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Carbon dioxide elimination and cardiac output changes

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Dear Editor,

I read with interest the paper by Monnet et al [1]. The authors found that changes in end-tidal carbon dioxide (EtCO₂) partial pressure more closely followed changes in cardiac index (CI) induced by passive leg raising than did concurrent changes in stroke volume estimated by the pulse contour method. Their findings are consistent with those recently found by García et al. [2] in ventilated intensive care patients with acute circulatory failure, where cardiac output was monitored with esophageal Doppler.

The authors quoted as background previous papers reporting end-tidal CO₂ changes in animal studies and case reports in humans in the setting of cardiac arrest and cardiopulmonary resuscitation. While these reports are interesting and of some relevance, more informative systematic studies of the relationship between CO₂ elimination and haemodynamic and cardiac output changes are available to support their findings quantitatively.

The authors stated that “the amount of exhaled CO₂ is proportional to CI in stable respiratory and metabolic conditions”. Breen and Isserles, using data from animal and computer models, proposed a linear but not proportional relationship [3, 4]. Weil et al. [5] in 1985 used data from an animal model to suggest a logarithmic relationship. More recently, we tested a model suggesting a simple exponential relationship between short-term relative change in CO₂ elimination rate (VCO₂), which mirrors EtCO₂ concentration change, and change in pulmonary blood flow. This was validated using prospective data from patients during run onto cardiopulmonary bypass and during cardiac surgery and liver transplantation, across a wide range of haemodynamic states. This relationship is based on the assumption that, when considering the mass balance relationship described by the Fick equation for lung gas exchange, both VCO₂ and the arterio-venous CO₂ content difference will change in response to a change in pulmonary blood flow [6]. The results in the paper by Monnet et al. are consistent with this model. A mean change in CI of 12 % was accompanied by change in EtCO₂ of 5 % overall, and a mean change in CI of 33 % by change in EtCO₂ of 10 % in responders.

These theoretical and clinical studies provide quantitative confirmation for the findings of Monnet et al. In addition, they support the authors' proposition that, in patients undergoing controlled ventilation, pulmonary CO₂ elimination (using EtCO₂ measurement as a surrogate) provides robust real-time tracking of significant changes in cardiac output that potentially may be used to guide

haemodynamic management in peri-operative and critical care patients.

Conflicts of interest Assoc. Prof. Philip Peyton has applied as an inventor on a US Patent Application No. 12/743224: “System and method for monitoring cardiac output”.

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