New Directions in Interventional Pediatric Cardiology

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Historical Perspective

- **1844 – Claude Bernard**
  - Inserted a mercury thermometer into the carotid artery of a horse to measure temperature

- **1929 - Werner Forssmann**
  - Inserted a urological catheter into his own forearm and under fluoroscopic guidance guided it to the right atrium
    - Won the Nobel Prize in 1956

- **1953 – Sven-Ivar Seldinger**
  - Developed the percutaneous technique of vascular access

- **1966 – William Rashkind**
  - Developed the equipment and technique for balloon atrial septostomy in the treatment of Transposition of the Great Arteries
Historical Perspective

• 1974 – Grüntzig and Hopff
  – Dilated peripheral vessels with a non-compliant “static” balloon

• 1974 – King and Mills
  – First percutaneous ASD device closure

• 1982 – Jean Kan
  – Described balloon valvuloplasty in the treatment of congenital pulmonary valve stenosis

• 2002 – Philipp Bonhoeffer
  – Designed and implemented a pulmonary valve stent

Advances in Pediatric Cardiac Catheterization

• Diagnostic Era: 1950 – 1970
  – Angiography was the primary diagnostic modality in congenital heart disease.
  – Supplanted by echocardiography in the 1980’s

• Early Interventional Era: 1970 – 1990
  – Balloon valvuloplasty for congenital pulmonary and aortic valve stenosis
  – Balloon angioplasty for coarctation of the aorta
  – Device closure of PDA and ASD
Advances in Pediatric Cardiac Catheterization

- **Current Era: 1990 – present**
  - **Vascular Access**
    - Improvements in equipment
      - 21 ga needles and small flexible wires
      - Small sheaths
    - Novel approaches to access
      - Carotid cut-down for aortic interventions in small neonates
      - Trans-umbilical venous access for balloon atrial septostomy

- **Technological advances**
  - Miniaturization of angioplasty balloons to fit through 3 or 4 fr sheaths
Advances in Pediatric Cardiac Catheterization

• Current Era: 1990 – present
  – Technological advances
    • Miniaturization of stents and stent delivery systems

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• Current Era: 1990 – present
  – Technological advances
    • Smaller, softer and more maneuverable catheters
      – Improve vascular accessibility
      – Reduce vascular damage

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Advances in Pediatric Cardiac Catheterization

• Current Era: 1990 - Present
• Advances in Interventional devices
  – Septal closure devices
    • ASD and VSD
  – Vascular closure devices
    • Coils and plugs
  – Percutaneous valve
    • Pulmonary
    • Aortic

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• Current Era: 1990 – present
  – New techniques for vascular perforation
    – RF wire
    – Excimer laser

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• **Procedural sedation**
  – Pediatric cardiac anesthesiology
    • Knowledge of congenital cardiac anatomy
    • Knowledge of the interaction between anesthetic agents and a given patient's cardiac physiology
  – General anesthesia
    • Improves hemodynamic stability
    • Improves patient compliance
    • Allows the Interventional cardiologist to concentrate on the task at hand

Patient M.A.

• 4 year old female from Kuwait
• History of severe CHF in infancy
• Failure to thrive - 13 kg (4 % ile)
• Normal PA pressures
• Qp:Qs = 2:1
• Normal PVR
Patient M.A.

Percutaneous Technique

- Catheter is advanced retrograde into the LV
- Wire is used to cross VSD and advanced to main PA
- A snare catheter is advanced from IVC to the MPA
- LV wire is snared in the MPA and pulled down to the IVC

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Percutaneous Technique

- The snared wire is brought into the IVC
- Wire is externalized through venous sheath to create an arterio-venous wire loop
- Delivery sheath is advanced from the venous side, across the VSD into the LV
- Wire is removed

Percutaneous Technique

- Device is advanced through the delivery sheath to the LV.
- LV disk is deployed in the body of the LV and brought against the septum
- RV disk is deployed
- Device is released

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Patient M.A.

Patient M.A.
Patient M.A.
Patient M.A.

- Flouro time 19 min
- No residual VSD shunting
- Patient discharged after 23 hour observation
- No complications
**Case #2**

- Patient J.M.
- Born at 30 wks and 1.4 kg
- On day 6 developed significant tachypnea
- Echocardiogram showed critical aortic stenosis with severely decreased LV function
- Patient was transferred to CNMC for balloon aortic valvuloplasty
Patient J.M.

- Hemodynamics
  - Initial peak systolic gradient = 50mmHg
  - Post valvuloplasty gradient = 26mmHg
- Two additional valvuloplasties were performed
- JM is now 2 years old with moderate AS and mild AI

Case #3

- Patient G.T.
- Prenatal diagnosis at 28 weeks
  - Heterotaxy syndrome
  - Hypoplastic left heart syndrome
  - Mitral atresia, aortic atresia
  - Interrupted IVC with azygous continuation
  - Intact atrial septum with LA decompression through an ascending vertical vein to the innominate vein
Patient G.T.

- **Clinical course**
  - Baby delivered via scheduled C-section and transported to CNMC for emergent cardiac catheterization
  - Due to severe hypoxemia, the patient was electively cannulated for ECMO prior to catheterization
Patient G.T.
Patient G.T.

- **Clinical course**
  - DOL #2  Decannulated from ECMO
  - DOL #6  Norwood procedure with placement of a 5mm RV to PA shunt
  - DOL #22 Transferred to floor
  - 6 months old - Bidirectional Glenn

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Summary

- The field of Interventional pediatric cardiology has seen significant recent advances in technology and devices
- We are able to perform more advanced interventions on smaller patients with a higher degree of safety
- We are able to percutaneously close intracardiac defects that perviously required surgery
- We will be able to percutaneously replace heart valves