals, diminishing brain damage.[1] The term targeted temperature management is now preferred, and the most recent resuscitation guidelines recommend a constant temperature between 32–36 °C for at least 24 h, although the optimal target temperature remains uncertain, waiting for more large controlled trials on this matter.[3]

The initial management of the so called 'post-resuscitation syndrome' is challenging. Hypovolemia, excessive vasodilation and reversible myocardial stunning frequently results in early hypotension that can be life-threatening.[4,5] This hemodynamic instability is managed with the use of fluids, inotropes and vasopressors if needed.[3,4] Therefore, it is important to have a correct monitoring of hemodynamic and pulmonary variables, in order to optimize those therapies,[5] sometimes using invasive devices.

The PiCCO® (pulse index continuous cardiac output) system, in use for over 10 years, allows the measuring of a large number of variables throughout central venous and peripheral arterial catheterization alone. Among other parameters, it is used to measure cardiac output (CO) through a transpulmonary thermodilution method.

Despite the unquestionable utility of PiCCO® in situations of hemodynamic instability, as a thermodilution method, it is assumed that the temperature within the artery stays stable during calibration and measurements. That might not be the case during hypothermia and other variations of body temperature.

Transthoracic Doppler echocardiography (ECHO) has long proved its accuracy in CO estimation, including in critically ill patients.[6–10] It can be performed in different scenarios, including therapeutic hypothermia, and it is not influenced by temperature changes.

Therefore, the aim of the present study was to assess the concordance between the CO values measured by PiCCO® (CO_{PiCCO}) and by ECHO (CO_{ECHO}), in patients under therapeutic hypothermia following cardiac arrest.