Reverse Fick principle as a viable cardiac output measurement technique during Veno-Venous Extracorporeal Membrane Oxygenation

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Argomento: ECMO

Introduction

The accurate measurement of cardiac output (CO) in patients undergoing VV-ECMO represents a challenge. Both pulmonary artery thermodilution (PATD) and transpulmonary thermodilution (TPTD), are severely affected by an unpredictable loss of Indicator into the extracorporeal circuit. The reverse Fick (RF) principle may prove to be a viable alternative of equal if not higher accuracy.

Methods

Eight healthy pigs (66.9 ±3.27 kg) were cannulated for VV-ECMO in a femoro-jugular approach (21 and 19 Fr) and equipped with a pulmonary artery (PAC) and PiCCO catheter. The animals were mechanically ventilated (GE Carescape R860) and acute respiratory distress syndrome (ARDS) was induced with oleic- or hydrochloric-acid, targeting a PaO2/FiO2 of 150 mmHg. Blood flow (ECBF) was set at 60 ml/kg with sweep gas flow in a 1:1 ratio to the ECBF. CO was measured with PATD (CO_{PATD}) and TPTD (CO_{TPTD}) and compared to RF (CO_{RF}), calculated as:

$CO = VO_2/(CaO_2\text{-}CvO_2)$

Measurements were performed every 4h for 24h after achieving ARDS.

Results

PaO_2/FiO_2 after lung damage was 130.6 ±16.98 mmHg. Baseline natural lung VO_2 was 256.8 ±22.85 ml/min, decreasing to 41.38 ±6.86 ml/min after initiation of gas flow. CO_{PATD}, CO_{TPTD} and CO_{RF} were 5.96 l/min ±1.23, 6.84 l/min ±1.37 and 3.2 ±1.96 l/min. CO_{PATD} and CO_{TPTD} showed a bias of 2.94 l/min [±3.43] and 3.69 l/min [±4.24] compared to CO_{RF}. This was not related to the ECBF (p=0.49), mixed venous saturation (p=0.95), total VO_2 (p=0.12) or heart rate (p=0.97). These bias values were remarkably similar to the ones shown by Russ et al. (ASAIO 2021, PMID: 34860710) where cardiac output was measured by a flow sensor around the pulmonary trunk.

Conclusion

Various gold-standard measurement techniques for CO display poor agreement and high variability during ECMO. CO_{RF} is a possible alternative to indicator-based techniques, and a prompt evaluation

against direct flow measurements is required.

Figure 1:
Bias comparing CO_{PATD} to CO_{RF}

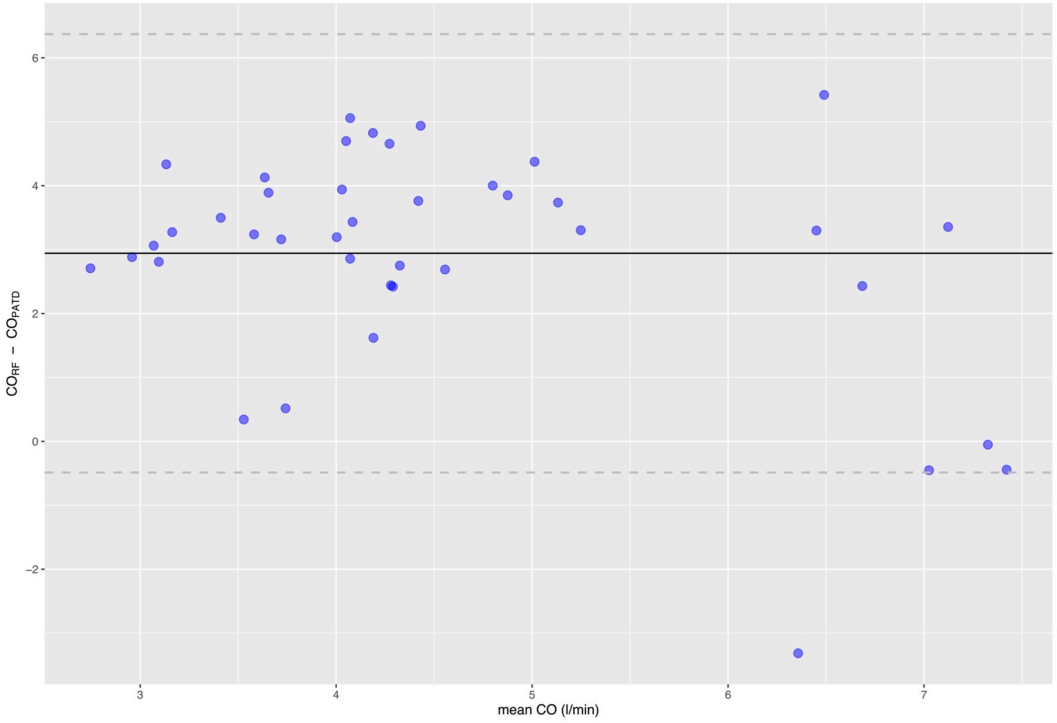

Figure 2:
Bias comparing CO_{TPTD} to CO_{RF}