Cerebral circulation and metabolic properties in patients undergoing normothermic cardiopulmonary bypass

VALORISATION

Cardiac surgery, because of its complexity (extensive monitoring and equipment), is one of the most expensive surgical treatments. It is not surprising that healthcare is increasingly interested in cost and cost-effectiveness of this kind of treatments. For the majority of cardiac surgical operations, the use of cardiopulmonary bypass (CPB) or heart-lung machine (HLM) is a *conditio sine qua non.* CPB is a technique that uses a HLM to temporarily take over the function of the heart and lungs during surgery. A HLM mechanically circulates and oxygenates blood for the body while bypassing the heart and lungs. The HLM is maintaining perfusion to all body organs and tissues while the surgeon works in a bloodless surgical field. The present thesis contributes to a better understanding of cerebral perfusion processes related to the use of the heart-lung machine, and shows ways to attenuate possible deleterious effects.

In the last decade, mortality of patients operated on while using a CPB drastically decreased. Reduction in neurocognitive impairment, however, did not reach the same magnitude, with a growing body of evidence showing the negative impact of CPB on clinical outcome. The two major causative factors for neuropsychological dysfunction after cardiac surgery are global brain hypoperfusion and cerebral emboli generated by either surgical or perfusion-related interventions. Additionally, it was found that the minority of patients having cardiac procedures (15% to 20%) consume more than 80% of the blood products transfused during operations. To counteract these problems, CPB technology has evolved with advances in oxygenators design, surface biocompatibility, blood-pump technology and, more recently, in reducing circuit size and priming volume. In an attempt to attenuate the adverse effects of CPB such as inflammatory reactions, transfusion requirements and extreme hemodilution, recently the use of minimized cardiopulmonary bypass systems (mCPB) has gradually increased. Evident benefits of mCPB, however, do not come without consequences. Venous air emboli may be sucked into the venous line at the site of cannulation, which can result in arterial microemboli. Additionally, excessively low sub-atmospheric venous line pressures can cause in-pump gaseous microemboli in abundance as well. It is clear that every effort should be made to prevent air from being entrained or formed *de novo* in the circuit to decrease the total arterial embolic load. Recent literature shows that mCPB using a volume buffer capacity embedded into the venous line and enhanced pump servo-regulation, combined with anti-obstructive venous cannula design, can prevent venous line pressures from peaking down to excessively low levels with concomitant gaseous microbubble formation, while pump speed adapts to venous drainage to maintain a maximal level of support available at that instance. Based on the positive results of clinical and preclinical trials the use of mCPB as well as the use of retrograde autologous priming technique can lead to significant cost reduction in health care.

Because cardiac surgery is still associated with blood transfusion, our second challenge was to attenuate the negative effect of hemodilution and homologous blood transfusion on clinical outcome, another issue that could have both social and economic importance. Next to allergic reactions, transmission of infectious diseases and acute lung injury, there is mounting evidence that transfusion of packed red blood cells increases morbidity and mortality. Moreover, acute hemodilution and resulting low haematocrit during CPB has demonstrated to have a detrimental effect on cognitive function. Additionally, transfusion of red blood cells is not only related to poorer early and late outcome, but also makes surgery more expensive. In our centre, in 2014, cardiac surgical patients consumed 12% of the total amount of blood products that amounted to € 560.000. Additionally, a systemic review performed in 6 western European countries has shown that mean costs of transfusing 2 units of packed red blood cells were €878 providing a burden to the health care system. We found that both retrograde autologous priming of the cardiopulmonary bypass circuit and the use of mCPB significantly attenuate acute hemodilution and blood transfusion requirements in coronary artery bypass surgery. Obviously, our both attempts proved to have a significantly positive effect on both patient safety and cost-effectiveness. The knowledge transfer of retrograde autologous priming might be an interesting technique that can be shared through continuous education. The industry, however, should make additional effort to create safer mCPB systems. Therefore, using retrograde autologous priming as well as applying mCPB should be considered to be an integral part of a multimodal approach for conservation of blood transfusion.