Case reports

Failure of Continuous Cardiac Output Measurement Using the PiCCO Device During Induced Hypothermia: A Case Report

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ABSTRACT

Continuous cardiac output measurement using pulse contour analysis is a technique gaining widespread acceptance in intensive care units. We report a case where a pulse contour analysis computer (PiCCO®, Pulsion Medical Systems, Munich, Germany) failed to calibrate in a patient who was undergoing induced hypothermia for anoxic brain injury. Despite several attempts to calibrate, using increased cold injectate volumes and exchanging both the PiCCO® device and the arterial catheter, we were unable to correct the calibration problem and hence were unable to monitor cardiac output. Subsequent rewarming of the patient allowed calibration of the arterial waveform and continuous cardiac output measurement.

We were unable to find any previous reports of this problem using a PiCCO® device, although similar problems with thermodilution cardiac output estimation using the pulmonary artery catheter during hypothermic cardiopulmonary bypass have been documented. (**Critical Care and Resuscitation 2004; 6: 99-101**)

Key words: Cardiac output, pulse contour analysis, thermodilution, hypothermia, intensive care, anoxic brain injury

Induced hypothermia has been proposed for the management of anoxic brain injury[1] and traumatic head injury. There is also increasing interest in its use in fulminant hepatic failure, stroke and encephalitis.[2] These patients often have a pre-existing cardiovascular derangement or may subsequently develop it as a consequence of hypothermia. In these situations it may be advantageous to monitor the patient's cardiac output.

Estimation of cardiac output using pulse contour analysis and transpulmonary thermodilution is a technique which has enjoyed increasing popularity. The PiCCO® device (Pulsion Medical Systems, Munich, Germany) is a commercially available system which uses a thermistor tipped arterial catheter, a central line linked temperature sensor and a pulse contour analysis computer to estimate cardiac output. We report a failure of the PiCCO® device to estimate cardiac output in a patient undergoing induced hypothermia following asystolic cardiac arrest.

CASE REPORT

A 70-year-old man was admitted to the Austin Hospital emergency department, hypotensive and bradycardic with a one-hour history of central chest pain and dizziness. He had a past medical history of left nephrectomy, myocardial infarction 10 years previously, angina and left ventricular dysfunction. On initial assessment he was conscious with a heart rate of 35 beats per minute (bpm) and a blood pressure of 60/30 mmHg. Atropine 1.2 mg and adrenaline 300 µg were administered intravenously by the attending paramedics

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and an infusion of adrenaline at 15 µg/min was commenced.

On arrival at the emergency department his heart rate was 35 bpm and blood pressure was 70/40 mmHg. A 12 lead ECG confirmed the diagnosis of complete heart block. External precordial pacing paddles were applied and he was paced at a rate of 80 bpm. The adrenaline infusion was increased to 30 µg/min, which maintained his blood pressure at 85/47 mmHg, and he was transferred to the cardiac catheterisation suite for insertion of a temporary transvenous pacing wire. On arrival, he had an asystolic cardiac arrest. Cardiopulmonary resuscitation (CPR) was initiated, he was intubated and mechanically ventilated with 100% oxygen and after 3 minutes the circulation was restored with a heart rate of 40 bpm. However, he had another asystolic cardiac arrest 13 minutes later and received a further 5 minutes of CPR and a total of 3 mg of adrenalin and 0.6 mg atropine, intravenously.

A temporary pacing wire was inserted via the right femoral vein and cardiac pacing commenced in VVI mode at 90 bpm. The blood pressure increased to 120/75 mmHg so the adrenaline infusion was discontinued. A coronary angiogram was performed which revealed severe diffuse triple vessel disease with chronic occlusive disease of his right coronary artery not amenable to angioplasty or stenting.

He was transferred to the intensive care unit (ICU), haemodynamically stable without inotropic support, sedated with propofol and mechanically ventilated. Active body cooling was initiated (using a fan and ice packs applied bilaterally to the axillae, neck and groin and an infusion of one litre of cold 0.9% saline) in an attempt to reduce the risk of anoxic brain injury. Propofol sedation was continued and neuromuscular paralysis was established using intravenous vecuronium.

The patient's core temperature was reduced to 35.7°C, as measured by a 12F rectal temperature probe (Agilent Technologies, USA). A 5F "Pulsiocath" modified arterial catheter (Pulsion Medical Systems) was inserted into the left femoral artery and connected to a PiCCO*plus*® pulse contour analysis computer (Pulsion Medical Systems). Once connected, we were unable to calibrate the arterial pressure wave with cold injectate thermodilution. The process of calibration was repeated several times with no success. Larger cold injectate volumes (20 mL) were used and all connecting cables were changed, with no success. The monitor was then thought to be at fault, so it was exchanged for another PiCCO*plus*® and subsequently for a Phillips Intellivue® pulse contour analysis computer (Philips Medizinsysteme, Germany) but with no beneficial effect. Finally, a defective pulsiocath was postulated as the reason for failure of calibration, so this was changed. Again this was unsuccessful. Attempts to monitor cardiac output were abandoned, although the Pulsiocath® was left in situ.

Hypothermia was maintained for 12 hours before rewarming was commenced. At a temperature of 35.8°C recalibration of the arterial pressure waveform with the PiCCO*plus*® pulse contour analysis computer was successful, revealing a cardiac index of 2.2 L/min/m^2. The patient was successfully extubated the day following his cardiac arrest and discharged to the ward with no neurological sequelae.

DISCUSSION

Estimation of cardiac output using transpulmonary thermodilution involves the administration a central venous bolus of cold injectate, typically 15 - 20 mL of 0.9% saline at less than 8°C. A fibre-optic thermistor is positioned in the femoral artery at the tip of a modified arterial catheter. The PiCCO® system estimates cardiac output from pulse contour analysis based on the method of Wesseling.[3] An arterial thermodilution curve is constructed using a modified Stewart-Hamilton equation and used to calibrate an arterial pressure waveform. Measurements have been found to be in agreement with pulmonary artery thermodiltion and direct Fick method. The parameters: intrathoracic blood volume (ITBV) and extravascular lung water (EVLW), are also estimated using the thermodilution curve.[4]

It is well known that rapid temperature changes in the pulmonary artery introduce errors when determining cardiac output by thermodilution,[5,6] especially in the context of hypothermic cardiopulmonary bypass. Bottinger *et al*, conducted a prospective study of continuous cardiac output (CCO) measurements versus intermittent cardiac output (ICO) measurements in patients undergoing hypothermic cardiopulmonary bypass and found that at temperatures less than 36°C there was poor correlation between methods. They postulated that induced hypothermia caused high levels of thermal instability or thermal noise in the central compartment, thus invalidating the cardiac output measurement.[7] Spackman and Albertstein recognised a significant discrepancy between CCO and ICO measurements during the use of an upper body warming blanket. This phenomenon disappeared when the warming blanket was switched off.[8]

Investigators using the PiCCO® system to monitor cardiac output during hypothermic cardiopulmonary bypass have minimised this problem by calibrating the arterial pressure waveform prior to surgery and avoiding recalibration until the patient returned to the intensive care unit.[9]

We conducted a PubMed® and Medline® search using the search headings "induced hypothermia",

"hypothermia", "cardiac output", "transpulmonary thermodilution", "pulse contour analysis". We also consulted product information for Pulsiocath®. We were unable to find any data relating to the accuracy of PiCCO® under conditions of induced hypothermia. We hypothesise that under hypothermic conditions thermal instability, thermal noise and reduced signal to noise ratio renders the PiCCO® subject to the same inaccuracies that conventional thermodilution is subject to at extremes of temperature. In our case this resulted in the failure of the PiCCO® to calibrate the arterial pulse contour. With renewed interest in induced hypothermia in post cardiac arrest patients this may be a recurrent problem. If CCO monitoring is required using the PiCCO® system, calibration should be undertaken prior to cooling and not repeated until the patient has been rewarmed.

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