Editorial Commentary

Selective versus standard cerebro-myocardial perfusion in neonates undergoing aortic arch repair: towards a further improvement for arch repair in neonates and infants

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Provenance and Peer Review: This article was commissioned and reviewed by the Section Editor Raffaele Giordano (Department of Advanced Biomedical Sciences, Adult and Pediatric Cardiac Surgery, University of Naples Federico II, Italy).

Comment on: Luciani GB, Hoxha S, Angeli E, *et al.* Selective Versus Standard Cerebro-Myocardial Perfusion in Neonates Undergoing Aortic Arch Repair: A Multi-Center Study. Artif Organs 2019;43:728-35.

Submitted Feb 07, 2020. Accepted for publication Jun 15, 2020.

doi: 10.21037/jtd-20-13

View this article at: http://dx.doi.org/10.21037/jtd-20-13

There is wide variability in practice regarding perfusion strategies for arch repair (AAR) in neonates and infants. Deep hypothermic circulatory arrest (DHCA) has been traditionally used in for this purpose, but there is wide evidence in literature of potential harmful effect on central nervous system that translate in cognitive damage over the long-term follow-up (1). Therefore, many efforts have been done to improve safety of DHCA, firstly limiting its duration (2), and refining strategies for cooling and rewarming, as well haematocrit and blood gas management. In the aim to reduce long-term cerebral morbidity, in recent years selective cerebral perfusion (SCP) has been increasingly employed for aortic arch reconstruction in neonates and infants (3), similarly to what have happened in adult cardiac surgery for treatment of aortic aneurysms and aortic dissection (4,5). Actually, there are not enough evidence that points to superior central nervous system outcomes to establish superiority of a technique over the other (6). Moreover, when SCP is used, there is no consensus related on one side, to ideal amount of flow and perfusion pressure and, on the other how to monitor cerebral perfusion and bilateral flow distribution to allow a safe perfusion (7). Despite these considerations according to the database of the Society of Thoracic Surgeons Congenital Heart Surgery [2010–2013] SCP resulted to be widely used strategy (43%), while DHCA and mixed perfusion accounted for 32% and 16% of cases, respectively (8).

Myocardial protection is also an important issue in complex heart operation that include arch repair and is usually obtained by means of cardioplegic arrest with crystalloid or hematic solution delivered anterogradely or retrogradely.

Animal research models suggests that the neonatal heart may be more sensitive to ischemia-reperfusion damage compared to mature hearts.

Following initial report by Asou and colleagues (9), several combined cerebro-myocardial perfusion (CMP) techniques have been proposed in order to prevent the damage from prolonged myocardial ischemia. In 2003, Ishino and Sano (10), introduced a "working beating heart technique" with aortic cross-clamping and without selective coronary perfusion. The authors demonstrated that, maintaining both ventricles adequately loaded, the heart keeps beating, during aortic cross-clamp. The procedure is performed at 34 ℃, perfusing the innominate artery for a radial mean arterial pressure between 30–45 mmHg and a mean aortic root pressures of between 40–50 mmHg to perfuse coronary circulation without changes on the electrocardiogram.

In 2010, Lim and colleagues (11) reported a combined perfusion technique using dual arterial cannulas: one placed into the innominate artery and the other into the aortic root, both Y-connected to one roller pump: flow distribution was regulated by cannula size and diameter of

the Y-connector, but was not distinctly adjustable to both organs.

In 2012, a novel technique for SCP combined with separately independent myocardial perfusion (MCP) during surgery for aortic arch lesions was reported both by De Rita (12) and Ruffer (13).

Selectivity of perfusion was achieved by innominate artery cannulation, either directly, or by interposition of polytetrafluoroethylene graft, for cerebral perfusion (SCP), and aortic root cannulation with cardioplegia needle for coronary perfusion (MCP). Independent cerebral and coronary blood flow were ensured by 2 different arterial pumps. A controlled regulation of each flow was achieved by varying the speed of the individual pump. In this setting SCP and MCP were established to be respectively 30–50 and 15–20 mL/Kg/min (30% and 10–20% of the calculated CPB full flow, 150 mL/kg/min). Bicaval venous cannulation and left ventricular vent ensured an unloaded beating heart during selective coronary perfusion in moderate hypothermia. This double delivery system evidenced the advantage to adjust and optimize tissue perfusion by individualizing SCP on cerebral NIRS values of both hemispheres, and MCP on ECG trace, heart rate (70–80 bpm) and direct visualization of myocardial coloration. Potential advantage of this setting is the ability to switch from coronary perfusion to blood cardioplegia via the same delivery line in case of signs of ischaemia evident on continuous EKG monitoring.

All these reports demonstrated enhanced myocardial recovery and reduced heart related morbidity and mortality compared to SCP with arrested heart. The reported positive effects could be essentially correlated to avoid any myocardial ischemic period in case of isolated aortic arch procedure or at least shortened it when a concomitant intracardiac repair is performed.

The recent paper by Luciani *et al.* (14) compared standard selective CMP technique with selective and independent CMP technique for neonatal AAR. To date, this report represents the first multicentric and largest study on combined cerebral-myocardial perfusion for arch repair in neonates.

Main finding of this study was the ability to individualize the selective coronary perfusion titrating to intra-operative monitoring and correlate it to early postoperative cardiac morbidity. Individualization of coronary blood flow, guided by clinical appearance of the beating heart and ECG trace, resulted significantly higher blood flows compared to those achieved with standard perfusion with single arterial pump supporting both cerebral and myocardial flows.

The rate of early cardiac events was five-fold greater in neonates with standard CMP. Among patients with a selective individualized coronary perfusion, a coronary blood flow less than 50 mL/kg/min was associated to a three-fold greater risk for postoperative higher troponin I levels, higher inotropic support, and low cardiac output syndrome.

There are also limits in this study. First the small number of patients, 69 in 3 different institution, over a relatively long, 9 years, period. The two group are slightly different and, some variables that could have an impact on result, like gestational age, comorbidities, genetical syndrome, and preoperative status, were not analyzed. Cardiac morbidity was defined as composite endpoints that included many factors, some of these could be also related to technical issues (i.e., coronary relocation in arterial switch) or reflects different institutional policies, for example type and length of inotropic support.

According with this study and other reports few considerations can be made:

- Technique of combined cerebral-myocardial perfusion technique is safe, versatile and feasible for treatment of neonatal complex heart disease that includes arch repair. Early and mid-term neurological and cardiac morbidity is encouraging compared to standard perfusion technique;
- Recommended combined perfusion, cerebral and myocardial, flow is related to temperature and should not go below 50 mL/kg/min at 25 ℃ (14), or 70 mL/kg/min at 28 ℃ (11);
- Both cerebral and myocardial flows can be finely titrated to intra-operative monitoring by selective and independent CMP set-up;
- Both techniques were associated with excellent results in term of survival and freedom from recurrent aortic arch obstruction;
- Individualization of coronary perfusion may result in better myocardial protection and better early postoperative cardiac function allowing earlier weaning from mechanical ventilation, shorter ICU and hospital stay.

Despite lack of definitive argument, it is undeniable that there is a global tendency to an increase adoption of technique of regional perfusion during arch repair in congenital heart surgery. To generate more evidence-based data, both related to safety of perfusion technique and outcome there is clearly need for prospective

multicentric studies.

Acknowledgments

Funding: None.

Footnote

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jtd-20-13). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Cite this article as: Di Chiara L, Galletti L. Selective versus standard cerebro-myocardial perfusion in neonates undergoing aortic arch repair: towards a further improvement for arch repair in neonates and infants. J Thorac Dis 2020;12(9):5039-5041. doi: 10.21037/jtd-20-13