Diagnostic and Therapeutic Trends in Congenital Heart Disease

Watch the Next Decade

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Overview of CHD

- Most common birth defect and leading cause of mortality among birth defects
- Incidence:
  - ~1% of live births
  - 10% of still-births
- Occurs in > 50% of pts with any birth defect.
- Causes:
  - Genetics
  - Infection (Rubella)
  - Teratogens
  - Maternal Illness (Diabetes)
Projected 5-year mortality rates for 40-year-old ACHD patients in comparison with that expected for the general UK population based on the results of the standardized mortality ratio (SMR) analysis.

Points indicate the equivalent age, expressed as the age of subgroup of UK population with the most similar 5-year mortality (y axis).

Diller et al Circulation 2015
Medical Co-Morbidities in CHD Patients

- Heart failure
- Arrhythmia and sudden death
- Exercise intolerance
- Compromise of other organs
  - lungs, liver, kidney
- Infective endocarditis
- Chronic venous insufficiency
- Complications during pregnancy
- Neurocognitive disabilities
Heart Failure Is Not Related to Ischemia!

• Residual structural problems.
  – Valve stenosis or insufficiency
  – Residual left-to-right shunts

• Sequelae of cardiac repair itself
  – Right ventriculotomy in TOF

• Systemic right ventricle

• Single ventricle
  – Circulatory failure in “failing Fontan”
Usual Heart Failure Therapies May Not Work

• In patients with systemic right ventricle or right ventricular failure, usual therapies for left ventricular failure may not work
  – Carvedilol and ACE inhibitors of uncertain benefit
  – Cardiac resynchronization therapy may be difficult in complex anatomy.

• 3% of transplants in adults done in CHD patients
  • Percentage likely will increase over time.
  • Challenges include allosensitization, technically difficult anastomoses, and previous thoracotomies
Pulmonary Vascular Problems

- Peripheral pulmonary artery stenoses (e.g., TOF)
- Pulmonary hypertension
  - Abnormal heart structure or function
  - Eisenmenger’s syndrome
  - Even mild ↑Rp is problematic with Fontan physiology.
- Pulmonary vein stenosis
  - Progressive and often lethal
Arrhythmias

• Clinical burden in ACHD patients: congenital, perioperative insult and hemodynamic pathophysiology
  – Bradycardia (SND & AV block)
  – Atrial & ventricular tachycardias
  – Thrombosis & sudden death

• “Standard” therapies like ablation, complex pacing, & ICDs can be
  – Technically challenging
  – Higher risk
Hepatic Bridging Fibrosis and Cirrhosis

- Congestive hepatopathy and hepatic fibrosis/cirrhosis in CHD results from high systemic venous pressure
  - Especially common in S/P Fontan
- Generally asymptomatic until late in disease
  - Methods for surveillance other than biopsy of limited utility
- Associated with hepatocellular carcinoma
- No medications proven to be protective
More Women with CHD Are Having Children

• From 1998-2007, deliveries increased by 40% in women with CHD, compared to 21% in the general population

• Death
  – OR=6.7, 95% CI 2.9-15.4

• Combined CV outcome
  – Death, heart failure, arrhythmia, CVA/TIA, embolic events, and other CV complications
  – OR=12.5, 95% CI 10.8-14.4

• Absolute mortality rate only 0.15%.

Opotowsky et al, Heart, 2012
Neurocognitive Problems Are Common

• Few data are available in adults!
• Cognitive, behavioral, and neurological abnormalities are significantly more likely in children with CHD than the normal population
  – Expected to track into adulthood.
• Risk factors for adverse outcome include:
  – Patient factors
  – Medical variables including management
  – Sequelae of heart disease itself
Fontan patients have reduced cortical volumes and thickness.

Spans frontal, temporal, parietal, and occipital lobes, as well as subcortical gray matter.
Neurodevelopmental burden

Congenital Heart Disease  Acquired CV Disease

Cerebrovascular lesion burden

Marelli et al, Circulation, 2016
Where Are We Going?

“I never make predictions, especially about the future.”

Sam Goldwyn Mayer

Adapted from Smith R, ISMPP
Genetic Causes of Congenital Heart Disease

Currently, up to 1/3 of congenital heart defects are thought to be caused by genetic abnormalities

- Aneuploidy
- Microduplication or microdeletion syndromes
- Single gene disorders
  - De novo point mutations contribute to 10% of severe CHD in whole exome analysis

Zaidi et al., Nature 2013
Future Research: Genetic and Epigenetic Causes of Congenital Heart Disease

- Identify new genetic variants associated with CHD
  - WES accounts for 1% of the genome
  - WGS will uncover more etiology genes
- Understand role of epigenetic mutations
- Study mechanisms by which genetic variants effect malformations

Digital three-dimensional (3D) printing will improve the education, communication, presurgical planning and simulation in CHD.
Better Ventricular Assist Devices Will Be Devised for Congenital Heart Disease

Baldwin et al, Circulation 2011

Chopski et al, Medical Engineering & Physics, 2016,
Percutaneous Lymphatic Embolization of Abnormal Pulmonary Lymphatic Flow as Treatment of Plastic Bronchitis in Patients With Congenital Heart Disease.
Dori, Yoav; MD, PhD; Keller, Marc; Rome, Jonathan; Gillespie, Matthew; Glatz, Andrew; MD, MSCE; Dodds, Kathryn; MSN, CRNP; Goldberg, David; Goldfarb, Samuel; Rychik, Jack; Itkin, Maxim
26w Aortic Valvuloplasty - Percutaneous U/S Guided Needle Course
23w Fetal Aortic Valvuloplasty - Percutaneous
5 weeks post fetal balloon dilation of the aortic valve
A Blood Resistant Surgical Glue for Minimally Invasive Repair of Vessels and Heart Defects

- Elastic and biocompatible hydrophobic light-activated adhesive.
- Strong adhesion to wet tissue, and not compromised by exposure to blood.
- Can close septal defects in beating porcine heart.
Collaboration and Dissemination
Thank You!

Hypoplastic Left Heart Syndrome/Fontan

Tetralogy of Fallot

D-transposition