Evaluation of a capnodynamic method for monitoring effective pulmonary blood flow in an ischemia and reperfusion porcine model

Thorir Sigmundsson^{1,2}, Caroline Hällsjö Sander^{1,2}, Tomas Öhman¹, Magnus Hallbäck³, Håkan Björne^{1,2}
¹Department of Anaesthesiology, Surgical Services and Intensive Care Medicine, Karolinska University Hospital, Solna, Sweden
²Department of Physiology and Pharmacology, Karolinska Institutet, Stockholm, Sweden
³Maquet Critical Care AB, Solna, Sweden

Introduction

A capnodynamic equation can be used to calculate effective pulmonary blood flow (CO_{EPBF}) i.e. cardiac output (CO) minus shunt.¹ An ischemic injury with subsequent reperfusion increases the concentration of carbon dioxide temporarily, a situation that theoretically could affect the agreement of a capnodynamic method.

The aim of the current study was to evaluate CO_{EPBF} during rapid changes in PvCO₂ in an ischemia and reperfusion porcine model.

Methods

A ventilatory pattern containing cyclic reoccurring expiratory holds was used to create the required alterations of alveolar carbon dioxide concentration and the mathematical model used to calculate CO_{EPBF} assumed a steady state in PvCO₂ levels.

CO_{EPBF} was compared to a reference method for CO, an ultrasonic flow probe around the pulmonary trunk in eight pigs.

A 10 Fr Reliant catheter (Medtronic) was placed in the aorta below the diaphragm via the femoral artery and inflated until blood flow in the contralateral femoral artery was abolished according to ultrasound doppler. Hemodynamic measurements, lactate levels and PvCO₂ were obtained at baseline before balloon inflation, at minute 27 of ischemia and after deflation at minute one, three and five during reperfusion.

Results and discussion

The ischemic model resulted in significant changes in lactate and PvCO₂ levels from baseline 1.5 mmol/L (1.2-2.4) and 8.5 kPa (7.2-11.4) to 8.2 mmol/L (7.2-9.0) and 5.2 kPa (4.1-6.2) at minute 27 of ischemia and 10.4 mmol/L (7.8-11.4) and 10.7 kPa (9.0-12.3) at minute one after deflation. Bland Altman plot at baseline showed bias 0.7 L/min, limits of agreement (LoA) -0.2 – 1.6 L/min and a percentage error (PE) 22%. At minute five bias was 0.02 L/min, LoA -1.8 – 1.8 L/min and PE 36%.

Bland Altman analysis	Bias	LoA	PE
Baseline	0.7	-0.2 to 1.6	22%
Ischemia 27 min	-1.5	-3.0 to 0.0	34%
Reperfusion 1 min	14.6	7.9 to 21.3	-
Reperfusion 3 min	1.1	-2.5 to 4.7	68%
Reperfusion 5 min	0.02	-1.8 to 1.8	36%

Conclusion

CO_{EPBF} recuperates fast after rapid changes in PvCO₂ resuming acceptable levels of agreement in 5 minutes.

1.Hallsjo Sander C et al. BJA. 2014;112(5):824-31.