Key events in the history of cardiac surgery and paediatric cardiology*

Tom R. Karl,1,2 Gerard R. Martin,3 Jeffrey P. Jacobs,1,2 Gil Wernovsky4

1Division of Cardiovascular Surgery, Johns Hopkins All Children’s Heart Institute, Johns Hopkins All Children’s Hospital, Saint Petersburg, Florida; 2Departments of Surgery and Pediatrics, Johns Hopkins University, Baltimore, Maryland; 3Department of Cardiology, Children's National Health System, Washington, District of Columbia; 4Division of Critical Care Medicine, Children’s National Health System, Washington, District of Columbia, United States of America

Abstract In this report, the authors prepared an opinion poll regarding the most important people, events, technologies, concepts, discoveries, and therapies in paediatric cardiology and cardiac surgery. The results were presented in continuous slide show format at the 2017 Seventh World Congress of Pediatric Cardiology & Cardiac Surgery (WCPCCS 2017), Barcelona, Spain. The presentation (under international copyright) is made available herein for educational purposes.

Keywords: Pediatric cardiology; cardiac surgery; history

Received: 21 November 2017; Accepted: 5 December 2017

All we know is still infinitely less than all that remains unknown.

William Harvey (1578–1657)

The 2017 World Congress of Pediatric Cardiology and Cardiac Surgery (WCPCCS 2017) was held in Barcelona, Spain, from 16 to 21 July, 2017. In preparation for this congress, which itself promised to be a significant historic initiative, the authors, on invitation of the organising committee, took the initiative to nominate the most important events that have shaped our speciality. The history of paediatric cardiology is rich and fascinating. However, it is fair to say that our own era of complex diagnostic imaging, sophisticated intensive care, and neonatal open-heart surgery comprises a very small portion of the timeline (Fig 1). If one were to take the work of Galen (de Curandi, c. 162 AD) as time 12:01 AM in a single day and the WCPCCS 2017 as midnight, then cardiopulmonary bypass would not appear until 11:26 PM. The Raskind septostomy would appear around 11:26 PM, and the Norwood operation around 11:40 PM. This brings to mind the often quoted words of Isaac Newton, who said, paraphrasing Bernard de Chartres, that "If I have seen further, it is by standing on the shoulders of giants". This statement, to be sure, constitutes the essence of progress and discovery in any field. Yet, amidst the complexities and demands of our own careers, it is sometimes easy to overlook this fact. Our aim in undertaking this study was to document, present, and further preserve some of the key events and contributions that have brought us to the point of the 2017 World Congress. In doing so, we sought to recognise and honour the many great contributors of past and present eras, and to place our own careers in a realistic perspective. The results of the survey were tabulated and the authors prepared a presentation of the outcome in the format of a continuous "slide show", which was displayed in various venues of the Convention Center between scientific presentations of the WCPCCS 2017.

Method To assess the relative importance of the many contributions that have influenced our speciality, we
conducted an opinion poll among paediatric cardiologists, cardiac surgeons, and cardiac intensivists, all of whom were currently working in these capacities in various parts of the world. The methodology involved writing to a selection of eminent practitioners who were known to the authors and perhaps more likely to respond (“convenience sample”). The question posed was, by intent, somewhat free form. Respondents were asked to nominate as many events, people, technologies, concepts, discoveries, and so on as they desired. The unifying thread was that the choices would be considered outstanding or seminal in the history of paediatric cardiology and cardiac surgery. No time constraints were imposed, allowing nominations from any period, including the present. No justification for the choices was required, and the responses represent personal expert opinions, which, by design, were not necessarily evidence based.

Results

In all, 86 individuals were invited to offer an opinion. From this group, there were 48 respondents (56%) for whom a breakdown is given in Figure 1. There were 28 cardiologists and intensivists – 58% of respondents – and 20 surgeons – 42% of respondents – representing 16 countries in Australasia, North America, Africa, Europe, and the Middle East. The authors collated the responses and grouped them by the number of nominations for each category. Some of the responses could have been assigned to multiple categories, but were counted only once. Nominations were grouped according to the number of times each was submitted. Ultimately, the 50 highest scoring nominations were included in the WCPCCS presentation. They were grouped as follows, and presented in alphabetical order:

Group 1 included items receiving 24 or more votes, including the following:
- Arterial switch operation
- Blalock–Taussig shunt (Blalock, Taussig, and Thomas)
- Cardiopulmonary bypass
- Echocardiographic imaging (including foetal echocardiography)
- Fontan/Kreutzer procedure and subsequent modifications
- Dr William Norwood and the Norwood Procedure
- Rashkind atrial septostomy
- Prostaglandin

Group 2 included items receiving 15–21 votes, including the following:
- Dr Robert Anderson (nomenclature and anatomic concepts)
- Dr Philipp Bonhoeffer and transcatheter pulmonary valve replacement (over all other interventional catheter procedures)
- Cardiac critical care as a discipline
- Computer technology
- Databases (STS, PHYS, PC4, IMPACT)
- Digitisation of cardiac images
- Electronic health records
- Foetal echocardiography
- Interventional catheterisation, including atrial septal defect closure, persistent ductus arteriosus closure, balloon valvotomy, all types of balloon dilations, and all types of stents
- Mustard and Senning procedures
- Persistent ductus arteriosus ligation
- Dr Richard and Dr Stella Van Praagh (nomenclature and anatomic concepts)

Group 3 included items receiving 10–14 votes, including the following:
- Ablation of accessory pathways
- Cardiac catheterisation for haemodynamics and angiography
- Cardiac MRI and CT
- Cardiac transplantation
- Coarctation repair (Dr Clarence Crafoord)
- Cross-circulation for support in cardiac surgery
- Dr Aldo Castaneda
- Dr C. Walton Lillehei’s multiple contributions
- Extracorporeal membrane oxygenation
- Implantable cardiac pacemakers and defibrillators
- Genetics and genomics and the secondary heart field
- Nitric oxide
- Surgery for the neonate (early correction of CHD)
- Ventricular assist devices, especially Berlin Heart

Group 4 included items receiving five to nine votes, including the following:
- Adult CHD as a discipline
- Dr Kurt Amplatz
- Dr Leonard Bailey
- Cardioplegia
- Channelopathies
- Deep hypothermic circulatory arrest
- Dr Marc de Leval
- Electrocardiography
- Dr Paul Gillette
- Heparin
- Implementation of clinical trials in CHD (various)
- Dr James Lock
- Mechanical and biological prosthetic heart valves
- Dr Alexander Nadas
- “Natural History Study” of CHD
- Neurodevelopmental outcome analysis
- Paediatric cardiac nursing as a discipline
- Pulmonary hypertension management
• Dr Giancarlo Rastelli (the Rastelli operation and right ventricle to pulmonary artery conduits)
• Sir Donald Ross and the pulmonary autograft procedure
• Sir William Harvey
• Stem cells in heart disease
• Transoesophageal echocardiography

An additional 215 items received at least one vote. The categories of nomination, speaking broadly, can be grouped as follows: individuals (9), operations (8), specific types of interventional cardiologic procedures (7), medications (4), technology (7), imaging (6), organisation of care (4), nomenclature (1), support systems for surgery (4), concepts (3), basic science (4), and clinical outcome research (2).

Finally, during the 2017 WCPCCS, the organisers – including Jeffrey P. Jacobs, Gil Wernovsky, Mitchell Cohen, and David Cooper – of the 2021 WCPCCS to be held from September 19 to 24, 2021, in Washington, DC, United States of America (www.WCPCCS2021.org), presented a timeline of important events in the history of congenital and paediatric cardiac care, which can be found as Figure 1. A color version of the timeline is available at WCPCCS2021.org

Discussion
Many of the attendees of the Congress have expressed an interest in obtaining a copy of the presentation, so the authors, in conjunction with Cardiology in the Young, have decided to make the entire work available (Fig 2). The presentation is protected by international copyright but can be freely used for academic and educational purposes. Permission to reproduce any of the material in the presentation can be requested from the authors. The slide show is reproduced here in the exact format presented at the WCPCCS in Barcelona.

Conclusion
There appears to be considerable interest in our heritage, as evidenced by the number of recent requests for this presentation, as well as the interest expressed during the WCPCCS for both access to the presentation and copies of the timeline. The task of ordering events by their importance is clearly subjective and probably impossible to complete in a simple survey of this type. We clearly recognise the importance of many other people, technologies, procedures, disciplines, and much more. These contributions constitute the “shoulders of giants” on which we currently stand. Nonetheless, it is particularly interesting to note the diversity of responses from what could be considered a rather homogeneous group of paediatric cardiac practitioners. The authors hope, however, that the responses will be thought provoking, and a tribute to those who have contributed in ways that we will continue to recognise and honour.
Timeline created for the 2021 WCPCCS exhibit in Barcelona

1600s
De Motu Cordis (Harvey)
Rheumatic fever described (Sydenham)

1800s
Stethoscope (Laennec)
Anesthesia
Measured cardiac output (Fick)
Tetralogy described (Fallot)
Transposition described (Baille)
The Principals & Practices of Medicine (Osler)
X-Ray imaging discovered (Roentgen)
Cardiac surgery for stab wounds
Discovery of protamine
Artificial ventilation described
First children’s hospital (Hôpital des Enfants Malades, Paris))

1900s – 1950s
Electrocardiography (Einthoven)
Atlas of Congenital Heart Disease (Abbott)
Discovery of heparin
Endotracheal intubation and mechanical ventilation
Cardiac catheterization
Persistent ductus arteriosus ligation
Isolation of digoxin from foxglove
Mechanisms of pulmonary hypertension described
Hypoplastic left heart syndrome described
Preventative cardiology
Wolff-Parkinson-White arrhythmia
Coarctation repair (Crafoord)
Blalock-Taussig shunt (Blalock, Taussig, Thomas)
Battery operated Pacemaker (Bakken)
AC defibrillation (Zoll)
First implantable pacemaker (Senning)
Atrial septectomy (Blalock and Hanlon)
Waterston shunt
Potts Shunt
Pulmonary valvotomy (Brock)
Pulmonary arterial band
Cross-circulation (Lillehei)
Open heart surgery with cardiopulmonary bypass (Dennis and others)
Senning operation
Glenn shunt
Pulse oximetry
Clinical use of coumadin (warfarin)
Sudden cardiac death described
Penicillin for rheumatic fever

Figure 1.
Timeline of Pediatric and Congenital Cardiac Care, prepared by the organisers – including Jeffrey P. Jacobs, MD, Gil Wernovsky, Mitchell Cohen, and David Cooper – of the 2021 WCPCCS to be held from 19 to 24 September, 2021, in Washington, DC, United States of America (www.WCPCCS2021.org).
1960s
Transvenous pacemakers
Dedicated cardiac ICU (adult)
Cardiopulmonary resuscitation described
Description of fetal circulation
Mustard operation
Morphologic descriptions of congenital heart disease
Natural History Study 1
Long QT syndrome described
Rashkind procedure
Transcatheter closure of ductus arteriosus (Portmann)
Kawasaki disease described
Fontan and Kreutzer right heart bypass
Di George syndrome described
Rastelli operation
Amiodarone introduced
Closed mitral commissurotomy
Ventricular assist device (DeBakey)
Pulmonary autograft aortic valve replacement (Ross)
Lung transplantation
Surgical ablation of WPW
Transvenous defibrillation
Heart transplantation

1970s
Polytetrafluoroethylene (Gore-tex) for clinical use
Transesophageal echocardiography
Prostaglandin E1
Transcatheter ASD closure (King)
Extracorporeal membrane oxygenation
Arterial switch for TGA/VSD (Jatene)
High frequency oscillatory ventilation
Adult congenital heart disease/Grown up congenital heart disease specialty
Percutaneous coronary intervention
Electrophysiologic mapping
Expansion of clinical applications of genetics/genomics
Total parenteral nutrition
Gamma globulin for Kawasaki disease
Cyclosporine introduced
Pediatric intensive care
Transesophageal echocardiography
Norwood Procedure
Neonatal arterial switch operation

1980s
Ablation for arrhythmia in adults
Implantable cardiac defibrillator (trans-thoracic and trans-venous)
Heart lung transplantation
Natural History Study 2
Transcatheter pulmonary valvotomy (Kan)
Xenotransplantation (Bailey)
Pediatric cardiac intensive care
Pulmonary artery angioplasty
Balloon expandable vascular stents
Recognition and study of developmental disabilities in cardiac patients

(continued)
Boston Circulatory Arrest Trial
Nitric oxide
Total cavopulmonary connection (de Leval)
Indomethacin for ductal closure
Society of Thoracic Surgeons Database
Fetal cardiac intervention
Extracardiac Fontan (Marcelletti et al)
Focalization of pulmonary arteries in infants
World Congresses: London, New York, Bergamo, Bangkok

1990s
Ablation for arrhythmia in children
Primacorp trial (milrinone)
Amplatzer atrial septal defect closure
ABO incompatible heart transplantation
Cardiac MRI evolves
Expansion of databases and registries
Palivizumab trial
Adenosine for supraventricular tachycardia
Radiofrequency ablation for arrhythmia treatment
Berlin Heart VAD development
Electronic medical records
Telemedicine
Tissue engineering for cardiac implants
World Congresses: Paris, Honolulu

2000s
Fetal cardiac catheter intervention
Transcatheter pulmonary valve replacement (Bonhoeffer)
Hybrid surgical strategy for hypoplastic left heart syndrome
IMPACT Registry
Single Ventricle Reconstruction trial
Transcatheter aortic valve implantation
Carvedilol Trial
Home inter-stage monitoring following palliation for HLHS
Robotic Surgery
Channelopathies and sudden cardiac death
Public reporting of surgical outcomes
World Congresses: Buenos Aires, Cairns

2010s
Pediatric Critical Care Consortium
3D printing for congenital heart imaging
Stem cell trials in heart disease
MAP-IT Registry
National Pediatric Cardiology Quality Improvement Collaborative
Fetal Cardiac Intervention Registry
Genetic link of CHD and neurodevelopment (Pediatric Heart Network)
World Congresses: Cape Town, Barcelona

2020s
8th World Congress of Pediatric Cardiology and Cardiac Surgery.
To be held September 19-24, 2021, Washington D.C.
Figure 2.
Slide show presentation displayed at the 2017 Seventh World Congress of Pediatric Cardiology & Cardiac Surgery (WCPCCS 2017), Barcelona, Spain.
Norwood WI, Kirklin JK, Sanders SP.

This is a report of a new palliative procedure for HLHS that has resulted in early ongoing survival of two infants with aortic atresia. On the basis of experience with a third patient, an operation for future physiologic correction is proposed.
Evolution and Specialization of Cardiac Nursing and Pediatric Cardiac Intensive Care

Developed synergistically with technology and neonatal surgery for complex congenital cardiac disease
First physically and administratively separate unit in Boston in late 1970’s
Originally staffed by cardiologists and catheterization specialists
Pediatric Cardiac Intensive Care Society developed in 1990’s
Currently one of many different models of care

(continued)
Detailed Morphology of Congenital Cardiac Disease

Dr. Adib Jatene (1929-2014)
São Paulo, Brasil

Arterial Switch Operation 1975

Nitric Oxide

Selective Pulmonary Vasodilator
Eliminated need for Hyperventilation After CHD Surgery
Drug Testing During Cardiac Catheterization
LMolecule of the Year” - 1992
Nobel Prize in Medicine & Physiology - 1998

Use of Inhaled Nitric Oxide and Acetylcholine in the Evaluation of Pulmonary Hypertension and Endothelial Function After Cardiopulmonary Bypass

David L. Weiss, MD; Ira Adatia, MD; Therese M. Giglia, MD;
John E. Thompson, BRT; Thomas J. Kilic, MD

Circulation 1993

Inhaled nitric oxide as a therapy for pulmonary hypertension after operations for congenital heart defects

Oscar Torrecillas, MD; Mlaber Powell, MD; Phidias Antoniou, MD; Yvonne Ruffles, MD;
Pascal Vuill, MD and Denis Scher, MD, Paris

J Thorac Cardiovasc Surg 1993

Very-low-dose inhaled nitric oxide: A selective pulmonary vasodilator after operations for congenital heart disease

JTCVS 1994

William J. Rashkind

Reported 1st Balloon Atrial Septostomy in a neonate (“Bobby”) in Life Magazine
(and then in JAMA 1 month later)

“Father of Interventional Cardiology”
William Harvey and the Discovery of the Circulation

- Medical Degree - University of Padua 1602
- “Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus” (de Motu Cordis) published in Latin in 1628

“In truth, when, from a variety of investigations through dissection of the living ... from the symmetry and magnitude of the ventricles of the heart and of the vessels entering and leaving ... I began privately to think that it might rather have a certain movement, as it were, in a circle...”

Paul C. Gillette 1943-2013

- Pediatric Residency and Cardiology Fellowship at Texas Children’s Hospital and Baylor College of Medicine
- American Academy of Pediatrics
  - 1975 - Young Investigator Award
  - 1982-83- Chair of Section on Cardiology
  - 2009 Founder’s Award
- 1998 - Pioneer in Pacing and Electrophysiology Award from the Heart Rhythm Society
- 2013 - Lifetime Achievement Award from The Pediatric and Congenital Electrophysiology Society
- Over 300 Peer-Reviewed publications
- Huge NASCAR fan, member of the Eagle Club at Texas Motor Speedway

(continued)
James E. Lock

- Medical School at Stanford University
- Pediatric Residency and Cardiology Fellowship at University of Minnesota
- Fellowship in Cardiovascular Physiology - University of Toronto, Hospital for Sick Children
- Pioneering Interventional Cardiologist who has trained numerous academic physicians in cardiopulmonary physiology, interventional cardiology, many of whom are now Division Chiefs, and Cath Lab and ICU Directors
- 1st Textbook on Pediatric Interventional Catheterization
- 1999 - Designed first ASD occlusion device approved by USA Food and Drug Administration
- 2000-2009 Director of NMT Medical
- Long time Chairman of the Department of Cardiology, Alexander S. Nadas Professor of Pediatric Cardiology and Physician-In-Chief at Boston Children’s Hospital
- Over 300 Peer-reviewed manuscripts

Alexander S. Nadas 1913-2000

- Born in Budapest, Hungary
- Graduated Medical School Semmelweis University
- Second Medical Degree from Wayne State, Detroit, USA
- Dismissed from Catholic Hospital for Advising Contraception
- Arrived Boston Children’s Hospital at Invitation of Charles Janeway

Initial Work:
- Cardiac Manifestations of Cystic Fibrosis
- ECG findings in Congenital Heart Disease

First textbook in Pediatric Cardiology

Began Training Program in Pediatric Cardiology in 1950s and long-term professional relationship with Dr. Donald Fyler

- Charter Member of American Academy of Pediatrics Section of Pediatric Cardiology
- American Heart Association established the Alexander S. Nadas Lectureship in 1986
- Born with Bicuspid Aortic Valve, had two bouts of Endocarditis, and died of Congestive Heart Failure
- Over 230 Peer-reviewed publications between 1951 and 1990

(continued)
Randomized Clinical Trials Begin in Pediatric Cardiac Disease

- **40-60%** of Children With **Complex CHD** Have Some Disability In:
  - Motor Function, Attention, Learning, Executive Function
  - Anxiety, Depression
  - Frequency Decreased with Less Severe Disease
- Multifactorial
- Few Preventative Treatments Available As Yet
- Guidelines Recently Developed
### Diagnosis and Management of Pediatric Pulmonary Hypertension

**AHA/ATS Guideline**

Pediatric Pulmonary Hypertension: Guideline From the American Heart Association and American Thoracic Society

**2015 ESCERS Guidelines for the diagnosis and treatment of pulmonary hypertension**

The Joint Task Force for the Diagnosis and Treatment of Pulmonary Hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS)

---

**Vasodilator Therapy for Primary Pulmonary Hypertension in Children**

Bohui J. Benj, MD, Greg Maida, MS, MA, Allard P. Fishman, MD

---

**7th World Congress of Pediatric Cardiology and Cardiac Surgery**

16-21 July, 2017 • BARCELONA

---

**Aldo Castañeda**

- University of Guatemala Medical School
- Surgical and cardiothoracic residencies at the University of Minnesota (which at the time [1950s] was performing the world’s first open heart surgeries)
- 1972: Recruited to Boston Children’s Hospital in 1972
- Chief of Cardiovascular surgery and Surgeon-in-Chief at Boston Children’s Hospital for 24 years
- Pioneer of neonatal cardiac surgery
- 1983: Helped pioneer the arterial switch operation for transposition of the great arteries
- Trained a generation of pediatric cardiac surgeons

(continued)
### Cross Circulation

March 26, 1954. L. Walton Lillehei and his associates — Morley Cohen, Herb Warden, and Richard Varco — used controlled cross-circulation to correct a ventricular septal defect in an 11-year-old boy. The boy’s anesthetized father served as the oxygenator.

### Ventricular Assist Devices (VAD)

**Berlin Heart**
- 1996: The EXCOR Stationary Driving Unit iksus received CE approval.
- 1999: The EXCOR mobile driving unit received CE approval.
- 2002: The first child in the USA is supported by EXCOR Pediatric.
- 2003: INCOR received CE approval after successfully completing the Multi-Center Study.
- 2008: The INCOR patient Jean-Pierre Doffe celebrated his five-year anniversary while on the system and therefore setting an INCOR world record.
- 2008: EXCOR Pediatric received unrestricted IDE Approval in the USA.
- 2009: The 500th patient received INCOR VAD at the German Heart Institute.
- 2011: EXCOR Pediatric received FDA approval for the U.S. market. The number of children who had been on EXCOR Pediatric reached over 1,000.
- 2012: The longest support time of a toddler on EXCOR Pediatric reached 2.5 years.
- 2013: The EXCOR Pediatric 15 ml blood pump received CE approval.
- 2014: The 1,500th pediatric patient was supported by EXCOR Pediatric.

### HeartMate
- **Left ventricular assist device** (Patients can be fully mobile):
  - Battery
  - A cable connects the control unit and internal LVAD through an incision in the abdomen.
  - Control unit
- **LVAD** (pumps blood into the aorta in the body):
  - Blood from the left ventricle enters the LVAD.
  - LVAD Cable connecting to control unit.
  - Heart is shown in cross-section.

(continued)
ExtraCorporeal Membrane Oxygenation (ECMO)

- Developed during the 1960s and 1970s
- Robert Bartlett, MD (a surgeon at the University of Michigan) and his colleagues pioneered the clinical use of ECMO in newborns with respiratory failure
- Bartlett reported the first neonatal survivor of ECMO, referred to as Baby Esperanza, in 1976. Baby Esperanza suffered lung damage from meconium aspiration syndrome. ECMO was applied as a last-ditch effort to save her life. The baby spent three days on Bartlett’s machine and survived.

Deep Hypothermic Circulatory Arrest

Deep hypothermic circulatory arrest is a surgical technique that involves cooling the body to temperatures below 20°C (68°F), stopping the circulation and greatly reducing brain metabolism.
Heparin was first discovered by Jay McLean and William Henry Howell. McLean was a second-year medical student at Johns Hopkins University who was assisting Howell in the investigation of pro-coagulant preparations. McLean isolated a fat-soluble anticoagulant in canine liver tissue in 1916.

**Cardioplegia**

*The Lancet* [July 2, 1955]

**Conclusions**

Cardiac arrest in diastole inevitably results from an injection of potassium citrate into the root of the aorta so that the bulk of it enters the coronary arteries.

D. G. Melrose  
M.A., B.M. Oxf

B. Dreyer  
M.D. Cape Town, F.R.C.S.

H. H. Rentall  
M.B. Lond., F.R.C.S.

J. B. E. Baker  
M.A., B.Sc., B.M. Oxf

(continued)
Computing, Digitization of Data, & The Internet

Big Data – Advanced Statistical Analyses – Database Linkage
Transfer of Images and Data Sets to Remote Locations
Rapid Dissemination and Availability of Information
Collaboration of Best Practices Across Centers
Development of Telemedicine

Aprostadiel (PGE1)
Naturally occurring prostaglandin approved by the
Food and Drug Administration (FDA) in 1981

Dilatation of the Ductus Arteriosus
by Prostaglandin E1, in Aortic Arch Abnormalities

Michael A. Hayman, M.D., William Berman, Jr., M.D.,
Abram M. Rudolph, M.D., and Victor Winstead, M.D.
Transesophageal Echocardiography

- Rapid transition from early experiences in children in 1989

**Efficacy of intraoperative transesophageal echocardiography in children with congenital heart disease.**

Cyan SE*, Kimball TB, Meyer RA, Bailey WW, Lowe E, Baustian WP, Kaplan S.

**AMERICAN SOCIETY OF ECHOCARDIOGRAPHY REPORT**

Indications and Guidelines for Performance of Transesophageal Echocardiography in the Patient with Pediatric Acquired or Congenital Heart Disease

A Report of the Task Force of the Pediatric Council of the American Society of Echocardiography


- To guidelines in 2005

OR and Catheterization Lab

- Improving diagnosis
- Guide and evaluate interventions

First aortic coarctation repair

19th October, 1944, Stockholm

(11 y.o. boy, XCI = 2 hr)

Crafoord end-end anastomosis

(continued)
PDA Ligation

Dr. Robert E. Gross in 1938
Boston Children’s Hospital
Lorraine Sweeney 7 year old

Echocardiography

M-mode echocardiography
2 Dimensional echocardiography
Doppler echocardiography
Fetal Echocardiography
Color Flow Imaging
Transesophageal Imaging
3 Dimensional Echocardiography

(continued)
Transcatheter PVR
Dr. Phillip Bonhoeffer, 2000

Balloon Pulmonary Valvuloplasty
Kan, NEJM 1982
Lababidi, Am J Cardiol 1983

Percutaneous transluminal balloon valvuloplasty for pulmonary valve stenosis

Jean S. Kan, M.D., Robert I. White, Jr., M.D., Sally E. Mitchell, M.D., James H. Anderson, Ph.D., and Timothy J. Gardner, M.D.

ABSTRACT Transluminal balloon valvuloplasty was used to treat congenital pulmonary valve stenosis in 20 patients. Follow-up catheterization was performed in 11 patients at intervals of from 2 to 12 months after the procedure. Peak systolic pressure gradient across the pulmonic valve decreased from 68 ± 27 to 25 ± 5 mm Hg (p < .001) after valvuloplasty. There were no complications. Follow-up catheterization demonstrated persistent relief of right ventricular hypertension in the patients with typical pulmonary valve stenosis.

Device Closure of ASD
King & Mills procedure in dogs, Surgery 1972
King-Mills Umbrella, in 17 year old girl, JAMA 1975
Rashkind Single Umbrella Device, Circulation 1983
Double Disc Approach: Lock, Mullins, Hellenbrand, 1989

Device Closure of PDA
First report by Portsman 1967
Rashkind Double Disc 1979
Hellenbrand 2004 (Multi-center Trial)
**Outcome Registries for CHD**

**NICOR**

**CHSS**

**European Association for Cardio-Thoracic Surgery**

**IMPACT Registry**

**National Pediatric Cardiology Quality Improvement Collaborative**

---

**Fetal Echocardiography**

First articles......1969

  - The fetal echo-cardiogram
  - Kratochwil A, Sasai D.
- **Invest Radiol. 1972 May-Jun;7(3):152-8.**
  - Echocardiography of the fetal and newborn heart.
  - Winsberg F.
  - Ultrasonic identification and examination of fetal heart structures.
  - Egeblad H, Bang I, Northeved A.

**Major Early Investigators**

- Charles Kleinman
- Liv Hatle
- David Sahn
- Norman Silverman

(continued)
Cardiac Catheterization
Werner Forssman 1904-1979
First Right Heart Catheterization 1929
Shared Nobel Prize in 1956 with Courand/Richards

Electrocardiography
Willem Einthoven (1860-1927)
MD from University of Utrecht
String galvanometer to record ECG
ECG without direct leads on heart 1903
Described P,Q,R,S,T waves
Nobel Prize in 1924

(continued)
Adult Congenital/Grown-up Heart Disease (ACHD/GUCH)

Original Founders
Joe Perloff (UCLA)
Jane Somerville (Brompton)
Paul Wood (Brompton)

SPECIAL ARTICLE
Pediatric Congenital Cardiac becomes a Postoperative Adult
The Changing Population of Congenital Heart Disease
By Joanna E. Pencina, M.D. Circulation 1973

Near misses and disasters in the treatment of grown-up congenital heart patients
Jane Somerville MD FRCP J R Soc Med 1997

ORIGINAL RESEARCH ARTICLE
Circulation 2016
Congenital Heart Defects in the United States
Estimating the Magnitude of the Affected Population in 2010
Susanne M. Gibbons, Owen J. Devine, James E. Rock, Matthew E. Oster
Tiffany Riehl-Conn, Wendy N. Nemeth, Ping Xu, Adolfo Corea
Kathy J. Kinsey, Arlene J. Mandell

Living in USA with CHD: 1.4M Adults, 1M Children

Cardiac MRI/CT
CT studies began in 1971
MRI studies began in 1977

Complex CHD MRI Reconstructions
Fetal MRI

CT anomalous RCA

(continued)
Radiofrequency Ablation

- Intra-cardiac catheters record electrical activity 1940-50
- Recording His ECG/programmed electrical stimulation (PES) 1960
- Dual pathways in WPW documented in 1967
- Initiation/Termination of atrial rhythms (PES) 1960-70
- Arrhythmia Surgery for WPW 1968 Cobb
- High energy shocks ablate pathways Scheinman/Gallagher 1980-81
- Radiofrequency current Budde 1987

Past

Present

Giancarlo Rastelli
1933-1970 (Parma, Italy and Rochester, USA)


(continued)
Donald N. Ross
GUY'S HOSPITAL AND NATIONAL HEART HOSPITAL, LONDON

REPLACEMENT OF AORTIC AND MITRAL VALVES WITH A PULMONARY AUTOGRRAFT

The finding of late degenerative changes in a proportion of aortic homografts prompted the use of the patient's own pulmonary valve as a replacement. As a living autograft, the transplanted pulmonary valve has the prospect of long-term or permanent survival, whilst retaining the advantages of an aortic homograft. Similarly it can be used to replace the mitral valve. The excised pulmonary valve is replaced with a homograft.

Ross Operation 1967

Sir Donald Ross
1922-2014 (London)

7th WORLD CONGRESS OF PEDIATRIC CARDIOLOGY & CARDIAC SURGERY
16-21 JULY, 2017 • BARCELONA

“There are limits to our knowledge, but no limits to our ignorance.”

VSD closure technique in ccTGA
Fontan technical modifications (TCP)
Computational fluid dynamics of Fontan circuit
Role of the lymphatic system in Fontan physiology
Analysis of human error in cardiac surgery
Extraordinary mentor and humanist

Dr. Marc R. de Leval
London, UK

Marc R. de Leval Fellowship

(continued)
Dr. Leonard Bailey
Loma Linda, USA

Neonatal cardiac xenotransplant
26th October 1984

Dr. Guillermo Kreutzer
Buenos Aires

Dr. Francis Fontan
Bordeaux


Fontan-Kreutzer operation
Right heart bypass for tricuspid atresia

(continued)
Blalock-Taussig-Thomas Operation

Johns Hopkins Hospital, Baltimore

A gender and racially integrated team employs a complex novel procedure to palliate a desperately unwell child.

Eileen Saxon Nov 29, 1944

1924-

Kurt Amplatz

Born in Austria; emigrated to US 1953
40 year Career at University of Minnesota
1983 Malcolm P. Hansen Professor of Radiology
Co-founded AGA Medical Corporation
Frequently described as “a simple country doctor”
Designed and created multiple devices widely used in interventional procedures

Dr. Helen Taussig
1898-1986

Dr. Alfred Blalock
1899-1964

Mr. Vivian Thomas
1910-1985

(continued)
Cross circulation 1954-1955

University of Minnesota

Dr. C. Walton Lillehei
(1918-1999)

45 patients with major cardiac malformations underwent open repair utilizing cross-circulation (VSD, TOF, AVSD)

Twenty-seven patients (＞50% infants), had VSD closure

Eight hospital deaths, 2 late deaths @ 30 year f/u, with seventeen 30 year survivors in NYHA Class I

At least 820 cardiothoracic surgeons in 36 countries can trace their surgical lineage to Lillehei

Dr. Christiaan N. Barnard
1922 - 2001

First Human Heart Transplant
3rd December 1967
Capetown, South Africa

Ms. Denise Darvall
LIFE
GIFT OF A HUMAN HEART
A dying man lives with a dead gift beat!

Mr. Louis Washkansky

(continued)
Neonatal Surgery/Early Correction