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Measuring cardiac output with an aortic impedance model

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Keywords

afterload, arctangent aortic pressure area relationship, cardiac output measurement, non linear model, septic shock, thermodilution

Comments

This paper provides evidence that model simulated cardiac output provides continuous pulse by pulse analysis of cardiac output that tracks cardiac output calculated from thermodilution. Although the MCO consistently underestimated cardiac output when uncalibrated, once calibrated the MCO consistently tracked TDCO over a range of cardiac outputs. This suggests that with a single calibration to thermodilution, MCO provides a non-invasive low risk method of assessing cardiac output. Additionally, the monitor would appear to be useful as a 'trend' monitor to cardiac output over a wide, clinically relevant range.

The paper makes no comment on patient demographics, whether radial or femoral arterial pressure monitoring affected results and had a relatively small number of subjects (only five monitored for three days). Disappointingly, no comment was made on the practicalities of using MCO.

Introduction

A continuous calculation of cardiac output can be obtained from information derived from the arterial pressure waveform. This mathematical formula depends on the aortic compliance, elasticity and impedance, and on the total peripheral resistance. The model has been validated against thermodilution in patients undergoing cardiac surgery in a range of cardiac outputs (3.1-6.9 l/min).

Aims

To evaluate whether continuous cardiac output monitoring by model simulation is reliable in patients with sepsis and a wide range of cardiac outputs.

Methods

Thirty-two patients with septic shock on mechanical ventilation were monitored for 1-3 days. Patients received dopamine, dobutamine, norepinephrine and epinephrine to alter the hemodynamic state. Bolus injection thermodilution cardiac output (TDCO) was calculated by injecting pulses of 10 ml ice-cooled 5% glucose solution four times within 3 min. Each set of four estimates were averaged to give TDCO value. The model-simulated cardiac output (MCO) was estimated from arterial pressure wave by a non-linear 3-element model of aortic input impedance. For comparison of TDCO and MCO, four phase-controlled TDCO and four simultaneously obtained estimates were averaged. Values were calibrated with the first TDCO of the day.

Results

From thirty-two patients, 189 paired cardiac output measurements were obtained. On day 1 the bias (mean difference between MCO and TDCO) prior to calibration was - 1.92 ± 2.3 l/min (95% limits of agreement). The bias increased with higher cardiac output. For the 15 patients studied for two consecutive days the TCDO:MCO ratio was 1.39 ± 0.28 (95% limits of agreement) and did not change on day 2. After calibration with the first TDCO reading of the day the bias was 0.1 ± 0.81 l/min (95% limits of agreement). In 14 of 15 patients changes in TDCO were adequately tracked by MCO.

Discussion

Changes in bolus TDCO were reflected by calibrated MCO over a range of cardiac output values. An initial, single, calibration is required and is sufficient to monitor cardiac output continuously from arterial pressure over a 2-day period. Management of patients with septic shock should ideally aim to modify cardiac output. This development in continuous monitoring of cardiac output may allow manipulation of systemic blood flow to become a major goal in the treatment of septic shock. To be able to obtain comparable readings of variations in cardiac output is relevant in the debate on the pros and cons of pulmonary artery catheterization required for the bolus TDCO technique.

References

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