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EDITORIAL

The Evolution of Paediatric Cardiology Service in Oman

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Congenital heart diseases were highlighted for the first time in Thomas Morgan's paediatric textbook in the year 1896.[1] Thirty years later, in 1926, Dr. John Morse briefly alluded to congenital heart diseases in his paediatric textbook. At that time, the future of children born with different degrees of congenital cardiac defects was not promising. In 1937, Dr. John Strider ligated a patent ductus arteriosus (PDA) in a 22-year-old male patient but unfortunately the patient died in the post-operative period due to sepsis which was before the antibiotics' era.[2] A year later, on 26th August 1938, Dr. Robert Gross ligated a PDA in a 7-year-old patient.[1] That day may be considered the 'birth day' of paediatric cardiology services.

Dr. Alfred Blalock performed the first aortopulmonary shunt (Blalock–Taussig shunt) in a 15-month-old child with a diagnosis of tetralogy of Fallot on 29th November 1944. In 1947, Helen Taussig summarised her research and clinical experience into a book titled "Congenital Malformations of the Heart" which became the standard reference for paediatric cardiology and surgery. The modified Blalock-Taussing shunt operation using plastic prosthesis was first described by Klinnerin 1962.[3,4] The first intracardiac repair was performed on 2nd September 1952 by F. John Lewis for an atrial septal defect in a 5-year-old girl using total body hypothermia. In May 1953, Dr. John Gibbon successfully closed an atrial septal defect in an 18-year-old patient using a heart lung bypass machine and screen oxygenator. The first intracardiac repair for tetralogy of Fallot using cross circulation was performed in 1954.[5] Thereby, setting the wheel of advancement in the cardiology field in motion due to tremendous advances in the field of medical technology in late 80s and 90s.

THE INITIATION OF PAEDIATRIC CARDIOLOGY SERVICE IN OMAN

In Oman, establishment of the Royal Hospital (RH) in 1987 was a turning point in the evolution of medical services. Before the RH, Al Nahdha Hospital and Khoula Hospital were the main medical care provision institutes in the country. However, some medical services shifted from the latter hospitals to the RH. Some of the major subspecialties in adult medical and surgical fields such as adult cardiology, gastroenterology, oncology, vascular surgery, orthopaedics and haematology were established at the RH. At that point of time, the paediatric services were focused on preventive measures such as the immunisation. The only paediatric subspecialty which was available at the RH was oncology and haematology. The paediatric haematology specialty was initially run by 1 consultant; later on, a specialist joined the consultant. In the early 1990s, paediatric cardiology service was initiated by an adult cardiologist who was interested in congenital heart diseases. The service provided more case-based consultations for the diagnosis and follow-ups. There was no designated unit or department for such a service initiative. Some selected cases needing surgical interventions were sent abroad, while many were provided humanitarian care only.

With the passage of time, 1 paediatric cardiology consultant and a senior specialist were attached to the general paediatric unit; they were serving adult cardiology section as well. In 1991, the number of paediatric patients with congenital heart diseases increased and there was an urgent need for the establishment of full-fledged paediatric cardiology services. The consultant paediatric cardiologist was asked to focus solely on paediatric cardiology services, while the specialist continued to serve both the adult and paediatric cardiac patients. The paediatric cardiologists continued working with the same limited capacity for several years, despite new services being added to the specialty. The new paediatric cardiac services included facilities for paediatric cardiac catheterisation. Initially, paediatric echocardiography studies and paediatric catheterisation were allotted 1 day per week.

Later on, the paediatric cardiology services were allotted an additional consultant and 1 full-time paediatric registrar. The team was working with no designated unit or department up until 2004. The team was initially provided with 4 beds. As the number of patients increased, they were distributed under

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the general paediatric, paediatric intensive care and neonatal units. There was an urgency for establishing a fully functional and structured paediatric cardiology service unit thus the paediatric cardiac unit expanded.

After establishment of Sultan Qaboos University Hospital (SQUH) in 1990, a paediatrician interested in paediatric cardiology joined the hospital and started providing echocardiography service for patients suspected of having heart diseases and referring the confirmed cases to RH for any required intervention. Later on, a trained paediatric cardiologist has replaced that paediatrician and currently this service is provided by 3 paediatric cardiologists. From 2006 onwards, paediatric echocardiography screening was provided at some regional hospitals by either an adult cardiologist or paediatrician trained in the basic principle of echocardiography. In 2007, a trained paediatric cardiologist joined Armed Forces Hospital and commenced a non-invasive paediatric cardiology service for eligible patients. In 2014, non-invasive paediatric cardiology services were initiated at Sultan Qaboos Hospital (SQH) in Salalah by 1 trained paediatric cardiologist.

In 2004, an Omani cardiology consultant joined the paediatric cardiology unit at RH and changed the overall work dynamics and the vision of the unit. As a result, an acute surge in the paediatric cardiology services was witnessed. Most cases were managed and treated as per the currently accepted advanced management approaches and protocols. However, cases which were beyond the paediatric cardiologists' management capabilities were sent abroad. These involved patients requiring ablations by expert electrophysiologists. The focus was on establishing paediatric cardiac surgical and interventional procedures with successful outcomes to match the international standards.

TEAM BUILDING AND THE ORGANISATION OF THE SERVICE

The paediatric cardiology surgical service was not started until the late 1980s. The first PDA ligation in Oman was done in 1989. Yet, the paediatric cardiac surgical services lacked a systematic structure for many years. The service handled scattered surgical procedures that were performed based on case discussion among the surgeons and the cardiologists. The first open heart surgery was performed on 2nd of December 1990. An 11-year-old boy with secundum atrial septal defect was successfully operated by an adult cardiac surgeon. At that time, even internationally, the norm was that adult cardiac surgeons performed paediatric cardiac surgeries as there was a lack of dedicated paediatric cardiac surgeons in many centres.

In late 1990s, a 4-bed paediatric post-cardiac surgery intensive care unit (PCSU) was established at the RH. The paediatric cardiac surgical procedures for low and medium risk cases became more frequent and well organised. However, complex cases were sent abroad. The PCSU was managed by cardiac surgeons and the input of the paediatric cardiologists was based on only case consultations. The work of the 2 teams was mainly focused on handing over the cases in the pre-surgical meeting. The cases were referred back to the paediatric cardiologists at variable postoperative periods depending on the surgeons' interest in continuing with the follow-up. Due to the disorganised transfer of care, many cases were lost for postoperative cardiac follow-up. Many patients were discharged home without the allocation of a postoperative cardiac follow-up appointment by paediatric cardiologists.

After the Omani consultant paediatric cardiologist mentioned earlier joined the team, he worked towards building a complete paediatric cardiology service team in 2004. The team consisted of cardiologists, cardiac surgeons and paediatric intensivists. The new Omani cardiologist emphasised on fostering collaboration, cooperation and effective team dynamics among the team members. In 2005, the paediatric cardiologist's contribution to the immediate postoperative period became an integral part of the care. A combined rounds of the paediatric cardiologists and the surgeons with shared decision became the norm. The paediatric cardiologists and the surgery team formed the main pillars of the care in order to achieve the best outcomes for the patients. A major improvement in the team dynamics was achieved in mid-2009, when the paediatric intensivists took the responsibility of managing the PCSU. The cardiac surgeons continued to operate on children and adult patients until 2013 when a total of 3 surgeons (i.e. 2 previously existing surgeons and 1 newly appointed) were allocated for paediatric cardiac cases only. Two years later, the team was fortunate enough to get a newly appointed paediatric cardiac surgeon.

THE INITIATION OF PAEDIATRIC CARDIOLOGY SURGICAL SERVICES IN OMAN

As years passed, the team moved on with performing increasingly complex surgeries for congenital cardiac anomalies. The first tetralogy of Fallot and first atrioventricular septal defect intracardiac repair operations were done in 1992. The first Fontan operation was done in 1993. The first arterial switch operation for transposition of great arteries was performed in 1998. The latter operation was considered a landmark of excellence for any paediatric

cardiac surgery unit. By 2003, the first Ross' procedure was done on a newborn as a salvage procedure following avulsion of the aortic valve secondary to balloon valvuloplasty. The first double switch operation for congenitally corrected transposition of the great arteries was executed in August 2013 by a visiting paediatric cardiac surgeon. In 2015, the most complex surgical procedure in a newborn, Norwood's procedure, was performed successfully.

As the cardiac surgery procedures evolved, the service was expanded to operate on younger and smaller children including newborns and those who weighed less than 2.5 kg. The number of paediatric cardiac surgery cases steadily increased with time and currently approximately 350–400 paediatric cardiac surgical procedures are performed per annum. It is worthy to note that the cardiac surgery related morbidity and mortalities have declined over the years; this may be attributed to improvements in the team's experience and the cardiac surgery techniques. The quality of care further improved as paediatric intensivists managed the PCSU applying advances in inotropic drug support, chest care and newer ventilation modalities.

In 2017, the PCSU successfully adopted the fast-track approach for many postoperative procedures setting the postoperative length of stay as a key performance indicator. Additionally, as more critically ill patients were operated, the extracorporeal membrane oxygenation (ECMO) support was increasingly utilised in the immediate postoperative period. In 2016, the PCSU has become a member in the Extracorporeal Life Support Organization. The outcome of the ECMO support has been comparable with the international figures for this category of patients.

PAEDIATRIC CARDIOLOGY MEDICAL SERVICES IN OMAN

Today, the paediatric cardiology team consists of 8 paediatric consultant cardiologists that are expert in all fields of super-specialisation. Having an expert team has had a positive impact on the quality of care, service outcome and expansion of the service. Paediatric electrophysiology and fetal cardiology were added to the service in 2014. A year later, a paediatric cardiologist who is specialised in cardiac imaging (computed tomography and cardiac magnetic resonance) joined the unit. In 2022, a paediatric echocardiography consultant joined the unit. Currently, the RH has 4 paediatric cardiology interventionists who perform all types of interventions for congenital heart diseases/defects in adults and children.

In terms of the RH's history of interventional procedures, it can be argued that due to the advances in medical technology, the interventional procedures have become the standard treatment for many cardiac defects. The first intervention was balloon atrial septostomy (Rashkind's procedure) done in 1990 while the first diagnostic cardiac catheterisation done in children was in 1988. The first device closure for PDA was done in 1995. In 1999, atrial septal defect was the second cardiac defect closed by devices. The first ventricular septal defect device closure was carried out in 2008. In 2000, balloon angioplasty for coarctation of aorta was introduced, followed by coarctation stenting in 2009. Balloon angioplasty and stenting for pulmonary arteries were initiated in 2007 and 2008, respectively.

The first PDA stenting for a neonate with cyanotic heart disease and reduced pulmonary blood flow was performed in 2011. In 2013, percutaneous pulmonary valve implantation was introduced as a modality to treat right ventricle outflow tract disease. The unit is one of the early units in the world that introduced sinus venosus atrial septal defect device closure in 2018. With the opening of a specialised arrhythmia clinic in September 2014, the RH's paediatric electrophysiology service was started. In 2015, with the opening of the National Heart Center in the RH, the invasive electrophysiology service was started with devices implantation in children. Electrophysiology studies and ablations were first executed in 2016, after installation of the 3-dimensional mapping system.

Currently, in-step with international guidelines, the ablation therapy in children with uncontrolled arrhythmias is done with 'zero' fluoroscopy technique. In fact, the service now can be provided to children weighing 3 kg and to adults with complex cardiac anomalies having various types of arrhythmias. Fetal cardiology service (FCS) is provided to women with family history of congenital heart disease or those detected in antenatal scan to have a fetus with cardiac anomaly. Moreover, FCS incorporates family counselling, planning of the medical treatment, delivery mode and the postnatal care interventions. With regards to academic research output, year-on-year, under the aegis of the National Heart Center, this heart centre has published several articles in indexed journals.

Conclusion

Team work, dedication, continuous communication between all stakeholders and the hunger for continuous improvement were the primary contributors for our

unit's success. Negotiation, knowledge and expertise sharing have achieved magical outcomes for the team.

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