Effects, management and optimization of extracorporeal techniques and technologies in contemporary cardiac surgery

Chapter 16

Summary

The inflammatory response in cardiac surgery using extracorporeal circulation (ECC) has beenextensively discussed, we presented through literature research, various extracorporeal techniques that aim to reduce the impact on inflammation with the elimination of air-blood contact, the reduction of hemodilution through the length of the circuit and the use of coating in extracorporeal surfaces, such as minimally invasive extracorporeal circulation. The retrospective study associations between oxygen delivery and cardiac index with hyperlactatemia during cardiopulmonary bypass showed on 500 extracorporeal procedures that the management of DO2i in relation to O2ERi was 16% more specific in terms of negative predictive value for hyperlactatemia during CPB compared to the use of CI in relation to SvO2, patients who reported the absence of hyperlactacidemia had a low incidence of acute kidney injury and reduction in time of stay in intensive care unit. The literature review: "Goal-directed extracorporeal circulation: transferring the knowledge and experience from daily cardiac surgery to extracorporeal membrane oxygenation" described that in extracorporeal circulation, predictive target parameters have been found and consolidated, especially in terms of acute kidney injury and the prevention of anaerobic metabolism, while for ECMO management a vague path remains. In this context, we reviewed the strategies for optimal targeted therapy during CPB and ECMO, trying to transfer the knowledge and experience of daily cardiac surgery to venoarterial ECMO.

The retrospective research: "Perioperative incidence of ECMO and IABP on 5901 mitral valve surgery procedures" reported the incidence and outcomes of perioperative extracorporeal membrane oxygenation (ECMO) and intra-aortic balloon pump (IABP) in patients undergoing mitral valve surgery (MVS) via right mini-thoracotomy (RT) and conventional full sternotomy. FS). The ECMO and IABP incidence for the treatment of PCS was 0.2% and for Low Cardiac Output Syndrome (LCOS) 1.6% in elective mitral valve surgery was very low. The patients using the perioperative IABP in minimally invasive mitral valve surgery (MIMVS) via RT reported reduced mortality compared to FS in relation to the operative risk and surgical technique. A low incidence of VA-ECMO was found with the RT and FS approach; only one patient survived after VA-ECMO after minimally invasive mitral valve surgery.

The retrospective study: “Long-term ECMO, efficiency and performance of EUROSETS adult A.L.ONE ECMO oxygenator” collected on long-term use of more than 14 days of Eurosets A.L.ONE ECMO Adult oxygenator in polymethylpentene fiber, for ECMO procedures, including the procedures: Veno Arterial (VA) ECMO post-cardiotomy or not, veno-venous (VV) ECMO. In this research the device was safe with no iatrogenic issues over a 14-day period in the patients undergoing ECMO VA and in all patients undergoing VV ECMO with continuous administration of anticoagulation therapy. The study: “Water Condensation and Gas Exchange Correlation in Different Models and Fibers of Blood Oxygenators: How Can We Improve Performance?"presented the phenomenon of water condensation in blood oxygenators, a phenomenon that is constantly present during cardiopulmonary bypass and extracorporeal life support in the medium to long term. This perspective research found an inverse correlation between gas exchange and condensation in statistically significant values during the use of normothermia and a reduction in oxygenation performance in polypropylene and polymethylpentene fiber oxygenators. The carbon dioxide (CO2) used in the operating field to prevent brain or heart damage due to air embolism is a well-known strategy in open-heart surgery. However, there is no general consensus on the best delivery approach. In the retrospective research: “Continuous field flooding versus final one-shot CO_2 insufflation in minimally invasive mitral valve repair” showed that continuous CO2 insufflation by field flooding in MIMVR is associated with a lower incidence of microemboli and less agitation upon discontinuation of anesthesia, along with improved MV duration and intensive care unit length of stay. During Cardiopulmonary Bypass (CPB), gaseous microemboli (GMEs) reduce blood flow quality and capillary oxygen supply, increasing the incidence of postoperative neurocognitive disorders (POCD) after cardiac surgery. Our clinical analysis: “Clinical Evaluation of Micro-Embolic Activity with Unexpected Predisposing Factors and Performance of Horizon AF PLUS during Cardiopulmonary Bypass.” showed that Horizon AF PLUS is an effective and safe device without iatrogenic perioperative complications, for the reduction of microembolic activity during CPB procedures, with high efficiency in terms of oxygenation performance and thermal exchange.

There is limited evidence on the pharmacokinetic changes expected in adults with extracorporeal technologies. The study: "Propofol pharmacokinetics and pharmacodynamics-a perspective in minimally invasive extracorporeal circulation" presented that the minimally invasive extracorporeal group, used a lower dose of propofol during coronary artery bypass grafting, titrated to a bispectral index of 40–45, and an improvement in postoperative serum albumin concentration was observed compared with the conventional extracorporeal circulation group. Patients with coronary artery disease and concurrent heart failure (left ventricular ejection fraction < 35%) requiring myocardial revascularization are at risk for poor long-term prognosis and increased mortality. The study: "Minimally invasive extracorporeal circulation in end-stage coronary artery disease patients undergoing myocardial revascularization" demonstrated that in end-stage coronary artery disease, the MiECC technique was associated with a higher DO2i compared to cECC. The elevated plasma free hemoglobin is associated with multiorgan injury in the literature. The study: "Magnetic levitation pump versus constrained vortex pump: a pilot study on the hemolysis effect during minimal invasive extracorporeal circulation" presented a pilot study focused on plasma free hemoglobin levels in 40 patients undergoing isolated coronary artery bypass grafting (CABG). The pilot study suggested that the use of magnetically levitated centrifugal pumps for extracorporeal circulation support is associated with a lower risk of hemolysis. The use of magnetically levitated centrifugal pumps to support extracorporeal circulation is associated with a lower risk of hemolysis, although larger studies are warranted to confirm our results. In critically ill patients with ARDS requiring therapy with VV ECMO, increased plasma cell free hemoglobin concentration (CFH) was an independent risk factor for AKI. In patients with elevated CFH concentrations, higher plasma haptoglobin concentrations could protect against CFH-associated AKI. The choice of equipment during VV-ECMO with long-term use of a magnetic levitation pump could be crucial for the possible reduction of CFH and indirect bilirubin, but further research is needed to support our opinion.

The choice of equipment during VV-ECMO with long-term use of a magnetic levitation pump could be crucial for the possible reduction of CFH and indirect bilirubin, but further research is needed to support our opinion.