Coronary Artery Bypass Grafting in Single-Ventricle Patients Palliated with Fontan Procedure: Future Consideration

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“A new surgical procedure has been used which transmits the whole vena caval blood to the lungs, while only oxygenated blood returns to the left heart. The right atrium is, in this way, ‘ventriclized’, to direct the inferior vena caval blood to the left lung, the right pulmonary artery receiving the superior vena caval blood through a cava-pulmonary anastomosis”. By this statement, Fontan and Baudet started their article detailing the first Fontan procedure in 1971 [6].

Since 1971, the Fontan procedure has been applied for palliation of single-ventricle physiology patients. Multiple modifications of the original procedure were applied to improve morbidities and mortalities. Numerous investigators studied the short- and long-term outcomes of the procedure [5, 7]. The 32nd Bethesda conference in 2001 discussed the issue of caring of these patients going into adolescent and adulthood [1]. It is around the same time when The British Cardiac Society released its report detailing plans for care of the grown-up with congenital heart disease [12]. The rise of the new adult congenital heart disease specialty was dictated by the need for appropriate care given to the growing number of patients that currently exceeded the number of children with congenital heart disease, thanks to advances in medicine and surgery.

One of the risk factors of failing Fontan, also a result of Fontan, is the presence of aorto-pulmonary collateral

arteries (APCs). APCs are present in up to 80 % of single-ventricle patients undergoing pre-Fontan catheterization. Pre-Fontan coil occlusion of these vessels decreases single-ventricle volume load and improves outcome after Fontan procedure [8, 9, 14, 16]. These collateral vessels are usually branches of the right and left subclavian arteries including the left internal mammary artery (LIMA) and the right internal mammary artery (RIMA). Branches of subclavian arteries and intercostal arteries normally have extensive anastomotic connections with LIMA and RIMA. Successful occlusion of the APCs requires obliteration of the whole length of the vessel to prevent revascularization by distal feeder tributaries. In adults with coronary artery disease not amenable to percutaneous stenting, coronary artery bypass grafting (CABG) is the standard of care. LIMA is used in almost every patient and is the cardiac surgeon’s blood vessel of choice for CABG due to its superior long-term patency compared to other vessels [2, 10]. RIMA is used in less number of CABG cases due to the lack of anatomical proximity to the target coronary vessels. It is usually used in grafting the right coronary artery when feasible with patency equivalent to LIMA. Other arterial and venous grafts options are less frequently used with variable patency. The internal mammary arteries are strikingly resistant to the development of atherosclerosis secondary, at least in part, to its superior endothelial function with fewer fenestrations, lower intercellular junction permeability, greater anti-thrombotic molecules such as heparin sulfate and tissue plasminogen activator, higher endothelial nitric oxide (NO) production and its impermeability to the transfer of atherosclerosis producing lipoproteins [17].

Early cases of single-ventricle physiology palliated with Fontan procedure are in their 30 and 40s. This group of patients is approaching the common age of coronary artery

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disease. In the next 10–20 years, increasing number of these patients will require management of their coronary artery disease either via percutaneous route or CABG if not candidate for percutaneous modalities.

The increased incidence of coiling of APCs in single-ventricle physiology patients, particularly LIMA and RIMA, will carry a future challenge to surgical teams caring for these patients. The incidence of LIMA versus RIMA coiling is poorly described in the literature. A PubMed search revealed many articles investigating pre-Fontan coiling of APCs without clear specification of the vessel(s) being coiled [3, 4, 15]. A study designed to evaluate this incidence would be a great start. Although coiled LIMA and RIMA leading to lack of adequate graft vessels with high-quality patency appear to be the most stressing future concern in Fontan patients, it is not the only surgical issue in such circumstances. Re-do sternotomy and minimal experience of adult cardiothoracic surgery teams in performing CABG in single-ventricle patients previously palliated by Fontan procedure are two other examples. These issues and others were addressed to some extent in the literature, and their solutions have been proposed and implemented [11, 13]. Hybrid teams consisting of adult and congenital cardiologists and cardiothoracic surgeons may be the ideal team to manage these patients in the operating room and the immediate post-operative period. A surgical specialty equivalent to adult congenital heart disease may be another way to address this matter. Prospective studies evaluating the incidence of each coiled APC keeping in mind the future CABG for these patients may be warranted. Such a study would shed some light on the subject and thus would allow for further prospective studies.

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