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Closing Remarks

In the 17th century, William Harvey discovered the circulation of the blood, describing at this time the pumping function of the heart and the "in series" disposition of the pulmonary and systemic circulations. These concepts provided the foundation for the development of modern cardiac physiology. During the three centuries that followed the discovery of circulation, many scientists studied and expanded our knowledge of cardiac and pulmonary function. With the description of complex congenital cardiac diseases, in particular functionally univentricular hearts, and with the development of their palliative surgical treatment, we have uncovered another type of cardiac physiology. In these cases, the circulation of the blood is characterized by an "in parallel" disposition of the pulmonary and systemic circulations, with direct venous–arterial connections in the absence of one pumping ventricle.

The first step in surgical palliation of the functionally univentricular heart aims at adjusting the flow of blood to the lungs, either with construction of a systemic-to-pulmonary arterial shunt, or by banding the pulmonary trunk. This first step is very important for the future, because it is the basis for the correct development of pulmonary vascular resistances, and can represent the additional source of pulmonary blood flow needed in the second step. The use of experimental in vitro and/or mathematical numerical models to predict the dynamic behaviour of the flows after surgical palliation implies an intense collaboration between surgeons and bioengineers. This type of collaborative approach is particularly important with the second step, when different types of palliation are combined, creating from one side an "in parallel" circulation with a shunt, and from the other a direct connection between the superior caval vein and the pulmonary arteries, without any pumping element. For the third step, the physiology becomes even more complex, coming back to the "in series" model, but with direct but complete connection between the caval veins and the pulmonary arteries, albeit retaining, in some cases, a right-to-left intracardiac shunt. At this stage, the surgical palliation should avoid all types of abnormalities in the flow of blood, such as turbulence, vortexes, stasis, and so on. The palliative operation should also supply the lungs with a proper flow of blood. Should a fenestration be used in these procedures, the amount of blood shunting from right to left is crucial for determining the presence or absence of cyanosis, and absence of stasis. In this case, in vitro and/or computational studies could provide very useful information to the surgeons, suggesting the best type of reconstruction.

With the development of interventional cardiology, many situations can now be treated with transcatheter techniques, such as closure of shunts and fenestrations, stenting of the cavopulmonary anastomosis and, in the near future, the transcatheter tailoring of the cavopulmonary connection. With these techniques, it is possible to complete previous surgical procedures, reducing or stopping flow, dilating or opening an anastomosis, and often changing an elastic tissue to a rigid tube. The use of biomechanics, not only in cardiac surgery, but also in interventional cardiology, for previewing the effects of different procedures represents a most important tool for ensuring an overall satisfactory result.

During the workshop that engendered this supplement, the topic "biomechanics for staged and definitive surgical palliation of the functionally univentricular heart" was thoroughly examined. The message that emerges is clear. Teamwork is needed between bioengineers, paediatric cardiac surgeons, and cardiologists if we are to optimize the results of the surgical treatment of congenital cardiac malformations.

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