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Minimum acceptable oxygen delivery during cardiopulmonary bypass in neonates

Di Corte F., Gioia E., Mirabile C., Barbanti C., Pouard P., Bojan M.
Anesthesiology and Critical Care Department, Necker-Enfants Malades Hospital, Assistance Publique Hopitaux de Paris, Paris, France

Introduction : The target of an optimal perfusion during cardiopulmunary bypass (CPB) is mantaining the balance between oxygen consumption (VO2) and oxygen delivery (DO2). The level of the critical DO2, where the VO2 becomes supply dependent, has not been explored in neonates who are known to have higher metabolic rates than adults. The present study aims to identify the level of DO2 where the aerobic metabolism switches to anaerobic metabolism during normothermic neonatal CPB.

Methods: In a retrospective cohort of neonates, the DO2 was calculated from the CPB parameters recorded during aortic cross-clamping. Several normothermic DO2 thresholds were chosen between 270 ml $min^{-1}m^{-2}$ (critical DO2 in adult CPB) and 380 ml $min^{-1}m^{-2}$ (average value of DO2 in the present population). Assuming that the VO2 varies with body temperatures, the DO2 thresholds were adjusted for temperatures recorded during CPB. The observed DO2-time integrals were calcultated below the temperature-adjusted threshold (Figure). Hyperlactatemia (>3.3 mmol/L) measured off-bypass was used to identify the imbalance between DO2 and VO2. The ability of the different DO2 thresholds to predict hyperlactatemia off-bypass was explored using the ROC methodology.

Results: Overall, 8356 time points were analysed in 75 patients. Both the observed DO2-time integrals below the 350 and 360 ml $min^{-1}m^{-2}$ DO2 thresholds were discriminant for hyperlactatemia off-bypass, with a ROC areas of 0.633, 95% CI 0.502 - 0.763 and 0.666, 95% CI 0.538 - 0.793, respectively. When the DO2 was maintained below 360 ml ml $min^{-1}m^{-2}$ for more than 21 min or when DO2 was mantained below the 350 ml $min^{-1}m^{-2}$ threshold for more than 17 minutes the proportion of patients with hyperlactatemia concentration exceeded 70%.

Conclusions: When the DO2 level is mantained below 350 - 360 ml $min^{-1}m^{-2}$ during normothermic cardiopulmonary bypass in neonates, there is a high risk to induce anaerobic metabolism, as assessed by hyperlactatemia off-bypass. Several limitations related to the study design do not allow the statement on whether this is the critical DO2 level in neonatal CPB. However, 350 - 360 ml ml $min^{-1}m^{-2}$ is likely to represent the minumum acceptable DO2 required on normothermic neonatal bypass in order to maintain aerobic metabolism.