The effect of ventilation strategy on cardiac output during cardiopulmonary resuscitation

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INTRODUCTION

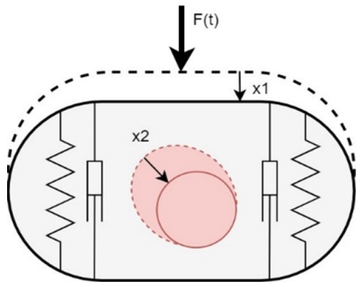
Sudden cardiac arrest (CA) remains a leading cause of death in many countries. Despite years of research on cardiopulmonary resuscitation (CPR) and attempts to improve outcomes, survival to hospital discharge remains consistently low. **The hemodynamic effect of ventilation during CPR remains poorly understood.**

While a consensus exists on the mechanism of cardiac pump during resuscitation, **there is no consensus for the effect of the respiratory pump on CPR quality and cardiac output (CO).**

Aim: to investigate how tidal volume (VT), ventilatory rate (VR), positive end expiratory pressure (PEEP), and inspired fraction of oxygen (FiO2) affect cardiac output during CPR in a virtual subject

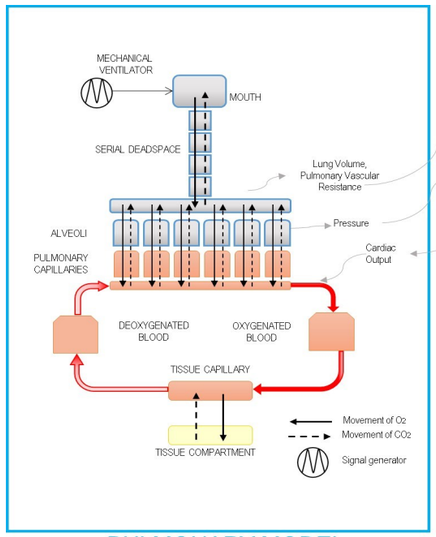
METHOD

Computational model: The ICSM modelling suite, is an integrated, computational model of the pulmonary and cardiovascular systems. The model includes a series deadspace volume, 100 independently configurable alveolar compartments, multiple cardiopulmonary interactions and a newly integrated model of chest compression (CC).[1,2]

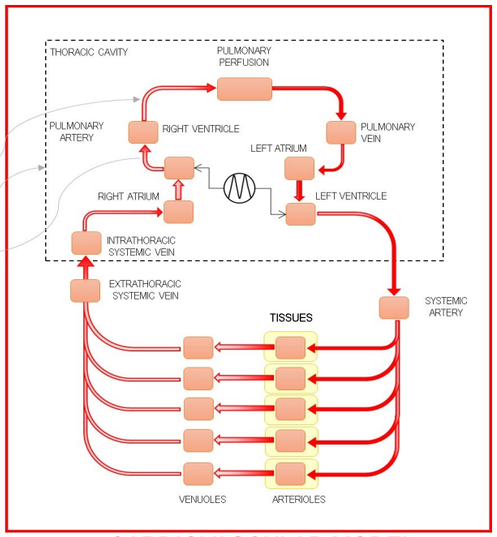


CHEST COMPRESSIONS MODEL

INTERDISCIPLINARY COLLABORATION IN SYSTEMS MEDICINE (ICMS)



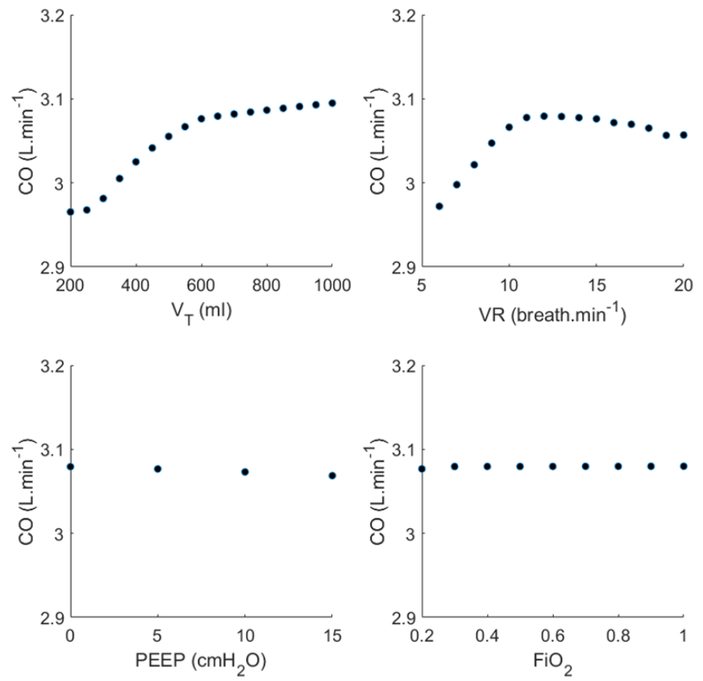
PULMONARY MODEL



CARDIOVASCULAR MODEL

Protocol: In a virtual healthy subject, after 5 minutes of spontaneous ventilation, CA was simulated for 5 minutes rendering the subjects apnoeic with an obstructed upper airway. CPR was simulated for 1 minute following the ERC guidelines (120 CC/min, 5cm depth, duty cycle 50%) and providing mechanical ventilation.

RESULTS & DISCUSSION



The effect of VT, VR, PEEP and FiO2 on CO during CPR

While each of these input parameters was varied, the other three remained constant at baseline values (V_T = 650 ml, VR = 12 breath.min^{-1}, PEEP = 0 cm H_2O and FiO_2 = 0.21).

During CPR, the CO is positively impacted by V_T and VR and remains relatively constant when PEEP and FiO_2 change. However, mechanical ventilation settings maximally increased CO by only 200 ml.min^{-1}.

Future work will investigate the optimal ventilation strategy using a global optimization algorithm that will identify the ventilation strategy to maximize CO, for a spectrum of subjects.

[1] C. Daudre-Vignier, M. Laviola, A. Das, D. G. Bates, and J. G. Hardman, "Identification of an optimal CPR chest compression protocol," *Annu Int Conf IEEE Eng Med Biol Soc,* vol. 2021, pp. 5459-5462, Nov, 2021.

[2] M. Laviola, A. Das, M. Chikhani, D. G. Bates, and J. G. Hardman, "Computer simulation clarifies mechanisms of carbon dioxide clearance during apnoea," *British Journal of Anaesthesia,* vol. 122, no. 3, pp. 395-401, Mar, 2019.

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