Editorial Commentary

# Current trends in perfusion strategies for neonates undergoing aortic arch repair: the rough path to the perfect idea

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Neonatal aortic arch repair carries out a significant risk of mortality and morbidity. Aortic arch hypoplasia or interruption can be observed as isolated defects or in association with complex biventricular or univentricular heart malformations. Surgical management is accomplished by complex surgery requiring perfusion strategies in attempt to mitigate the effects of organ ischemia.

To date antegrade cerebral perfusion seems the most widely adopted technique in this field even though several modifications adding myocardial and splanchnic flow have been described (1). These techniques were developed in order to be an alternative to deep hypothermic circulatory arrest (2,3) despite the latter is still in use in some centers and has not been demonstrated to be inferior to the other ones (2-4).

Cerebro-myocardial perfusion (CMP) is one of this alternative protection strategies in which the coronary arteries are perfused concurrently to the brain by the arterial line in attempt to reduce the ischemic time. Commonly a Y-connector is added to the central arterial line and blood is delivered to the coronary arteries by the cardioplegia line with the flow controlled by a single rotor.

Luciani and colleagues described in 2012 an alternative method for CMP in which the blood flow for the brain and for the myocardium are controlled and delivered by two independent rotors. The technique is very attractive and easy to reproduce and it offers a precise quantification of cerebral and myocardial flow (5).

In their recent work the authors published the results of the comparison of this technique (selective CMP) to the standard one (6) in neonatal surgery for aortic arch, either isolated or in association with other cardiac malformations. The paper is a retrospective and multicentric investigation of early and mid-term cerebral and cardiac outcomes.

To the best of our knowledge this is the largest study on CMP during neonatal aortic arch repair. The authors showed excellent results particularly in terms of early overall mortality and freedom from re-interventions: 2.9% *vs.* 12.1% (the last result referred at 5 years in the group using selective CMP) respectively.

Despite, as the same authors stated, some of the results of this work may be speculative due to the great heterogeneity of the study cohort, we are in completely agreement that their technique offer the possibility to have a more precise quantifications of myocardial blood flow delivery during selective perfusion. This situation can give actually a proper (and "relaxed") time to carry out an accurate arch reconstruction avoiding as the author underlined "to rush" during operation. This was well demonstrated by the freedom from re-interventions (of all type, i.e., surgical and interventional) rate showed in this work.

However, we are not fully convinced that some of the variables used by the authors are exhaustive to demonstrate completely the superiority of selective CMP over the standard one. The authors used the α-stat methods during

patient cooling instead the pH-stat acid-base monitoring for cerebral protection. Despite the target temperature of 25 degree, we believe that maintaining normal $CO_2$ level at any level of hypothermia may be must effective in neuroprotection avoiding cerebro-vascular vasoconstriction. Abdul Aziz and colleagues, in a recent best evidence topic, comparing several prospective randomized studies based on the age of the patients, showed as pH-stat strategy improves postoperative neurological outcomes especially in pediatric patients (7). Neurologic impairment is very challenging to define in the neonatal period, especially in children underwent to congenital heart operation due to a lot confounding factor (as the delayed cerebral development frequently observed in this population). For these reasons neuro-developmental impairment may be unrecognized despite the absence of clinical signs or documented lesion at MRI thus preventing a meaningful analysis (8-10).

Furthermore, evaluating their cardiac results the authors used peak post-operative cardiac troponin I level (cTnI) in the first 24 hours, ejection fraction less than 30% and use of two or more inotropic drugs to define postoperative cardiac morbidity. The role of cTnI and other plasma biomarkers to predict early postoperative outcomes of children underwent to neonatal heart surgery has been investigated also by our group in 2017 (11). In our paper we have described a good correlation between cTnI value and inotropic support time. By the use of these variables Luciani and coworkers showed a lower myocardial morbidity in the group that used selective CMP. However, as well as the authors observed some confounding factors continues to be present in their population to accept completely their results. The group treated with standard CMP was the group that required a major number of intracardiac procedures. On the contrary duration of cardiac arrest was longer in those patients treated with selective CMP reflecting a more complex anatomy (and a major number of univentricular physiology). Finally, and as the authors stated "unexpectedly", the neonates that had cardiac events were that with a shorter cardioplegic arrest.

These observations raise in the readers an important question: is only the time before aortic cross-clamp that must be taken in account when we discuss about myocardial protection or myocardial protection's methods (during ischemic time) play an important role too? The authors described the use of blood cardioplegia for myocardial protection in their work. In the recent years there was an ongoing debate about the optimal myocardial protective strategy in pediatric heart surgery, due to the rising in the use of novel product as Custodiol and Del Nido solution (12). Despite is difficult to find in the current literature a clear superiority of one solution instead another, a large number of papers have showed some advantage with the use of crystalloid solution. Angeli (one of the co-authors in this work) in 2011 and Giordano in 2016 showed excellent myocardial protection with the use of Custodiol solution in neonates underwent to arterial switch operation (13,14).

We would like finally to make a comment about the described intraoperative monitoring protocol of selective myocardial perfusion. The authors use sinus rhythm and heart rate faster than 60–70 bpm to define optimal myocardial perfusion flow. In our opinion considering the physiological reduction of heart rate during cooling and the possibility of rhythm anomalies despite the presence of optimal coronary flow, the monitoring of only heart rate may be not exhaustive. A tool to define the adequacy of myocardial blood flow should be ideally the direct measurement of coronary sinus venous saturation. From a practical point of view a myocardial flow rate of 100 ml/min/m$^2$ of body surface area, corresponding approximately to 40 ml/min/100 gr of cardiac muscle should be considered sufficient for cardiac protection under CPB on moderate hypothermia regardless of heart rate (15).

In conclusion Luciani and colleagues described a very interesting and attractive technique. A future investigation avoiding all possible confounding factors could confirm their results that, in any case, are outstanding. Considering the topic of this paper that approaches two very difficult and debating issue in the field of congenital heart surgery we believe that the authors added new interesting point of discussion to the current literature and for these reasons we strongly recommend this paper to the readers of this journal.

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## Footnote

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jtd.2020.01.60). The authors have no conflict of interest to declare.

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to the accuracy or integrity of any part of the work are appropriately investigated and resolved.



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