How to perfuse: Bilateral antegrade cerebral perfusion (BACP)

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Complex aortic pathologies such as acute dissections and thoracic aneurysms have been associated with significant morbidity due to the temporary requirement of circulatory arrest to facilitate arch reconstruction. To minimize neurologic dysfunction, the method of bilateral antegrade cerebral perfusion (BACP) is applied at the university hospital in Frankfurt, Germany.

All patients were operated at our center following the respective standardized institutional surgical, perfusion and temperature management protocols.
Propofol (AstraZeneca, Wedel, Germany) and Sufentanil (Janssen Cilag, Neuss, Germany) are applied for intravenous anesthesia. The left radial artery and the left or right femoral artery are cannulated for continuous blood pressure monitoring. A transesophageal echocardiographic probe is inserted in order to both confirm the diagnosis and assess the aortic valve. Temperature probes are placed for esophagopharyngeal and bladder temperature monitoring, respectively. The patient is positioned on the operating table in a supine position.

After systemic heparinization (400 international units/kg) and ACT-control (>400sec), the right axillary artery is directly cannulated (18F to 20F EOPA flexible arterial cannula; Medtronic, Minneapolis MN) followed by routine venous cannulation of the right atrium in a standard fashion 28/32 Fr. or 32/37 Fr. Two Stage Venous Cannula (Maquet, Rastatt). Alternatively, CPB is initiated through femoral artery cannulation until the desired core temperature of 28°C is reached before we switch to selective ACP via a Y-shaped side branch of the arterial line for open aortic arch repair. Regarding ECC, a self-designed “MOPS” (modified and optimized perfusion set) is used, including a Quadrox-I Adult safeline coated oxygenator with an integrated arterial filter (MAQUET, Rastatt Germany) and a VKMO 71000 cardiotomy reservoir (MAQUET, Rastatt Germany). A Plegiox heat exchanger (Maquet, Rastatt) is integrated into the tubing set for cooling BCP separately. The tubing set is not coated. Acid-base balance is maintained with the alpha-stat method and changed to pH – stat during cerebral perfusion.

To measure online blood gases and other perfusion related values, the heart-lung-machine (HLM) is equipped with a Spectrum Medical (Cheltenham Road East Gloucester, GL2 9QL, United Kingdom) M 4 – monitor. CPB is started, resulting in cardiac arrest by means of retrograde and selective antegrade perfusion, given intermittently every 20 min. Cooling is limited to 28°C bladder temperature, depending on the expected time of arch repair according to the findings on the preoperative CT scan. After opening of the aortic arch, the innominate as well as the left carotid artery are snared and occluded or clamped with silicone elastomer loops upon initiating selective antegrade cerebral perfusion (ACP), whereas the left subclavian artery is blocked by insertion of a Fogarty catheter (Edwards Lifesciences; Irvine, CA) to obtain a bloodless operation field (Figure 1).

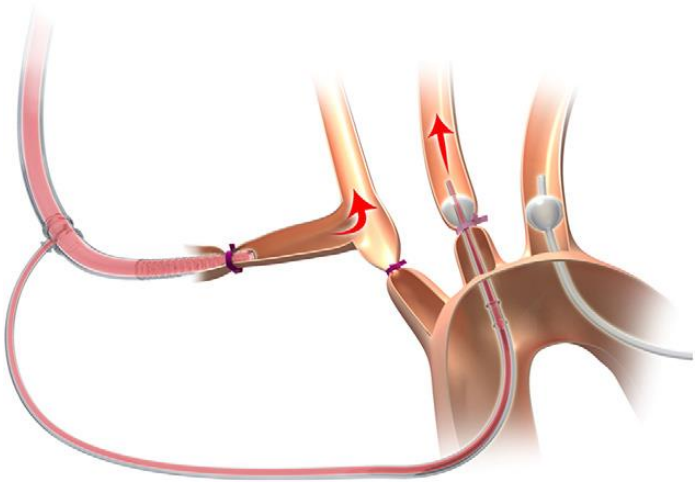

Figure 1: Schematic display of BACP cannulation (https://doi.org/10.1016/j.jtcvs.2012.07.063)

In patients with BACP, the elastomer loop snared around the left common carotid artery is temporarily loosened to allow for the placement of a retrograde BCP catheter (14 Fr. MIBB Edwards Lifesciences, Irvine CA) connected to the arterial CPB cannula via an Y-connector (DLP 10004D, Medtronic Minneapolis, MN) within the vessel for additional perfusion of the left hemisphere.
BACP is conducted with a perfusate temperature of 30°C in a pressure-controlled manner. Perfusion pressure is controlled via the pump unit and kept at 80 mmHg to facilitate a mean flow of 1.2 – 1.5 L/min. pCO_2-values in the period of BACP were measured online at actual temperature with the M4 Monitor. Regarding cerebral autoregulation, pCO_2-values in the range of 45-50 mmHg are recommended to ensure low cerebral resistance (Figure 2)

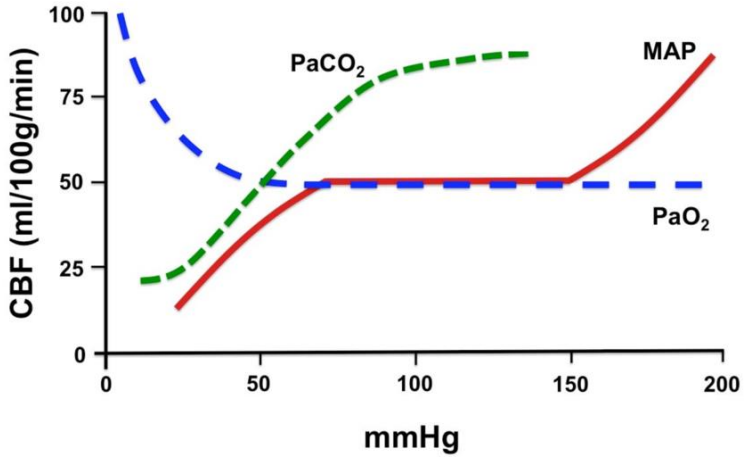

Figure 2: Brain Perfusion In Sepsis - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/236058968_fig2_Fig-2-Schematic-representation-of-cerebral-blood-flow-CBF-variations-associated [accessed 2 Jun, 2017]

If the duration of arch repair substantially exceeds 60 min, a balloon-tipped cannula connected to the arterial CPB line via a Y-tubing connector is inserted into the descending aorta for lower body perfusion. Consequently, if lower body perfusion is

desired, an additional pump circuit is not required. To maintain a steady level of cerebral perfusion in this setting, attention is paid to the fact that the perfusion pressure, as monitored on the pump unit, stays at 80 mm Hg while the NIRS measurements and the left radial artery pressure remain unchanged. This way it is safe to assume that although cerebral perfusion remains stable in this pressure-controlled setting, the additionally achieved pump flow is mainly distributed to the lower body.

The routine approach is to re-implant the arch vessels en bloc following the distal aortic arch anastomosis. After completion of the arch repair, the Fogarty catheter is withdrawn from the left subclavian artery, the elastomer loops around the innominate as well as left common carotid artery are released, and the arch vessels are carefully de-aired. Reconstitution of full-body perfusion via the right axillary artery is initiated after clamping the vascular graft. Rewarming of the body should not exceed 8 degrees temperature gradient between blood and water. Subsequent proximal repair follows during the rewarming period. The decision considering the strategy of proximal aortic repair is mainly based on the surgical inspection of the involvement of the aortic root, including the aortic valve leaflets as well as the coronary ostia. Associated cardiac procedures, if necessary, are conducted after the aortic repair. Once stable hemodynamic parameters and a core temperature of at least 36.5 degrees are maintained, the patient is gradually weaned from the ECC.

The methods presented in this work have previously been described in detail by El-Sayed et al., see http://dx.doi.org/10.1016/j.athoracsur.2016.10.024 for further reference.

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