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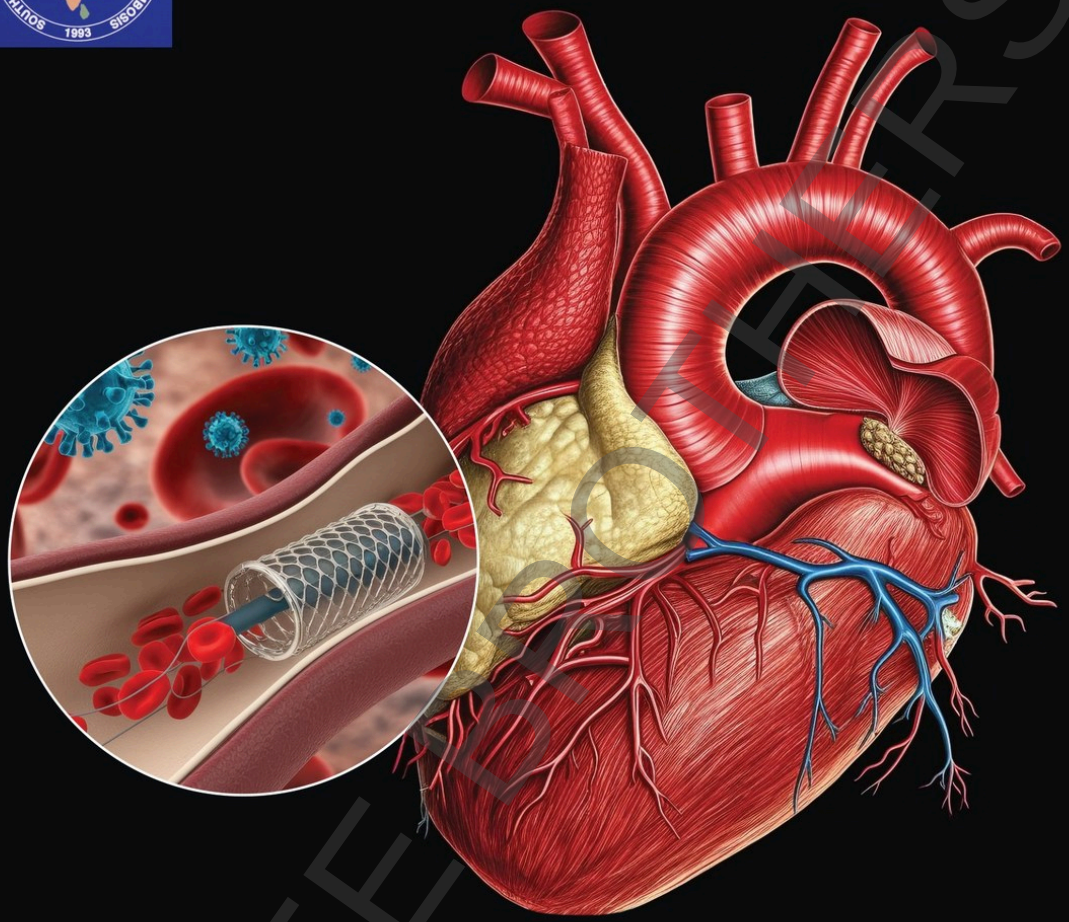

# Clinical Handbook of Coronary Artery Disease

Gundu HR Rao

2nd Edition

JAYPEE

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CHAPTER 7

# Development of Pediatric Cardiology in India

*IB Vijayalakshmi*

## BACKGROUND

In 1908, Dr Maud Elizabeth Abbott wrote a ground breaking article on congenital heart disease (CHD) based on findings of 400 cases. Dr William Osler said, "It is by far and away the very best thing ever written on the subject…." Her Atlas of Congenital Heart Disease published in 1936 described 1,000 cases became the basis for modern pediatric cardiac surgery. Today when three Indians, edited over 1,100 pages book, the legendary late Dr Joseph Perloff wrote, "Osler's Principles and Practice of Medicine devoted a scanty five pages to Congenital Affections of the Heart. Holt's Diseases of Infancy and Childhood devoted seven pages to Congenital Anomalies of the Heart.……This thousand plus page book is a remarkable achievement that addresses the seemingly impossible task of the spectrum of CHD from the 3rd week of intrauterine life to late end-of-life issues. A Comprehensive Approach to Congenital Heart Diseases by IB Vijayalakshmi, P Syamasundar Rao and Reema Chugh is a tribute to the authors and a rare gift to the reader. Three exceptional editors were chosen to achieve this goal together, they represent three generations, who have witnessed the major advances since the first blue baby operation at the Johns Hopkins Hospital in 1944."

Dr Helen Brooke Taussig, a pediatrician at John Hopkins, was the codeveloper of first successful "Blue Baby"operation at John Hopkins Hospital. The two great Indian pioneers of pediatric cardiology in India, Dr Kamala I Vytilingam and Dr S Padmavati both were trained in John Hopkins Hospital, under Dr Helen Brooke Taussig, "mother of pediatric cardiology". The journey of pediatric cardiology in India has thus been truly fascinating and full of challenges, determination and dedication. So much so that once great cardiac anatomist, Bob Anderson exclaimed to Dr Vijayalakshmi—"we have laid the solid foundation for structural heart diseases, now it is to the young Indian pediatric cardiologist to build it further". The remarkable journey of pediatric cardiology in India has many luminaries who have brightened the path of future.

## HISTORY OF BEGINNING OF PEDIATRIC CARDIOLOGY IN INDIA

The first formal Department of Cardiology in India was started in Christian Medical College (CMC) Hospital, Vellore in 1957, by Dr Vytilingam, who brought modern cardiology to India after a period of training at Johns Hopkins Hospital, Baltimore in the early 1950s. The DM cardiology training course was started in CMC in 1965. The Dr Vytilingam completed a year's training with Dr Helen Taussig in 1961. The availability of surgical help allowed her to look after both adult as well as pediatric patients. The birth of the specialty of pediatric cardiology in India took place at Vellore under Dr Reeve Betz who started the first cardiothoracic surgery department at Vellore in 1949. Dr T Thomas and Dr Gopinath joined Dr Betz subsequently and initiated the first open heart surgery programs

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in 1960.[1] Dr Vytilingam established one of the earliest cardiac catheterization laboratories in India. But real interventional cardiology started only in 1985.

## PIONEERS IN PEDIATRIC CARDIOLOGY


Dr Kamala I Vytilingam


Dr Gopinath


Dr S Padmavati


Dr PS Bidwai


Dr PS Sreemathi


Dr Rajendra Tandon


Dr Savitri Shrivatsava


Dr KM Cherian


Dr M Khalilullah


Dr Ramesh Arora


Dr KS Iyer


Dr Devi Prasad Shetty

## Dr S Padmavati

The first Indian doctor who completed training in pediatric cardiology is Dr S Padmavati who studied CHD as a fellow with Dr Helen Taussig from 1948 to 1951 and subsequently in pediatric cardiology department in Boston at the Massachusetts General Hospital. She had rare privilege of publishing a paper "Results of Operation for Pulmonary Stenosis and Atresia Transactions" with Dr Helen Taussig in Association of American Physicians in 1951.[2] On her return to India she was amazed to find the wards full of young women and children with acute rheumatic fever (ARF) and rheumatic heart disease (RHD). As she did not have access to surgical management of pediatric cardiac patients, she had to predominantly look after adults. She opened a cardiac clinic in Lady Hardinge Hospital where there were a lot of children with CHD. In 1980, she published her paper "Congenital Heart Disease in Delhi School Children".[3]

Dr Rajendra Tandon started pediatric cardiology in All India Institute of Medical Sciences (AIIMS) in 1963. The next year in 1964, Dr P Laxman Rao started pediatric cardiology in GMC, Andhra Pradesh. Some of the earliest pioneers who started pediatric cardiology in various parts of India are Dr Vishnu Jain in Patna in mid-60s, Dr Bachu Edibam Master in Jamshedpur, Dr SK Sanyal in Safdarjung Hospital, New Delhi, Dr Marylin Joseph in Tamil Nadu in 1972, Dr PS Sreemathi was the *first pediatric cardiac surgeon* in Madras, Dr IP Sukumar 1974 CMC/Vellore, Dr PS Bidwai, Chandigarh, Dr Savitri Srivastava joined AIIMS, New Delhi 1976, Dr Ramesh Arora in GB Pant Hospital in 1974.

## Dr Rajendra Tandon

Dr Rajendra Tandon (21 January, 1931–26 February, 2014) is the Father of pediatric cardiology in India. The contribution he has made in the field of clinical cardiology, especially in patients with CHD, is immense. He could hear the faintest of heart sounds that provided vital clues to the diagnosis of heart disease and a most astute clinician when it came to the art of bedside diagnosis. After his formative

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medical education (MBBS 1954; MD 1958) at the King George's Medical College, Lucknow, he subsequently trained in internal medicine at the Massachusetts General Hospital and in cardiology at the Children's Hospital, Boston, USA. There he worked with renowned leaders in pediatric cardiology and cardiac pathology such as Alexander Nadas and Jesse Edwards. He was a trained cardiac pathologist and, with Jesse Edwards, has published several classical papers in cardiac pathology that are referred till date. He then returned to India, as adept in expertly guiding a cardiac catheter through tiny blood vessels as he was in hearing the faintest heart murmurs through his favorite Hewlett Packard stethoscope and as skilled in identifying cardiac malformations at autopsy as he was in solving the crossword puzzle of complex CHD in a crying baby.

In early 1963 Dr Rajendra Tandon after completing a 2 year training program in pediatric cardiology, joined AIIMS, New Delhi and restricted himself almost entirely to pediatric cardiology. He retired as Professor and head of cardiology as well as chief of the cardiothoracic center at AIIMS in 1991. His interest in rheumatic fever (RF) bordered on obsession. He chaired the Indian Council of Medical Research group on RF that has yielded significant results. Dr Rajendra Tandon was the founder member and the patron of the Pediatric Cardiac Society of India (PCSI). He authored a small book on clinical approach to CHD that is remarkable for its direct and simple approach, and pledged the royalties from the book to the pediatric cardiac society of India.

## Dr PS Bidwai

Dr PS Bidwai, after training in USA, joined Postgraduate Institute of Medical Sciences (PGI), Chandigarh and remained active as a pediatric cardiologist. Also, three other pediatricians who obtained excellent training in pediatric cardiology came to settle in India. Dr Vishnu Jain of Patna worked with Dr Vlad and Dr Ed Lambert at Buffalo. Dr Bachu Edibam, Master of Jamshedpur, got her training with Dr Keith in Toronto and Dr SK Sanyal, who trained with Dr Norman Talner, settled at Safdarjung Hospital in Delhi. But again because of lack of surgical help, Dr Vishnu and Dr Bachu worked only as pediatricians, whereas Dr Sanyal went back to US. Dr IP Sukumar spent 2 years with Dr Keith in 1972–73 and took over the responsibility of pediatric cardiology at Vellore. The other person with training in pediatric cardiology was Dr P Syamsunder Rao who went back to US.[1] But over the years, he continues to convey knowledge of pediatric cardiology to Indian Physicians and has brought the pediatric interventional cardiology techniques to India by way of workshops and papers.

Professor Rajendra Tandon and Savitri Shrivastava of AIIMS immensely contributed to the growth of pediatric cardiology which, due to their efforts, is now a recognized major specialty in India.

## Dr Savitri Shrivastava

Professor Savitri Shrivastava did her MBBS from GRM College, Gwalior, Agra University in 1957 and MD (Medicine) at GRM College, Vikram University in 1961. She did her DM (Cardiology) at AIIMS, Delhi, India in 1971. Subsequently, from 1975 to 1976, she did her Fellowship in Pediatric Cardiology at University of Minnesota, Minneapolis, USA. She came back to AIIMS. Her special achievement in field of interventional cardiology described for the first time in the world was an original technique of balloon dilatation of the atrial septum (static balloon) in transposition of great vessels. This was published in Indian Heart Journal in 1988.[4] She also reported for the first time in the World "Percutaneous Catheter Commissurotomy in Rheumatic Mitral Stenosis" in the New England Journal of Medicine in 1985.[5] She was also instrumental in doing a lot of procedures for the first time in India at AIIMS. The procedures were balloon valvuloplasty for pulmonary valve, aortic valve, balloon dilation of aortic coarctation, aortoarteritis, peripheral pulmonary arteries, coil occlusions of Blalock-Taussig (BT) shunt, coronary "PICS Achievement Award" at the Annual PICS (Pediatric Interventional Cardiology Symposiums) meeting held in Miami, Florida on January 21, 2013. This is a great honor for an Indian. After her retirement from AIIMS, the good work is being continued at present by Dr Anitha

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Saxena who did school surveys for RHD disease with mobile echo machine and Dr Shyam Kothari who has worked on pulmonary hypertension.

## Dr KM Cherian

Corrective or palliative surgery has been the usual treatment of CHDs in children. Dr KM Cherian is a pioneer in pediatric cardiac surgery in India. KM Cherian is a leading Indian heart surgeon who has pioneered new treatments, founded new hospitals, and earned an international reputation. He is the founding chairman of Frontier Lifeline in Chennai, and the Dr KM Cherian Heart Foundation.

He started his career in CMC Hospital, in Vellore as a lecturer in surgery. He did his FRACS in Cardiothoracic Surgery in 1973. He worked as a special fellow in pediatric cardiac surgery in Birmingham, Alabama under *John W Kirklin* and in the University of Oregon under *Albert Starr*. He performed the country's first heart transplant after legalization of brain death. The first heart-lung transplant, the first pediatric transplant and the first transmyocardial laser revascularization (TMR) (laser heart surgery) were also performed by him. He has also performed the country's *first infant cardiac surgery*, first bilateral lung transplant; the first pediatric heart transplant; the first auto transplant; and the first heart and lung transplant (1999). Pioneering pediatric cardiac surgery in India, Dr Cherian has performed more than 39,699 operations! Truly, a stupendous task.

He has an honorary Doctor of Science from King George's Medical University, Lucknow. He was awarded "Padma Shri" by the Government of India in 1991. Dr Cherian was honorary surgeon to the President of India from 1990 to 1993. He is the first Indian to become the President of the World Congress of Thoracic Cardiac Surgeon and the first member of the American Association of Thoracic Surgery from India. He is the first Fellow of the Royal Society of Medicine, London. He is the Founder Chairman of Frontier Mediville, the first Medical Special Economic Zone (SEZ) and Medical Science Park in India, a truly fascinating place where every aspect of cardiac research including animal study and surgery can be performed and has housed more than 5,000 cardiac specimens brought from Chicago. The chamber of Dr Levi and Dr Saroja Bharathi is reconstructed!

Dr Cherian has authored more than 285 national and international publications, coauthored books on Pediatric Cardiac Surgery and is the only Asian author to contribute to the Textbook of Cardiac Surgery, an essential bible to all cardiac surgeons. His name is engraved in one of the stones at Kos Island, Greece along with three other Indian surgeons, the birthplace of the medical profession and Hippocrates, the "Father of Medicine" on the occasion of the 18th World Congress held by the World Society of Cardio Thoracic Surgeons held from 30 April to 3 May, 2008. Dr Cherian is also an advocate for organ donation and is the leading authority in heart transplant procedures in the country. His motto in life is "Service before Self". Truly, he is a real source of inspiration for generations to come. Dr KM Cherian is not an individual, but an institution!

## Dr KS Iyer

Dr Krishna S Iyer is one of India's front ranking pediatric cardiac surgeons, recognized for his clinical expertise and wide-ranging involvement with cardiac care for children in India and other developing nations. Dr Iyer initiated the first dedicated pediatric cardiac care program in Northern India, a pioneering initiative, at Escorts Heart Institute Research Centre (now Fortis-Escorts Heart Institute) in 1995. Under his guidance, this pediatric cardiac program has become the benchmark for cardiac care for children in India and its South East Asian neighbors. Dr Iyer has operated on more than 10,000 babies, children and adults with CHDs comprising various procedures like arterial switch procedure, double-switch operation total anomalous pulmonary venous connection (TAPVC) repairs, Fontan and Fontan-type procedures, corrections for tetralogy of Fallot, double outlet right ventricle (DORV), truncus, Senning operation, conduit repairs and wide range of one stage and multistage corrections for complex CHDs. He has done original work on rapid two-stage arterial switch procedure and performed the first successful rapid two-stage arterial switch and double-switch operation in

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India. His current interests are perfecting complex neonatal cardiac surgery, cardiac surgery in malnourished infants and children, salvaging late presenters of CHD and developing cost-effective cardiac care for children in developing countries. Dr Iyer completed his MBBS, MS (General Surgery) and MCh (Cardiothoracic and Vascular Surgery) from AIIMS, New Delhi. After basic training, he joined the Department of Cardiothoracic and Vascular Surgery at AIIMS and was Additional Professor at the time he moved to Escorts Heart Institute to setup its pediatric cardiac care division.

He trained in pediatric and infant cardiac surgery under the guidance of the renowned pediatric cardiac surgeon Dr RBB Mee as Senior Fellow at the Department of Pediatric Cardiac Surgery at Royal Children's Hospital, Melbourne in Australia in 1989. Since his return, he has endeavored to promote the specialty of pediatric and congenital heart surgery in India, especially in the nongovernmental sector. He has contributed prolifically to furthering the cause of pediatric cardiac care through over a hundred research publications in national and international journals, authoring sections in medical books on pediatric and neonatal cardiac surgery and travelling to cities across India and abroad to deliver lectures. He has been the founder President of Asia-Pacific Pediatric Cardiac Society and has been President of Pediatric Cardiac Society of India. He is currently Editor of the Indian Journal of Thoracic Cardiovascular Surgery. He is a permanent member of the Steering Committee of the World Congress of Pediatric Cardiology and Cardiac Surgery, and governing councilor of the World Society of Congenital Heart Surgery and the Asian Society of Cardiovascular and Thoracic Surgeons.

He is an invited international member of the American Association of Thoracic Surgeons. He is involved in many charities for underprivileged children, most notably the "Gift of Life" program of Rotary International. During his academic career, Dr Iyer won many awards. Some of these are the Institute Gold Medal for Best Graduate of the year at MBBS examination, Sorel Catherine Frieman Prize for proficiency in Pediatrics, Pfizer Postgraduate Medical Award, Gold Medal and Scroll of Honor and Hira Lal Gold Medal for being the best postgraduate in General Surgery. He was awarded the Doppler award for best paper at the Sixth International Symposium on Echocardiography in Cardiac Surgery held in Washington DC in 1994. He has been designated Paul Harris Fellow of the Rotary International Foundation for humanitarian services for children.

## Dr Devi Prasad Shetty

Dr Devi Prasad Shetty was trained in Guy's Hospital, London in 1989 and started his career at BM Birla Heart Research Centre in Kolkata where he was involved in the treatment of Mother Teresa. His involvement with Mother Teresa had a deep impact on him resulting in his becoming her disciple. Thereafter, he moved to Bangalore to commission the Manipal Heart Foundation. He founded a chain of super specialty hospitals which includes the Rabindranath Tagore International Institute of Cardiac Sciences in Kolkata and Narayana Hrudayalaya Health City in Bangalore. Currently, Narayana Hrudayalaya Group of Hospitals establishes and manages existing and upcoming health cities in Hyderabad, Jaipur, Jamshedpur, Ahmedabad and a few other cities.

Dr Devi Shetty and his team pioneered the concept of a "Health City", a 2,000–5,000 bedded conglomeration of multiple super specialty hospitals in a single campus. The economies of scale achieved through the health cities enable the group to provide affordable healthcare to thousands. Dr Shetty was also involved in coining the term "micro-health insurance". He spearheaded the launch of a health insurance for the farmers of Karnataka in association with the State Government. "*Yeshasvini*", the micro-health insurance scheme, launched 8 years ago with a premium of INR 5 per month per person, has revolutionized health insurance in the State. Dr Shetty actively sought and succeeded in replicating the micro-health insurance model in the neighboring states of Andhra Pradesh (Arogya Shree) and Tamil Nadu (Kalaignar Star Health Insurance). The huge success of this model has seen six more State Governments opting to adopt a Yeshasvini like micro-health insurance model in their respective States.

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Dr Devi Shetty took the pediatric cardiac surgery from classes to masses. In other words, he made the pediatric cardiac surgery affordable to even unaffordable have nots, so that no poor mother cries helplessly for her child.

Dr Shetty's Narayana Hrudayalaya Group, in association with the Indian Space Research Organization, manages the world's largest telemedicine program and has treated over 53,000 heart patients. Narayana Hrudayalaya telemedicine facility caters to the PAN-African satellite network which connects 56 African cities. The Narayana Hrudayalaya Group has extensive experience in performing complex heart operations such as pulmonary endarterectomy, repair of aortic aneurysms and repair of heart valves. Twenty years ago, Dr Shetty and his team pioneered neonatal cardiac surgery by operating on newborn babies with complex CHD. In addition to his administrative and medical commitments with the Narayana Hrudayalaya Group, Dr Shetty is also on the Board of Governors of the Medical Council of India (MCI), an apex body regulating medical education in India. His activities are profiled in several international publications like the Wall Street Journal, which referred to him as the *Henry Ford of cardiac surgery* in a cover page article, Forbes, Fortune and Business Week. Harvard Business School and Wharton Business School have based a case study acknowledging the unique business model of the Narayana Hrudayalaya Group. Dr Shetty is a recipient of the Padma Shri in 2003, Ernst & Young Entrepreneur of the Year in 2003, Dr BC Roy award in 2004, and Social Entrepreneur–World Economic Forum in 2005. So, the benefit of Dr Devi Shetty's contribution to the pediatric cardiac surgery extends to every nook and corner of India!

## Dr Ramesh Arora

Dr Arora established a registry of transcatheter noncoronary interventional procedures in the country and was awarded with national interventional council of CSI award for development of noncoronary interventional cardiology in India (1999). She started a nonsurgical (device) closure of patent ductus arteriosus (PDA) in 1987 by using Rashkind umbrella device for the first time in the country.[6]



**FIG. 1:** Dr Ramesh Arora is seen presenting on rheumatic fever and rheumatic heart disease, June 1980, in London in the first World Congress of Pediatric Cardiology.

For valvular lesions, especially percutaneous transluminal mitral commissurotomy (PTMC) in children was done in 1987 by her using double Mansfield balloon technique and in 1990 with Inoue balloon.[7,8] Nonsurgical closure of atrial septal defect (ASD) was first time attempted in the country by using various sizes of Sideris devices (1993), followed by STARFlex, CardioSEAL, and Amplatzer devices (1998).[9,10] She started devices closure of ventricular septal defect (VSD), both perimembranous and muscular, by using Rashkind umbrella device in 1995 and this was replaced by muscular Amplatzer VSD device in 1999.[11] First human use of especially designed perimembranous VSD device was done in December 2000 by Dr Arora.[12] Various other rare cardiac lesions were attempted like coronary arteriovenous (AV) fistula, ruptured sinus of valsalva pulmonary AV fistula, pulmonary artery (PA) to left atrial (LA) fistula, etc. She made all Indians proud by having done the highest number of PTMC and perimembranous VSD closure by device in the world, at a particular time! She is a bundle of energy and enthusiasm for innovations. So much so, when Dr Vijayalakshmi showed her the booklet with the diagram of Amplatzer device drawn by Kurt himself, she had jumped with joy!

## Bombay: Between 1970's and Early 1980s

The most significant contribution was of Late Dr Suman Kinare, Professor of Pathology, Seth

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GS Medical College and KEM Hospital, Bombay (now Mumbai). Dr Kinare established one of the finest departments of cardiac pathology, which has collection of rarest of rare congenital cardiac malformations. Almost at the same time, congenital cardiac surgery developed in private sector and Dr Nemish Shah at Bombay Hospital, pioneered successful surgery of common and cyanotic defects. Clinical cardiology, diagnostic pediatric catheterization developed at KEM hospital rapidly with Dr Susil Munsi, Honorary Professor. Dr DB Pahlajani introduced pediatric catheterization work at LTMMC and Sion Hospital.

## Mid 1980s to Late 1990s

This period saw lot of new developments. Pediatric diagnostic procedures and echocardiography developed rapidly at BYL Nair Hospital and TN Medical College, Bombay. BYL Nair took the lead in starting structural heart interventions along with Dr Satyavan Sharma as the team leader. First pulmonary balloon valvotomy was done by Dr Satyavan Sharma in 1986, followed by balloon dilatation of coarctation of aorta, congenital aortic stenosis (AS), discrete subaortic membrane, closure of PDA and ASD began at KEM and Bombay Hospital. Late 1990s saw emergence of dedicated pediatric cardiologists with Dr Bharat Dalvi being the first in Mumbai. Bharat's contributions in device closure of large ASD,[13] VSD, complex interventions and pediatric echocardiography are well known. Dr Prafulla Kerkar and KEM have enormous contributions including expertise in rupture of the sinus of Valsalva (RSOV) closure. Dr Nitu Mandke, Dr Suresh Joshi and Dr Patwardhan contributed a lot to maturing of pediatric surgery. Now this good work is continued by Dr Suresh Rao and Dr Shiva Prakash, dedicated pediatric cardiac surgeons in Mumbai. Dr IB Vijayalakshmi (1998) in Karnataka and Dr Bhavesh Takkar (2009) in Gujarat were the late entrants, but took interventions in pediatric cardiology to new heights by doing about 300–900 cases per year, respectively.

## Dr R Krishna Kumar

In 1998, the Amrita Institute of Medical Sciences (AIMS) was opened by her holiness "Amma" in Kochi, India. Dr Raman Krishna Kumar, MD now clinical professor and head of the AIMS department of pediatric cardiology, returned to India after completing his training in the US because there were only a handful of pediatric cardiologists practicing in India. Fifteen years later, AIMS vision is now a reality due to the dedication, tenacity, resourcefulness and collaborative spirit of Dr KK (popularly known) and his dedicated staff and leadership team. AIMS has established themselves as a world-class institution of medicine, academics and research, and has earned the distinguished honor of being named Children's HeartLink First Global Partner in Pediatric Care and Training. He has done pioneering work in coil closure of PDA, especially bioptome-assisted multiple coil closure in infants, small children and preterm infants.[14-16]

## Dr IB Vijayalakshmi

On November 14th 1998 for the first time in South India in government setup, pediatric cardiology department was started in Sri Jayadeva Institute of Cardiology. Dr IB Vijayalakshmi, first lady cardiologist of Karnataka, who headed the department was the first one to use Amplatzer septal occluder and Amplatzer duct occluder (ADO) on January 27th 1999 in South India. Thanks to Children's HeartLink, Minnesota, she was trained in four best centers in USA: (1) Fairview University Children's Hospital (Minneapolis), (2) St Mary's Hospital (Rochester), teaching hospital of Mayo Clinic Medical School and Children's Hospital Medical Centre (Boston, Massachusetts), (3) teaching hospital of Harvard University in 1998, and later was trained at (4) Children's Hospital at Chicago University in 2002 under Dr Ziyad Hijazi.

Thanks to the excellent training that she received she went on to do several interventions for the first time in the world. One such case was that of a 4-year-old child with noncompaction of left ventricle with the aorto-left ventricular tunnel (ALVT) closed with Amplatzer device in 2001. When the first ALVT was closed surgically by Evalon plug from aortic end by Dr Lillehei in Minnesota, then Dr Kurt Amplatz was part of that great team! So Kurt was excited about the ALVT being closed by his device. He donated

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**FIG. 2:** From left to right—Dr IB Vijayalakshmi with her source of inspiration Dr S Padmavati, Dr Kurt Amplatz, Dr Richard Vaan Praagh and Dr Fontan.



**FIG. 3:** Dr IB Vijayalakshmi is seen putting the red pin on Bengaluru to mark the centers using Amplatzer device. Dr Kurt Amplatz and his son-in-law watching the global map in the head office of AGA in 1998.

three devices to be tried for this case and wrote "Nobody can advise you, as no one has any experience, use your clinical acumen and all the best". True to his words the two sizes of VSDs were too big and compressing on the aortic valve, the third, 16 × 14 largest ADO was a bit small to block the aneurysmally dilated extracardiac portion of the tunnel, leading to hemolysis for 5 days. This case was presented at 37th Annual Scientific meeting and AGA Medical 4th International Symposium at Porto, Portugal, on 15th May, 2002 and published in pediatric cardiology journal.[17] In the same meeting, the first case of isolated dextrocardia with midmuscular VSD closed through the jugular approach with 16 mm Amplatzer device was presented by her.

When it was explained to Dr Kurt that the available Amplatzer devices require larger French sheaths to introduce and hence it was difficult to do the device closure in emaciated low-weight Indian children, he came out with innovative "modified Amplatzer device" in which only one layer of polyester material was stitched, instead of three layers! Thanks to this alteration, a large PDA in a 3.9 kg infant was closed with 10 × 8 ADO in 2002 and was presented in PICS-VI at Chicago,

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USA September, 2002 and initial experience in 10 infants was published in 2006.[18] This was done when nobody was doing device closure in children weighing less than 6 kg. When the angiogram of a PDA larger than aorta in a 4.5 kg infant was mailed to Dr Kurt, he came out with the custom-made angled PDA device which had no polyester material at all in it![19] These custom-made angled devices became the prototype for ADO II and ADO II additional size (AS) which were used in infants and newbornslater.[19,20] For the first time in the world, a case of sickle cell anemia with ASD was closed with device closure in 2005. This was presented in World Congress in Buenos Aires, Argentina. Thanks to the low profile and easy track ability of ADO II, first time in the world a case of left coronary cameral fistula to RV was closed with ADO II in 2011, which topped the top 20 publications in noncoronary section in 2013.[21] For the first time in the world, a case of aortico right ventricular tunnel (only the 17th case) was closed with ADO II in 2013.[22] For the first time in India the workshop of PDA closure with Nit-Occlud was done in 2002 with Dr Lee. For the first time ADO II was used to close Gerbode defects with no complete heart block.[23,24]

Dr IB Vijayalakshmi has written four text books for the cardiologists: (1) A monogram on "Acute Rheumatic Fever and Rheumatic Heart Disease"; (2) "Step by Step Echocardiography in Congenital Heart Disease"; (3) Chief Editor of a textbook "A Comprehensive Approach to Congenital Heart Disease" for which the book review has been written by Dr Crystal R Bonnichsen of Mayo Clinic and published in European Heart Journal. Dr Crystal writes—"As stated in the epilogue, the editors used the approach of "A Life-long Journey" to describe the management of CHD through the various stages, often called the "womb-to-tomb" approach. The editors undertook a formidable challenge by covering all aspects of CHD at all stages of life"; (4) Editor for "Cardiac Cathterization and Imaging (Pediatrics to Geriatics)". For the first time in the world, she has proposed and published "*Vijaya's Echo Criteria*" for diagnosis of carditis in ARF. In the recently revised Jones criteria, her two studies are cited and echo features are incorporated.[25] Her study has been quoted in latest editions of standard Pediatric Cardiology Textbooks like "Heart Diseases in Infants and Children" by Moss and Adams' and Park's Pediatric Cardiology for Practitioners.

*Dr Krishnam Raju* is a pioneer in Andhra Pradesh.

## Dr Nageswara Rao Koneti

Recently *Dr Nageswara Rao Koneti*, the leading pediatric cardiologist, has done the first fetal aortic valvotomy in India in October 2014. He is well-known for retrograde transcatheter closure of perimembranous VSD by over the guidewire technique and transvenous antegrade closure of muscular VSD in infants.[26]

## Dr Sivakumar

Dr Sivakumar was the first to do the Norwood stage I hybrid surgery in India. As hypoplastic left heart syndrome (HLHS) needs three-staged surgery involving a morbid first-stage, the morbidity is avoided by off pump bilateral PA banding, ductal stenting with large 8 mm stent and balloon atrial septostomy on 2nd or 3rd postnatal day. The first hybrid HLHS Norwood was done in Chennai at MIOT hospital in 2009 and the child is now studying in the first standard. Dr Sivakumar was also instrumental for the first attempt for percutaneous pulmonary valve implantation in 2010 in Chennai MIOT hospital. As the available Melody and Sapien valves could not be imported to India to cost constraints and lack of registration of the products. Hence, they decided to make their own transcatheter valve. They got a 22-mm Contegra bovine jugular vein conduit, shaved off the adventitia of the valve to make it thinner, and stitched it inside a Palmaz 5014 stent. It was then mounted on a 22 mm × 6 cm Cordis MAXI LD™ balloon and deployed in the right ventricular outflow tract (RVOT). On a 5 year follow-up, the young man passed his engineering and is now practicing in a software company.

## Dr Bhavesh Thakkar

Dr Bhavesh Thakkar, who started device closure in Gujarat in 2009 in UN Mehta Institute of Cardiology and research, is doing the highest

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number of device closure in ASD, VSD, PDA, RSOV and coronary AV fistula in India. He has done pioneering work in RVOT stenting and PDA stenting in India. Thanks to his dedicated and determined work, though started late, today he is leading in interventions in India, ably assisted by Dr Milan Chag, a well-trained pediatric echocardiographer.

## EVOLUTION OF PEDIATRIC ECHOCARDIOGRAPHY

From just three centers having M-mode echo in India (AIIMS-Delhi, CMC-Vellore and Perambur Railway Hospital) with no pediatric cardiologist, now we have Indian Academy of Echocardiography running certification course. Several centers doing pediatric echocardiography, transesophageal echocardiography and contrast echo. Echocardiographers are trained in doing the echo with inverted image, which is more like the real anatomy and this helps the cardiac surgeons. As more and more children are being taken up for surgery on echo diagnosis without catheterization and angiogram, it is very important that the precise diagnosis and details are given on echocardiography.

## JOURNEY OF CATHETER-BASED INTERVENTIONS

The various pediatric cardiac catheter interventions initiated in India are:

- Rashkind balloon septostomy in dextro-transposition of the great arteries (d-TGA) in early 70s—CMCH, Vellore
- Balloon pulmonary valvotomy in 1985 by Dr M Khalilullah at GB Pant Hospital, New Delhi
- Balloon aortoplasty of coarctation of the aorta (CoAo) 1985—Dr M Khalilullah, New Delhi.
- The first PTMC in "rheumatic mitral stenosis" was done in 1985 by legendary Dr Savitri Shrivastava
- Balloon aortic valvuloplasty 1986—Dr M Khalilullah, New Delhi
- Procedure of balloon dilatation of the atrial septum in transposition of great vessels by static balloon was introduced in 1988 by Dr Savitri Shrivastava and followed by Dr Ramesh Arora
- Dr Ramesh Arora started a nonsurgical (device) closure of PDA in 1988 by using Rashkind umbrella device for the first time in the country
- Device closure of PDA 1988—Dr R Arora, at GB Pant Hospital, New Delhi; and subsequently by using Amplatzer devices (1998)
- Nonsurgical transcatheter closure of ASD was first time attempted in the country by using various sizes of Sideris devices (1993), followed by STARFlex and CardioSEAL by Dr Ramesh Arora
- Dr Arora also did the first device closure of VSD, both perimembranous and muscular by using Rashkind umbrella device in 1995 and this was replaced by muscular Amplatzer VSD device in 1999
- Later for the first time in India, various Amplatzer devices were used to close ASD and PDA by Dr Ramesh Arora in North India and Dr IB Vijayalakshmi in South India in January 1999
- The valvular lesions, especially PTMC in children, was done in 1987 by using double Mansfield balloon technique and in 1990 with Inoue balloon by Dr S Srivatsav, Dr Satyvan Sharma and Dr Arora
- For the first time, transcatheter noncoronary interventional procedures council was established in 1999 in the country and Dr Ramesh Arora was awarded the national interventional council of CSI award for development of noncoronary interventional cardiology in India
- First human use of specially designed perimembranous VSD device was done in December 2000 by Dr R Arora
- Along with madam Arora, Dr IB Vijayalakshmi did the first PDA closure with specially designed angled device in neonates (2003). Incidentally, this was the first case in the world in whom 8.6 mm PDA larger than aorta (8.2 mm) was closed in a 4.5 kg infant[19]
- Between April 2003 and February 2004, 14 patients with large ASDs underwent transcatheter closure with balloon-assisted technique innovated by Dr Bharat Dalvi of Mumbai[13]

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- The first hybrid HLHS Norwood was done in Chennai at MIOT hospital in 2009
- Dr Nageswara Rao Koneti has done the first fetal aortic valvotomy in India in October 2014.

Various other rare cardiac lesions were attempted like coronary AV fistula, ruptured sinus of Valsalva pulmonary AV fistula, PA to LA fistula, etc. by Dr Ramesh Arora, Dr Vijay Trehan, Dr Praphul Kelkar, Dr Jayaranganath and Dr Kannan.

The development of pediatric cardiology in India was initially painfully very slow. Various reasons for this are: (1) Pediatric cardiologist used to be entirely dependent on the surgical team and unfortunately world-class surgical facilities were not available for decades in India; (2) Before the noninvasive two-dimensional (2D) real-time echocardiography with color Doppler, computed tomography (CT) angiography, and cardiac magnetic resonance imaging (MRI) became available, the diagnosis could only be confirmed by cardiac catheterization and angiography. But there were very few centers with catheterization laboratory and none with biplane camera. Since angiogram was the gold standard and the catheterization study was like a road map to surgeons, the surgeons were not ready to operate on patients without accurate diagnosis; (3) There were hardly any purely pediatric cardiology departments in hospitals, so adult cardiologists used to treat children who neither had will or skill to treat the children; (4) Pediatricians, who did MD in pediatrics, found it difficult to enter the cardiology training program, mainly oriented toward adult cardiac patients; (5) Since pediatric cardiology accounted for less than 20% of patients, the numbers of jobs available to a pediatrician trained as cardiologist were also limited.[1] The glamour attached to adult cardiology is still missing in pediatric cardiology.

## JOURNEY OF CARDIAC SURGERY

Indian cardiac surgery started by operating on adult ASD as some of the first few cases to be operated in any budding cardiac surgical program. There were no perfusionist, no interventional cardiologist, no transesophageal echocardiography machine and cardiac monitors were unreliable and not available. The concept of perfusion during open heart surgery was sketchy and some programs chose the pathologist or an anesthetist to become perfusionist, while others picked up the ward boys to turn the knob of the heart lung machine. The whole world would come to know that the heart surgery is going to happen because most of these hospitals borrowed a humongous diesel generator to be working as a standby power source in case of power failure when you are on cardiopulmonary bypass. Dr Devi Shetty of Narayan Hrudayalaya had the privilege of watching cardiac surgical programs blossoming in different parts of the country and he says a simple surgical ASD closure could take as long as 10 hours from early morning till evening! Of course postoperative management was not a problem because very few of them survived! One thing he witnessed as a young surgical aspirant was the dexterity, skill, innovative spirit and the passion of the pioneers of cardiac surgery in India. They were towering personalities and heroes in their day and they laid a very strong foundation for all budding and bubbling young pediatric cardiac surgeons like Dr KS Iyer, Dr Bhan, Dr Devi Shetty, Dr Rajesh Sharma, Dr Suresh Rao, and Dr Shiva Prakash and many more to follow.

Dr Devi Shetty exclaims it was a herculean task for him when disposables as simple as gloves were not freely available, since reusing of gloves was the norm. He was too scared to use swabs without radiopaque mark and in the end, landed up designing one! It was a big change, a change from Heathrow to Howrah, but it was a very fruitful journey and we have made a major progress, says Dr Shetty fondly. It used to take an hour to convince a patient to agree for an open heart operation. Today it takes less than 2 minutes to convince the patient for surgery. However, today if we tell a patient that he/she does not require an operation, you need to spend an hour to convince why operation is not required! Pendulum is now swinging in the extreme opposite direction exclaims Dr Shetty. For most of the pioneers, pediatric cardiac surgery was not a profession, but a passion! We have seen a compassionate but ill advice by a pediatrician damaging the hearts of thousands of children. A simple statement like "your child

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has a hole in the heart but do not worry it will get closed when he grows". This is what patient's mother wants to hear and this was the statement made by most of the pediatricians in earlier days. With this simple innocuous advice which turned to be most obnoxious for most of the VSDs, PDAs, aortopulmonary windows (APWs) potentially curable conditions became inoperable over a period of few months to few years. Transposition of great arteries, which needs surgery in the first few weeks of life became inoperable in a few months. I guess primarily because of more number of cardiologists—interventional and noninterventional—and technicians doing echocardiogram across the country, added to that cost of ultrasounds came down significantly making it affordable to small diagnostic labs. One thing good is that quality of echocardiography on children has improved significantly. Today, many centers in India are taking up cases for surgery without catheterization!

Dr Devi Shetty says that he used to watch his bosses instructing the anesthetist about how to anesthetize the patient and perfusionist about how to run the heart lung machine in the past. Today, cardiac anesthesia has grown so much as specialty in itself and the anesthesiologists have become so professional that younger generation of pediatric cardiologists have no clue how to anesthetize the patient or run a heart lung machine! It is amazing how so-called complex heart surgeries, conditions which were thought inoperable have become standard cardiac procedures today! It is heartening to see young pediatric cardiac surgeons in their 30s confidently performing complex pediatric cardiac surgeries in India. In the past there were hardly any takers for pediatric cardiac surgery; today, we have a waiting list of young surgeons to join pediatric cardiac surgical fellowship program. It is mainly because of the outstanding results of pediatric cardiac surgery by most cardiac surgeons of our country.

One of the greatest tributes for transforming pediatric cardiac surgery should be given to various state governments, which started low-cost health insurance schemes to sponsor surgical treatment on children. It started with Karnataka State Government's Yeshasvini micro-health insurance scheme which covers over 4 million farmers and their families followed by Vajpayee Arogyashree, School Health Program, not to forget ESI, Arogya Bhagya Scheme and several other Karnataka state sponsored schemes.

On the whole, India has now reached a stage of setting trend for the future of pediatric cardiac surgery. Since we produce 26 million babies a year, we obviously produce the largest number of children with heart disease in the world.

Today, thanks to excellent results (99% success rate) with device closure of ASDs, VSDs, PDA, APW, and also postsurgical residual shunts are being closed by transcatheter approach. Today great cardiac surgeons like Dr Stanley John and Dr KM Cherian who once said "I do not like lots of metal in the heart" have accepted the advantage of nonsurgical transcatheter interventions with no scar on the chest.

Dr Shetty says—"Journey as a pediatric cardiac surgeon for me is most fruitful, most enjoyable and rewarding. It is not uncommon for me to bump into a 6 feet 3 inch tall young man who will bend and touch my feet and say that I operated on him when he was 15 days old. I see his parents smiling with gratitude and sometimes his young wife with a healthy beautiful baby in hand. I do not think there is any other profession in this world as rewarding as a heart surgeon and especially the one dealing with children's heart". "If I have to come back to this world again, I would like to do exactly what I did in this life and enjoy operating on heart", says Dr Devi Shetty who has established 33 cardiac centers including one at great heights at Vaishno Devi to treat children with heart disease.

Almost all of us have similar experiences which are highly gratifying and satisfying. I had done aortic balloon valvuloplasty in a 14-hour-old neonate with hydrops fetalis caused by pinpoint AS. Today the little boy is so mischievous the mother cannot run behind him. In 1999 the first girl to get ASD closed with Amplatzer device is a practicing doctor now! When she scored 96.8% and got the medical seat wrote to me "God has devotees and great people have followers, I am following your footsteps".

For the first time in the country a national policy for CHD was proposed by me in 2004 and I concluded "Children are unique and special creation of God, worth far more than any

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earthly treasure! Hence they need special care, especially when they are born with disabling heart diseases. Heart care in children requires highly skilled dedicated pediatric cardiologists, with appropriate equipment and technology to save the precious lives. What is important is any treatment in adult does not increase the life span, whereas in children timely treatment can completely cure 65% of cases and they can lead a normal useful life". Since then, many centers started coaching fellows in pediatric cardiology. Now, Diplomate of National Board (DNB) itself has identified 11 centers training 22 fellows in pediatric cardiology and two centers in India offering DM in pediatric cardiology.

The work of pediatric cardiologist has changed very significantly in the last 15 years. Pediatric cardiology itself is getting divided into neonatal cardiology and pediatric cardiology subdivisions. Large departments of pediatric cardiology have specialists dealing exclusively with clinical work, diagnostic hemodynamic studies, interventionists, echo and Doppler experts, electrophysiologists, pathologists and more recently molecular cardiologists.

The introduction of therapeutic interventions has made pediatric cardiology more attractive. The pediatric cardiologist does not have to depend on surgical colleagues for relieving obstructions like pulmonic stenosis, aortic stenosis and CoAo. They candilate distally located peripheral pulmonic stenosis, which is not only difficult but at times impossible for a surgeon to reach. Atrial septal defect, patent ductus arteriosus, and some ventricular septal defects can be closed without operation. Coil embolization of collaterals, pulmonary and coronary AV fistulae and shunts is being done routinely at many centers in India. However, it should be clear that the physicians and surgeons looking after pediatric cardiac patients are complementing each other in the care and welfare of the sick babies and children and not competing with each other. The relationship between the cardiologists and the cardiac surgeon looking after pediatric cardiac patients is unique. In that, they are heavily dependent on each other in looking after the patients. It is this relationship, which is responsible for the growth of pediatric cardiology as a specialty. Hence, growth of pediatric cardiology is dependent heavily on the surgical expertise and help and vice versa.

Though pediatric cardiac surgical work is not as ego satisfying or rewarding financially as coronary bypass operation, it is more satisfying to see the smile on the face of children. Most of the pediatric cardiac surgical work needs to be subsidized by an active adult program and therein lies the tragedy.

## CONCLUSION

The history of pediatric cardiology in India is as intriguing as the discipline itself. The discipline today takes care of pediatric cardiac patients from newborn (intrauterine) to grown-up congenitals. The evolution of this subspeciality of cardiology is the result of years of perseverance, patience, and passionate dedication of several genius minds as pioneers. The journey of pediatric cardiology started virtually with only three centers having just M-mode echocardiograms in India. But the cardiac catheterization laboratory has clearly transformed from a diagnostic facility to a place for providing definitive treatment to nearly 65% of simple CHDs without scar on the chest. So fascinating is the history of interventional cardiology. Many surprises are bound to come as gifted minds toil night and day to make this world a better place with less suffering. Thanks to medical tourism, today India is the destination for pediatric cardiac surgery and interventions for many children from many other countries.

> *"One hundred years from now, it will not matter what kind of car I drove, what kind of house I lived in, how much was my bank account, nor what my clothes looked like. But the world may be a little better because I was important in the life of a child."*
>
> *—Anonymous*

Pediatric cardiology in India has experienced significant advancements over the past few decades, marked by improvements in diagnostic techniques, treatment modalities, and surgical interventions for congenital and acquired heart diseases in children. The

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inaugural pediatric cardiac surgery in India was conducted in 1949, with the first dedicated pediatric cardiac care center established in the 1960s. A substantial expansion occurred from the mid-1990s onward, leading to the establishment of numerous centers offering high-quality pediatric cardiac and surgical services. As of recent estimates, India hosts approximately 90 pediatric cardiac centers, a significant increase from the 14 centers reported in 2005. Kerala, with an estimated 450,000 annual births, has eight centers capable of performing neonatal cardiac surgeries. In contrast, Uttar Pradesh and Bihar, with annual births of 4.8 million and 2.7 million respectively, lack centers equipped for such procedures. *Sri Jayadeva Institute of Cardiovascular Sciences and Research (SJICR)*: Located in Bengaluru, SJICR is one of Asia's largest dedicated heart hospitals, with over 1,150 inpatient beds. It offers comprehensive pediatric cardiology services and has expanded to other cities, including Mysuru and Kalaburagi. In the early 90s, I facilitated the visit of Children's Heart Link, an NGO from Minneapolis, Minnesota, USA to leading heart specialty centers, Jayadeva Institute of Cardiology and Manipal Heart Foundation in Bengaluru. *Asian Heart Institute (AHI)*: Based in Mumbai, AHI was founded in 2002 and has treated over 450,000 patients. The institute is renowned for handling complex pediatric cardiac cases and offers free heart surgeries for underprivileged children with congenital heart diseases.

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