

## Pediatric interventional cardiology: Breaking new grounds

The management of congenital heart disease (CHD) has changed considerably in the recent years. On one side, there has been increased emphasis on earlier corrective surgeries and on palliative or radical repairs of conditions that were previously considered inoperable, whereas, on the other, there have been tremendous advancements in interventional transcatheter techniques, mainly attributable to the advancements in hardware and imaging techniques.

Pediatric interventional cardiology is a unique medical discipline in that the operator requires the knowledge base of pediatrics and cardiology coupled with the physical skills and attributes as that of surgical disciplines. The scope of practice of interventional cardiology is no longer limited to valvuloplasties and closure of simple cardiac defects but has expanded to include complex intracardiac, vascular, and valve interventions. The magnitude and complexity of these tasks have grown substantially so that not many interventionalists can master all of them. While the advancements in the field of interventional pediatric cardiology are taking giant strides in the west, in India there has been a slow, yet steady progress. The reasons are a multitude for the lag in acceptance of these recent technologic advancements, most important being the financial and regulatory restrictions. However, there

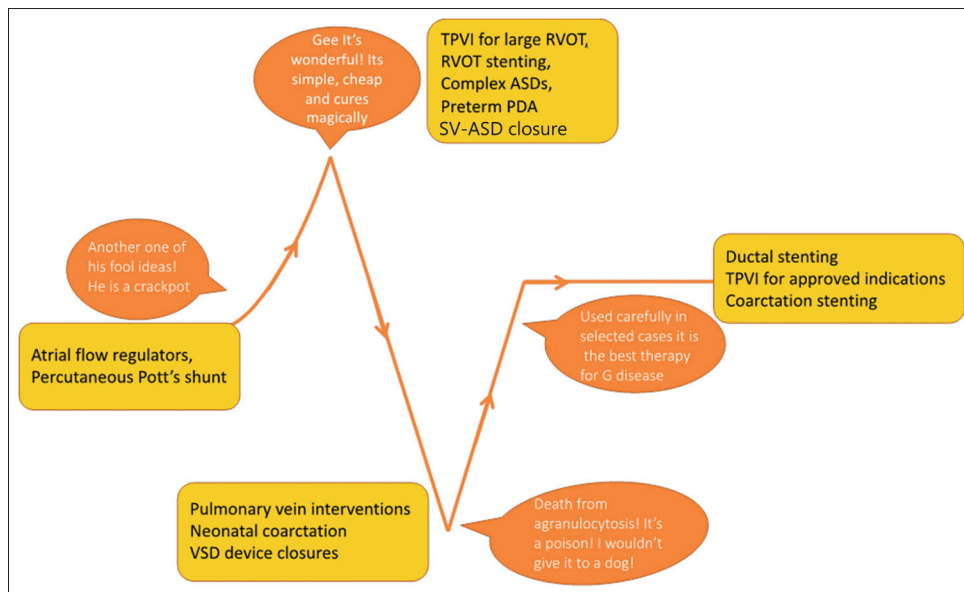
had been a few indigenous and innovative contributions from some of the developing countries, especially India.<sup>[1]</sup>

This issue of Annals focuses exclusively on therapeutic catheterization procedures performed in children and adults with congenital cardiovascular diseases. Undoubtedly, this issue will be a delightful read, full of innovations, out-of-the-box thinking, and executions.

### NEW KIDS ON THE BLOCK

Every novel drug or therapeutic agent follows a typical natural history, right from its introduction till the time its utility is confirmed by good quality data. It might be intriguing to notice that even transcatheter interventions for CHD follow a similar course. In Figure 1 we have attempted to categorize some of the recently described cardiac interventions along various phases of this natural history curve. Of late, the most discussed topics in the global pediatric cardiac internationalists fora are transcatheter pulmonary valves and transcatheter correction of superior sinus venosus defects. This journal issue has provided ample food for thought for readers interested in these upcoming techniques.

Transcatheter pulmonary valve implantation (TPVI) is gaining a wide attention among most pediatric



**Figure 1: Natural history of congenital cardiac intervention in comparison with that of any novel drug or therapeutic agent. VSD: Ventricular septal defects, RVOT: Right ventricular outflow tracts, ASDs: Atrial septal defects, PDA: Patent ductus arteriosus, SV-ASD: Sinus venosus - Atrial septal defects, TPVI: Transcatheter pulmonary valve implantation**

cardiologists practicing in India. TPVI in native right ventricular outflow tract (RVOT) poses unique challenges compared to TPVI in RVOT reconstructed with conduits or bioprosthetic valves. Last year, we published the early results of TPVI with Venous P-valves, MyVal, and Melody valve systems, which were encouraging.<sup>[2-4]</sup> In the current issue, Sivaprakasam *et al.* and Sivakumar *et al.* allude to the challenges of TPVI in dilated and dysfunctional RVOT and the strategies that were adopted to overcome them.<sup>[5,6]</sup> With newer valves coming up in the market and improved understanding of the native RVOT anatomy, increasing number of patients are being identified to be suitable for a TPVI. With an ever-growing population of adolescents and adults with repaired tetralogy in our country, there is immense scope for this technique to expand widely in the coming decade. However, prohibitive cost remains the major challenge.<sup>[7]</sup> Investing research interests in this area with a focus to design and manufacture indigenous valves will certainly prove fruitful for a very large subpopulation of repaired tetralogy of Fallot patients.

While strategies for TPVI are expanding at one end, on the other, few pediatric interventionalists have demonstrated out-of-the-box thinking by implanting these valves in nonpulmonary positions. Duarte *et al.* and Torre *et al.* have published their experience of Melody valves in tricuspid and mitral positions, respectively, in two children.<sup>[8,9]</sup> Although the longevity of such procedures remains unknown, it is worthy to be aware of the feasibility of such innovative options.

In the “How I Do It” section, the procedures for transcatheter correction of superior sinus venosus defects have been covered.<sup>[10]</sup> This article highlights the most basic points required to understand the nuances of this upcoming technique. Sivakumar K has consolidated all his experience and has come up with this protocol which might be applicable to resource-limited settings such as ours where there is limited access to three-dimensional printed models and advanced imaging tools such as virtual reality or holography.

## INNOVATIONS IN ATRIAL SEPTAL DEFECTS CLOSURE

Transcatheter device closure programs for atrial septal defects (ASD) have been well established. Substantial contributions have been made by Indian interventionalists with regard to transcatheter ASD closure.<sup>[1]</sup> Nevertheless, ongoing innovations continue to be reported by which, defects that are otherwise considered for surgical closure are being made amenable for transcatheter closure. Few such innovations include the use of multiple devices for closing multiple ASDs or closure of ASDs in carefully selected patients with anomalous retroaortic left circumflex artery or resorting

to transhepatic access in children with interrupted inferior vena cava<sup>[11-13]</sup> or cribriform septal occluder for fenestrated defects.<sup>[14]</sup> In this issue, Sagar *et al.* describe the utility of balloon interrogation, and discuss the pros and cons of simultaneous versus sequential delivery of multiple devices in the setting of multiple ASDs.<sup>[11]</sup> Successful device closure of ASDs in children weighing lesser than 10 kilograms have been reported from some Indian centres.<sup>[15]</sup> However, there are certain limitations to such innovations and the procedures are best restricted to experienced centers with a good cardiac surgical backup.

In another report, Pizzuto *et al.* report the utility of the new GORE® Cardioform occluder device as a rescue option in a patient who developed atrioventricular block following ASD closure with an Amplatzer Septal Occluder.<sup>[16]</sup> It is claimed that this device could close large defects at low mechanical stress on surrounding structures, thereby resulting in a lesser incidence of conduction disturbances.

## NONCONVENTIONAL USES OF OCCLUSION DEVICES

Off-label use of various occluder devices for closing restrictive perimembranous ventricular septal defects (VSD) is frequently done in India. Even selected indirect Gerbode defects and subpulmonary VSDs have been successfully closed percutaneously.<sup>[17,18]</sup> However, it should be borne in mind that failed attempts, suboptimal results and complications are seldom reported in the literature. Case selection remains paramount for successful outcomes, especially in India where regulations are relatively lenient for off-label indications. Vascular plugs are versatile devices that are ideally suited to close extracardiac vascular communications and their use is expanding in pediatric interventions.<sup>[19-21]</sup> With increasing number of palliated single-ventricle patients surviving beyond adolescence, interventions on the Fontan circuit including fenestration closures are being increasingly done. These patients need to be better analyzed with defined criteria before undergoing closure of fenestration.<sup>[22]</sup> Furthermore, partial occlusion of the Fontan fenestration has also been reported with the use of a flow regulator device.<sup>[23]</sup>

## UTILITY OF STENTS

The utility of stents in palliating or correcting children with CHDs is expanding. Stenting of RVOT and ductus arteriosus is being increasingly performed in addition to the established procedures of stenting the aortic coarctation and stenosed pulmonary arteries. Ductal stenting in small neonates with ductus-dependent

systemic circulation as a part of a staged treatment has been published in this issue by Anagnostopoulou *et al.* and Weryński *et al.*<sup>[24,25]</sup> Vertical vein stenting as a bailout procedure in selected neonates with obstructed total anomalous pulmonary venous drainage and a prohibitively high surgical risk has been previously reported.<sup>[26]</sup> In this issue, Lale *et al.* have reported their experience of successfully managing two cases with blocked modified Blalock-Taussig shunt by stenting.<sup>[27]</sup>

Arora *et al.*<sup>[28]</sup> report that newer noncompliant coronary balloons may emerge as excellent alternatives in neonatal coarctation, an intervention that still remains unconquered among neonatal interventions. Research using bioresorbable material for stents and devices is ongoing and the ideal material remains elusive. Mood *et al.* from Malaysia report their experience of iron bioresorbable stents in providing temporary palliation in neonates with reduced pulmonary blood flow conditions with a noncomplex patent ductus arteriosus (PDA) morphology.<sup>[29]</sup> This group observed accelerated neointimal proliferation in these bioresorbable stents and hence recommends their usage in neonates with an alternative source of pulmonary blood flow. These novel scaffolds mandate further research and it might be premature to take decisions based on the available data.

## ADVANCES IN VASCULAR ACCESS AND IMAGING

Advances in imaging and vascular access are the primary drivers of much of the expansion of pediatric interventional procedures. Excellent articles alluding to the techniques of axillary and carotid access for performing pediatric cardiac interventions have been published in the *Annals*.<sup>[30-32]</sup> Interventional echocardiography in the form of 3D echocardiography and intracardiac echocardiography has revolutionized peri-procedural imaging guidance. Recent additions like rotational angiography and fusion imaging further aid in selected complex structural interventions.<sup>[33]</sup>

Other emerging interventions including the use of atrial flow regulator in children, reduction devices for RVOT, percutaneous Potts shunt, and preterm PDA closure will be featuring in our subsequent issues.

## MULTICENTER REGISTRIES FOR INTERVENTIONAL PROCEDURES: THE WAY FORWARD?

The limited numbers of patients with any given congenital cardiac anomaly, and the heterogeneous subpopulations, makes pediatric cardiology a challenging area to obtain valid and generalizable data. For established interventional procedures, continuous critical evaluation of mid and

long-term outcomes is essential. Whereas for newer and upcoming techniques, the primary consideration should be how they compare with surgery in terms of clinical utility, morbidity, and mortality. For instance, there are cases of congenital systemic arterial fistulas and aorta to the right ventricular tunnels that have been managed using transcatheter techniques with good immediate and short-term results.<sup>[34,35]</sup> However, the medium and long-term outcomes are not known. Unless these patients are placed on rigorous follow-up, such outcome data will always remain unknown. Importantly, making management decisions based on small, single-center reports of a handful of cases may not be ideal. This problem can be partially circumvented by looking at cumulative multicenter data. Such an attempt has been done in the article by Koneti *et al.*, where they report an experience of congenital portosystemic shunts from five Indian centers.<sup>[36]</sup> However, there may be significant heterogeneity in practices between various centers, in addition to the bias inherent to retrospective review of records. Thus, this subspecialty is one in which prospective high-quality registry data would be particularly suitable. Similar registry databases are functional in the Western world, which have majorly contributed to the outcome data of various cardiac procedures. It is high time that the pediatric cardiology community in India come forward to establish such registries and generate data that are relevant to the indigenous population.

Till such data are available, from an interventionalists' perspective, although it is good to think "Can this problem be fixed percutaneously and an invasive surgery be avoided?," it is wiser to think "Will the cardiac surgeon with a loupe be able to fix it better than an interventional cardiologist with fluoroscope?."

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