Minimum acceptable oxygen delivery during cardiopulmonary bypass in neonates

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Introduction: The target of an optimal perfusion during cardiopulmonary bypass (CPB) is maintaining 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 calculated 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 min$^{-1}$m$^{-2}$ for more than 21 min or when DO2 was maintained 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 maintained 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 min$^{-1}$m$^{-2}$ is likely to represent the minimum acceptable DO2 required on normothermic neonatal bypass in order to maintain aerobic metabolism.