Long Term Clinical Outcomes of Paediatric Congenital Heart Disease

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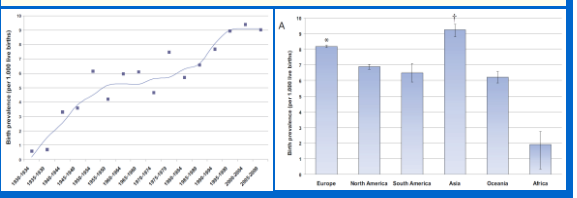
Birth Prevalence of Congenital Heart Disease Worldwide

A Systematic Review and Meta-Analysis



van der Linde at al. J Am Coll Cardiol 2011

Types of CHD

Left-to-Right Shunts

Ventricular septal defect | Atrial septal defect | Atrioventricular septal defect | Persistent arterial duct

Ventricular Outflow Obstruction

Coarctation of the aorta | Aortic valve stenosis | Pulmonary valve stenosis

Cyanotic Heart Conditions

Tetralogy of Fallot | Pulmonary atresia with ventricular septal defect | Pulmonary atresia with intact ventricular septum

Cyanotic Heart Conditions

Transposition of the great arteries

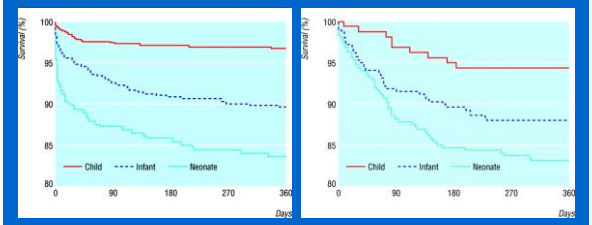
Functional single ventricles

Early Survival

Survival

Bypass cardiac surgery

Non-bypass cardiac surgery

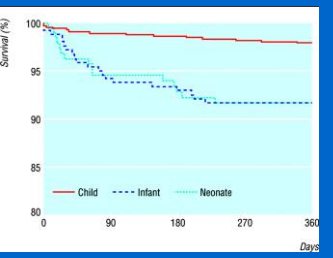


National cohort based on data from 13 UK tertiary centres (2000-1)

Gibbs et al. BMJ 2004

Survival

Catheter Intervention

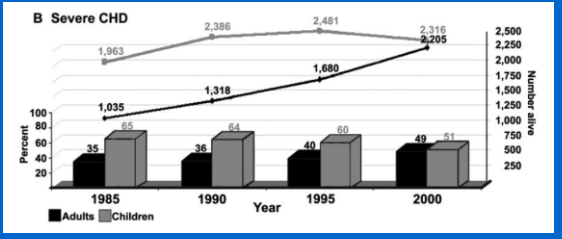


Gibbs et al. BMJ 2004

Congenital Heart Disease in the General Population

Changing Prevalence and Age Distribution

Ariane J. Marelli, MD; Andrew S. Mackie, MD, SM; Raluca Ionescu-Ittu, MSc; Elham Rahme, PhD; Louise Pilote, MD, MPH, PhD



Circulation 2007

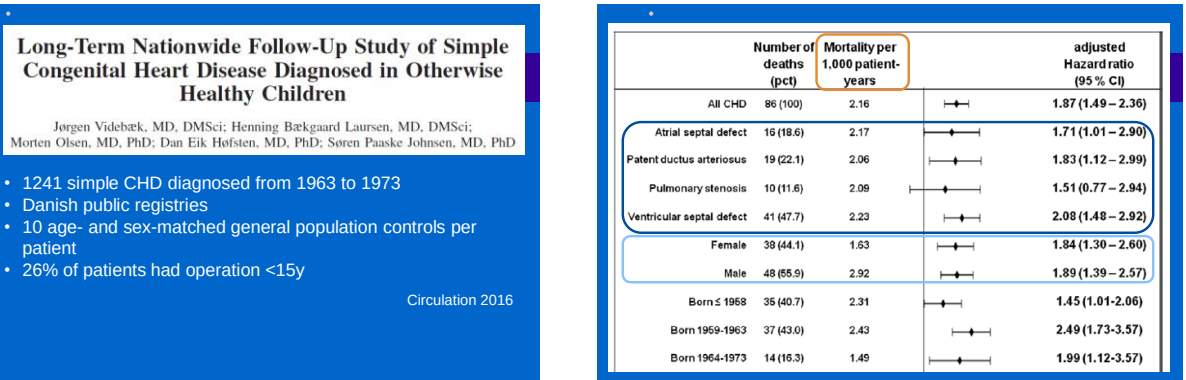
Long-Term Outcome Studies

Long-Term Nationwide Follow-Up Study of Simple Congenital Heart Disease Diagnosed in Otherwise Healthy Children

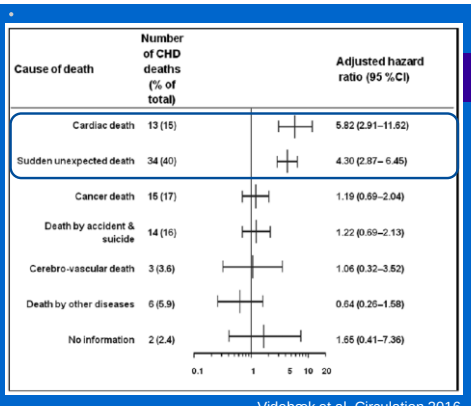
Jørgen Videbæk, MD, DMSci; Henning Bækgaard Laursen, MD, DMSci; Morten Olsen, MD, PhD; Dan Eik Høfsten, MD, PhD; Søren Paaske Johnsen, MD, PhD

- 1241 simple CHD diagnosed from 1963 to 1973
- Danish public registries
- 10 age- and sex-matched general population controls per patient
- 26% of patients had operation <15y

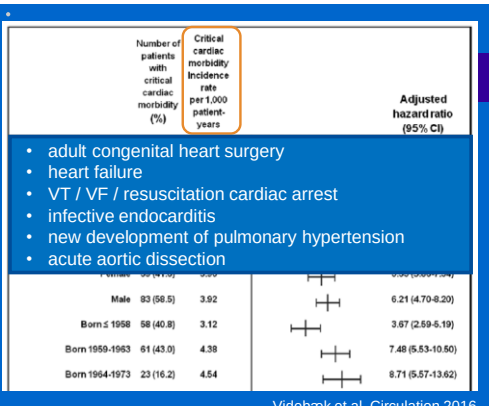
Circulation 2016



Videbæk et al. Circulation 2016



Videbæk et al. Circulation 2016



- adult congenital heart surgery
- heart failure
- VT / VF / resuscitation cardiac arrest
- infective endocarditis
- new development of pulmonary hypertension
- acute aortic dissection

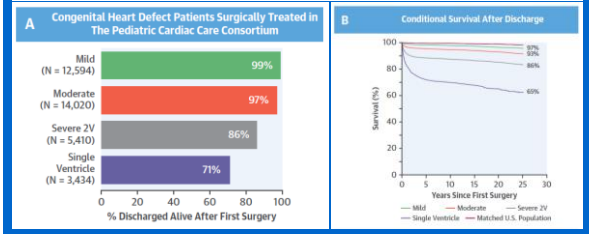
Videbæk et al. Circulation 2016

Why an increase in risk in 'simple' CHDs?

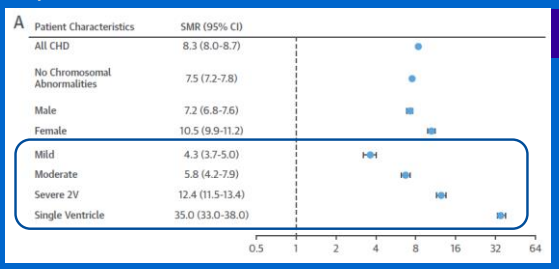
- even small volume shunt may not be insignificant
- cardiac surgery and/or catheter intervention is associated with ventricular dysfunction, valve dysfunction and arrhythmia
- associated syndrome and other congenital defects

Trends in Long-Term Mortality After Congenital Heart Surgery

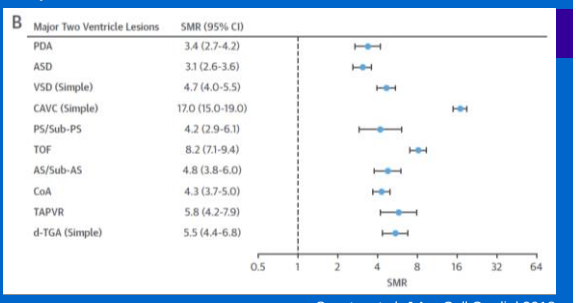
Logan G. Spector, PhD,[a] Jeremiah S. Menk, MS,[b] Jessica H. Knight, PhD,[c] Courtney McCracken, PhD,[c] Amanda S. Thomas, MSPH,[c] Jeffrey M. Vinocur, MD,[d] Matthew E. Oster, MD, MPH,[c] James D. St Louis, MD,[e] James H. Moller, MD,[f] Lazaros Kochilas, MD, MSCR[c]



J Am Coll Cardiol 2018



Spector et al. J Am Coll Cardiol 2018



Spector et al. J Am Coll Cardiol 2018

Interventional Treatment of Patients With Congenital Heart Disease

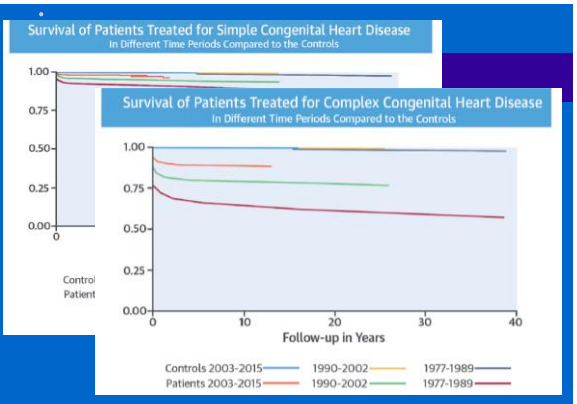
Nationwide Danish Experience Over 39 Years

Signe H. Larsen, MD, PhD,[a] Morten Olsen, MD, PhD,[b] Kristian Emmertsen, MD, DMSc,[c] Vibeke E. Hjortdal, MD, DMSc[c]

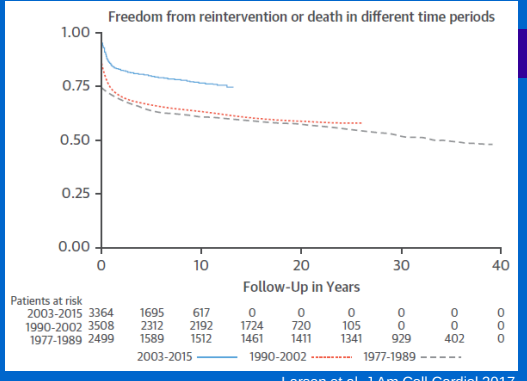
METHODS Using medical registries, the authors identified children (<18 years of age) treated for CHD in Denmark from 1977 to 2015, their need for reinterventions, and their long-term survival. Ten controls per patient, matched by sex and year of birth, allowed comparison with the background population. Survival was described using Kaplan-Meier curves.

RESULTS A total of 9,372 patients underwent 11,968 cardiac surgeries and 1,912 catheter-based interventions. Median age at first procedure decreased from 3.4 years (5th and 95th percentiles: 0.01 to 15.4 years) in 1977 to 1989 (period 1), 0.8 years (5th and 95th percentiles: 0.003 to 13.8 years) in 1990 to 2002 (period 2), and to 0.6 years (5th and 95th percentiles: 0.0 to 14.9 years) in 2003 to 2015 (period 3). More patients were born preterm (<37 weeks) in period 3 compared with those in period 1 (18.5% vs. 6.7%). Catheter-based interventions, not recorded before 1990, were increasingly used as the initial procedure in 5.8% of patients in period 2 and 25.9% of patients in period 3. An increasing part of the population did not undergo surgery at all (4.8% in period 2; 24.0% in period 3). Thirty-day survival increased from 97% (period 1) to 98% (period 2) to 100% (period 3). Ten-year survival increased from 80% (period 1) to 87% (period 2) to 93% (period 3). Compared with the background population, CHD was associated with lower survival in all 3 time periods.

J Am Coll Cardiol 2017

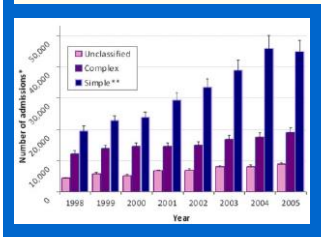


Larsen et al. J Am Coll Cardiol 2017



Larsen et al. J Am Coll Cardiol 2017

Trends in Hospitalizations for Adults With Congenital Heart Disease in the U.S.



Arrhythmia	139,237 (5,303)
CAD†	109,275 (4,235)
Heart failure	83,130 (2,905)
Pulmonary hypertension	43,516 (1,702)
Pregnancy	19,765 (822)
Bacterial endocarditis	6,138 (296)
Procedures	
Percutaneous ASD/PFO c	14,589 (2,413)
Pacemaker	12,687 (674)
PCI	11,262 (633)
ICD	4,476 (312)

Opotowsky et al. J Am Coll Cardiol 2009

Outcomes of Selected CHD

VSD

Long-Term Outcome of Patients With Ventricular Septal Defect Considered Not to Require Surgical Closure During Childhood

Harald M. Gabriel, MD,* Maria Heger, MD,* Petra Innerhofer, MD,* Manfred Zehetgruber, MD,* Gerald Mundigler, MD,* Maria Wimmer, MD,† Gerald Maurer, MD, FACC,* Helmut Baumgartner, MD, FACC*

RESULTS Follow-up was completed in 222 patients (97%). Mean age at last visit was 30 ± 10 years. Spontaneous VSD closure was observed in 14 patients (6%). No patients died, four patients (1.8%) had an episode of endocarditis, of whom two required aortic valve replacement, and one additional patient (0.4%) had surgical closure for hemodynamic reasons. For 118 patients who entered the study between 1993 and 1996 and were prospectively followed for 7.4 ± 1.2 years, event-free survival with end points defined as death, endocarditis or heart surgery was 99.1 ± 0.8% at three years, 96.5 ± 1.7% at six years and 95.5 ± 1.9% at eight years. At last visit, 94.6% of all patients studied were symptom free. Left ventricular (LV) size by echocardiography was normal in 198 (89%) patients, borderline in 23 patients and definitely enlarged in only one patient. None had systolic LV dysfunction, and pulmonary artery pressure (PAP) was normal in all patients. Mean exercise capacity was 92 ± 21% of expected, and 87% of patients had no arrhythmias on Holter monitoring, with the remainder showing benign rhythm disorders.

J Am Coll Cardiol 2002

The Unnatural History of the Ventricular Septal Defect

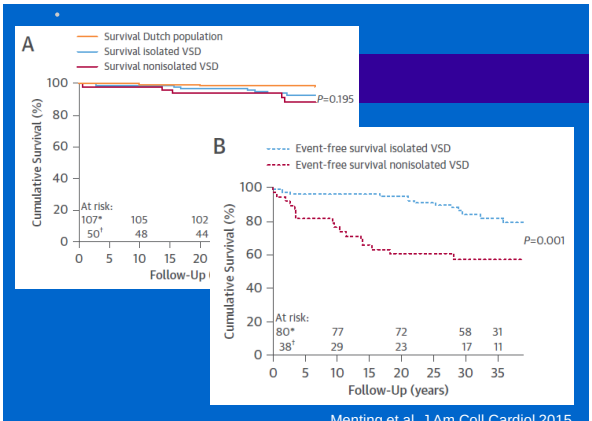
Outcome Up to 40 Years After Surgical Closure

Myrthe E. Menting, MD,* Judith A.A.E. Cuypers, MD,* Petra Opić, MSc,* Elisabeth M.W.J. Utens, PhD,† Maarten Witsenburg, MD, PhD,* Annemien E. van den Bosch, MD, PhD,* Ron T. van Domburg, PhD,* Folkert J. Meijboom, MD, PhD,† Eric Boersma, PhD,* Ad J.J.C. Bogers, MD, PhD,‡ Jolien W. Roos-Hesselink, MD, PhD*

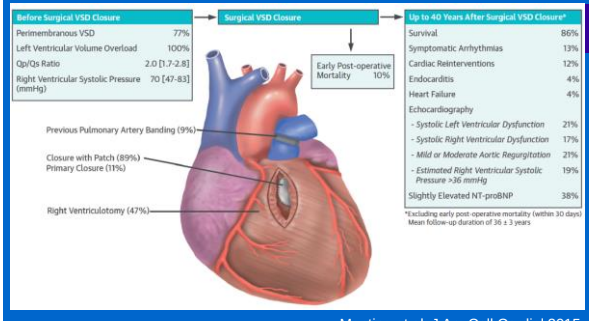
OBJECTIVES The objective of this study was to investigate clinical outcomes >30 years after surgical VSD closure.

METHODS Patients who underwent surgical VSD closure during childhood between 1968 and 1980 were reexamined every 10 years. In 2012, we invited eligible patients to undergo another examination, which included electrocardiography, Holter monitoring, echocardiography, bicycle ergometry, measurement of N-terminal pro-B-type natriuretic peptide, and subjective health assessment.

J Am Coll Cardiol 2015



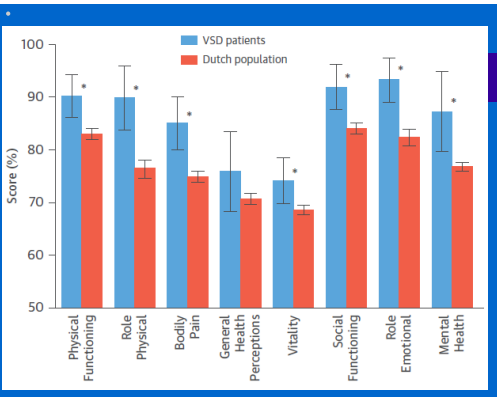
Menting et al. J Am Coll Cardiol 2015



Menting et al. J Am Coll Cardiol 2015

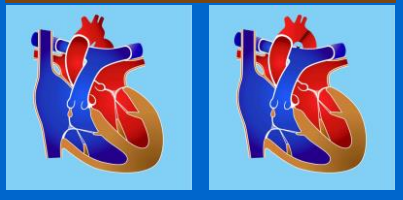
First Decade		Second Decade	
Residual VSD	2	Resection aortic (re)coarctation	3
Resection pulmonary stenosis	2	Balloon dilation aortic (re)coarctation	2
Resection aortic coarctation	1	Residual VSD	1
Resection subvalvular aortic stenosis	1	Surgery for restenosis aortic valve	1
Closure patent ductus arteriosus	1	Aortic root replacement	1
False aneurysm ascending aorta	1	Aortic valve replacement	1
Closure sternal dehiscence	1	Pulmonary valve replacement	1
		Balloon dilation pulmonary stenosis	1
Third Decade		**Fourth Decade**	
Bentall procedure	1	Stenting aortic recoarctation	1
		Aortic valve replacement	1
		Mitral valve replacement	1

Menting et al. J Am Coll Cardiol 2015

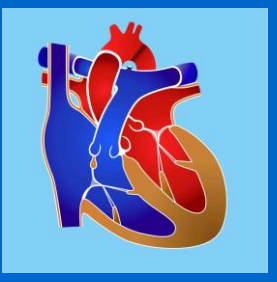


Menting et al. J Am Coll Cardiol 2015

Coarctation of the Aorta



Potential Long-term Complications



Local
- recoarctation
- aneurysm
- dissection

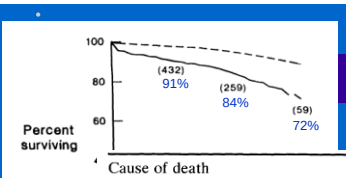
Ascending aorta and aortic valve
- aneurysm
- dissection
- aortic valve stenosis and regurgitation

Mayo Clinic experience

Retrospective analysis of 646 patients

- isolated operative repair of aortic coarctation from 1946-1981
- operations
  - end-to-end anastomosis in 87%
  - use of prosthetic materials or subclavian artery flap in 13%
- followed for a median duration of 20 years

Cohen et al. Circulation 1989



Cause of death	*n*	%
Coronary artery disease	32	37
Sudden death	11	13
Heart failure	8	9
Cerebrovascular accident	6	7
Ruptured aortic aneurysm	6	7
Perioperative death after subsequent cardiovascular surgery	6	7
Other	18	20
Total	87	100

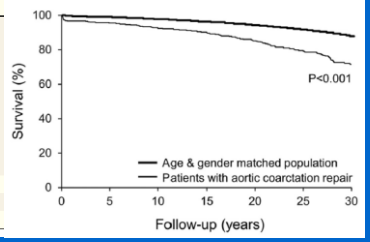
Cohen et al. Circulation 1989

Coarctation of the Aorta

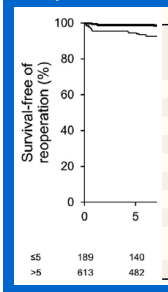
Lifelong Surveillance Is Mandatory Following Surgical Repair

Morgan L. Brown, MD, PHD,* Harold M. Burkhart, MD,* Heidi M. Connolly, MD,† Joseph A. Dearani, MD,* Frank Cetta, MD,†‡ Zhuo Li, MS,§ William C. Oliver,|| Carole A. Warnes, MD,† Hartzell V. Schaff, MD*

Characteristic
Age at operation
Mean ± SD, yrs
Range
Age group
≤1 yr
>1-≤5 yrs
>5-≤10 yrs
>10-≤20 yrs
>20 yrs
Female
Pre-operation hypertension
NYHA class III or IV

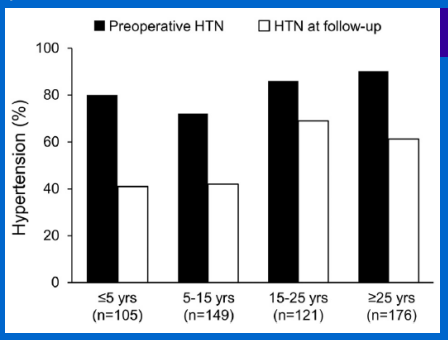


J Am Coll Cardiol 2013



Reoperation or Re-intervention Type	No. of Interventions
Coarctation re-intervention	
Surgical	40
Catheter based	13
Aortic valve replacement	52
Aortic valve repair	17
Coronary artery bypass grafting	13
Mitral valve replacement	10
Ascending aneurysm repair	8
Mitral valve repair	6
Descending aortic aneurysm	5
Aortic dissection	2
Other (maze, ASD/PFO, pericardiectomy, subclavian aneurysm, subaortic stenosis)	9
Total	175

Brown et al. J Am Coll Cardiol 2013



Brown et al. J Am Coll Cardiol 2013

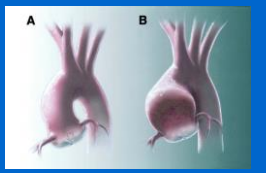
Aortic Arch Geometry

Gothic geometry and resting hypertension
Ou et al. Eur Heart J 2004

- Disturbance of fluid dynamics in the ascending aorta
- Changes in arterial pressure wave propagation
- Potential baroreceptor dysfunction when the transverse arch is shortened or absent

Bicuspid Aortic Valve

- found in 50-80% of patients of CoA (vs 1-2% of normal population)
- accelerated degeneration of the aortic media
- complications will develop in ≥33% of patients with bicuspid aortic valve
- associated with aortic dilation, aneurysms, and dissection



Fedak et al. Circulation 2002

Arterial–left ventricular–left atrial coupling late after repair of aortic coarctation and interruption

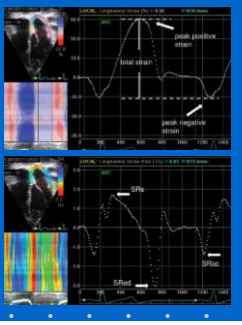
Vivian Wing-yi Li and Yiu-fai Cheung*

- ↑ carotid arterial stiffness
- ↑ carotid IMT

- altered LV strain and strain rate in three dimensions
- altered LV tosional deformation

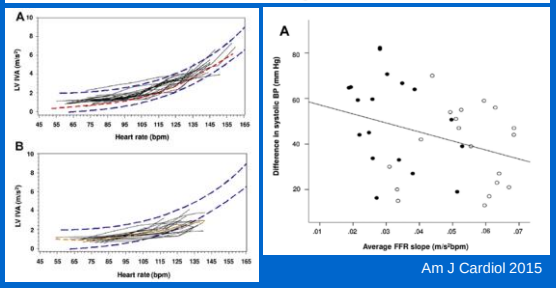
- Reduced atrial deformation

Eur Heart J Cardiovasc Imaging 2015



Left Ventricular Contractile Reserve in Young Adults Long-Term After Repair of Coarctation of the Aorta

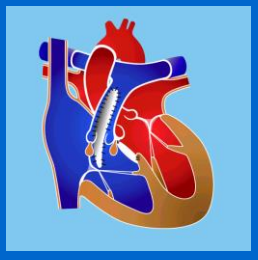
Vivian Wing-Yi Li, BSc, Robin Hay-Son Chen, MMedSc, Wilfred Hing-Sang Wong, MMedSc, and Yiu-Fai Cheung, MD*



Am J Cardiol 2015

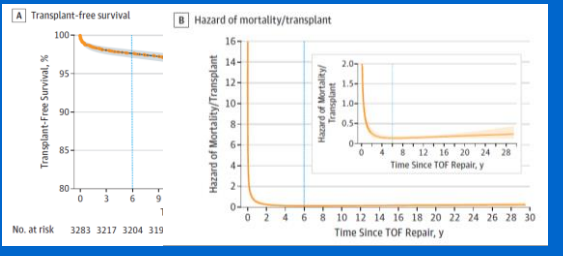
TOF

Repaired TOF

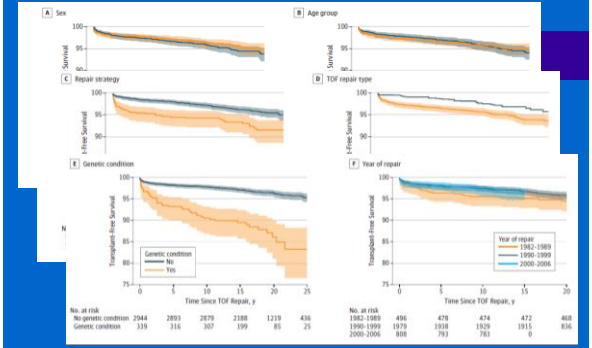


Long-term Outcomes of Tetralogy of Fallot
A Study From the Pediatric Cardiac Care Consortium

Clayton A. Smith, MD; Courtney McCracken, PhD; Amanda S. Thomas, MSPH; Logan G. Spector, PhD; James D. St Louis, MD; Matthew E. Oster, MD, MPH; James H. Moller, MD; Lazaros Kochilas, MD, MSCR



JAMA Cardiol 2019



Smith et al. JAMA Cardiol 2019

Underlying Cause of Death	No. (%)
Congenital heart disease	63 (43.45)
Disease of the circulatory system	22 (15.17)
Miscellaneous	19 (13.1)
External causes of injury and poisoning	16 (11.03)
Other congenital malformations	10 (6.9)
Respiratory diseases	8 (5.52)
Infections	2 (1.38)
Neoplasms	5 (3.45)

Smith et al. JAMA Cardiol 2019

Repaired Tetralogy of Fallot

- RBBB → RV dyssynchrony
- Pulmonary regurgitation → RV dilation (±TR)
- Transannular patch enlargement → Aneurysm and akinesia of RVOT

→ RV dysfunction

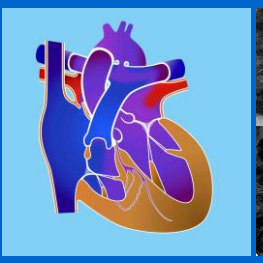
Ventricular-Ventricular Interaction

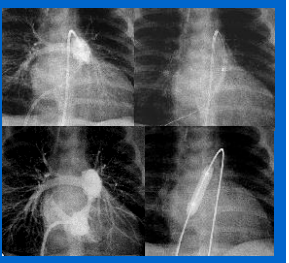
Volume overloading of right ventricle

- ↓ LV preload and compliance
- ↑ LV end-diastolic pressure
- Impaired LV myocardial deformation
- global LV mechanical dyssynchrony
- reduced LV torsion

PAIVS/PS

Radiofrequency Perforation for PAIVS

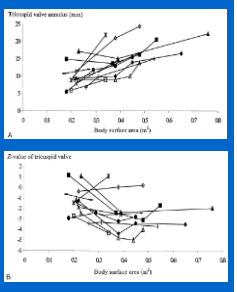


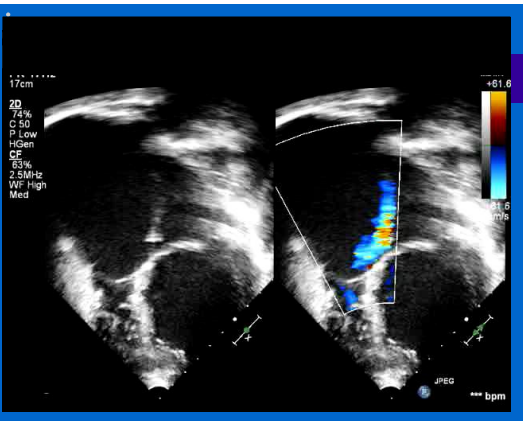


RV Growth in Repaired PAIVS

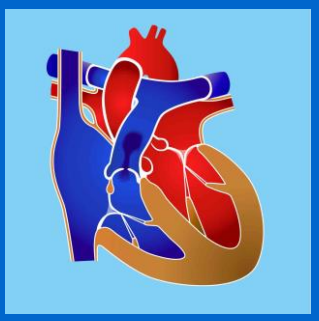
- growth of RV inlet and outlet
- growth of RV lags behind somatic growth
- a normal tricuspid annular growth may not be mandatory for achievement of a biventricular circulation

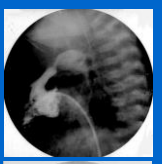
Cheung et al. Am J Cardiol 2002

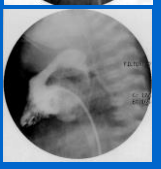




Balloon Pulmonary Valvoplasty

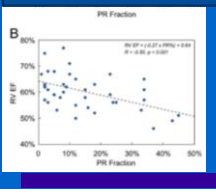


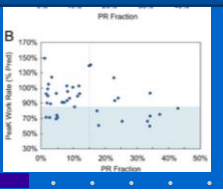




Long-Term Pulmonary Regurgitation Following Balloon Valvuloplasty for Pulmonary Stenosis: Risk Factors and Relationship to Exercise Capacity and Ventricular Volume and Function

- 34% had PRF >15%; 17% had PRF >30%
- PRF was related to larger balloon: annulus ratio and younger age at intervention





Harrild et al.
J Am Coll
Cardiol 2010

Right and left ventricular mechanics and interaction late after balloon valvoplasty for pulmonary stenosis

Li et al. Eur Heart J Cardiovasc Imaging. 2014

Fifty-Five Years Follow-Up of 111 Adult Survivors After Biventricular Repair of PAIVS and PS

Julia Zhuo Shi[1] · Pak-cheong Chow[1] · Wenxi Li[1] · Sit-yee Kwok[1] · Wilfred Hing-sang Wong[1] · Yiu-fai Cheung[1]

Pediatr Cardiol 2019

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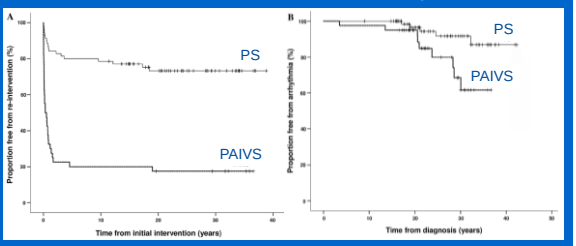
Reinterventions | Arrhythmias



Pediatr Cardiol 2019

Cardiac diagnosis	Age at diagnosis (year)	Type of arrhythmias	Management
PAIVS			
1	28.3	IART/atrial fibrillation	DC cardioversion PVR, TV repair, and cryoablation amiodarone
2	3.5 7.3	IART second degree heart block after Maze operation	Modified Maze operation Pacemaker implantation
3	20.9	IART	Transcatheter ablation
	23.8	IART	Diltiazem Metoprolol Warfarin
5	17.2 19.8	IART atrial fibrillation	DC cardioversion metoprolol warfarin
6	20.6	AVJRT	Transcatheter ablation verapamil
7	20.6	AVJRT	Transcatheter ablation
8	28.6	Lown's grade IVb PVC	–
9	30.0	Lown's grade IVb PVC	–
PS			
1	24.6	Sinus node dysfunction	–
2	42.3 45.9	Lown's grade IVa PVC IART/ atrial fibrillation	Sotalol
3	18.9	Idiopathic left posterior fascicular VT	Transcatheter ablation
4	21.1	Lown's grade IVa PVC	–
5	17.0	Lown's grade IVa PVC	–
6	32.2	Lown's grade IVa PVC	–

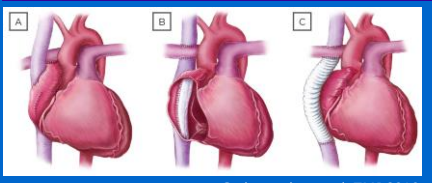
Shi et al. Pediatr Cardiol 2019

Cardiac diagnosis	Neurodevelopmental problems	Relationship to intervention	Management and outcome
PAIVS			
1	Left middle cerebral artery infarction epilepsy	Yes	Full recovery of hemiparesis, anticonvulsant
2	Left cerebral infarction infantile spasm	Yes	Residual right hemiparesis, seizure free on follow-up
3	Epilepsy mild MR, autism, ADHD	No	Anticonvulsant
4	Moderate MR	No	–
5	Epilepsy	No	Anticonvulsant
6	Autism	No	–
7	Mild MR	No	–
PS			
1	Epilepsy	No	Anticonvulsant
2	Borderline IQ	No	–
3	Moderate MR, autism	No	–
4	ADHD	No	Psychostimulant
5	Migraine	No	Antimigraine medication

Shi et al. Pediatr Cardiol 2019

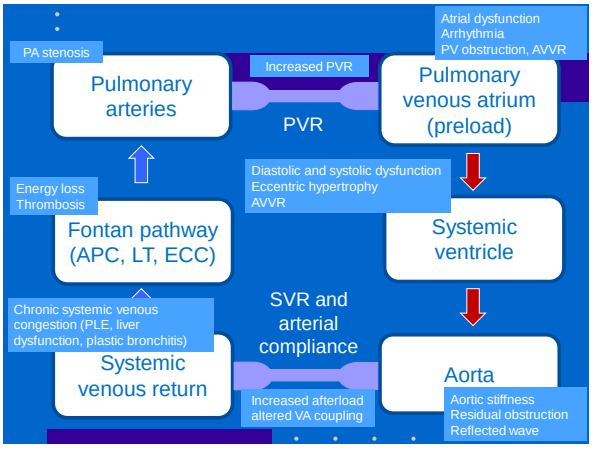
Single Ventricles

Evolution of Fontan-Type Procedures



Sathananthan et al. EMJ 2016

- a circulation in series
- non-pulsatile right-sided circulation



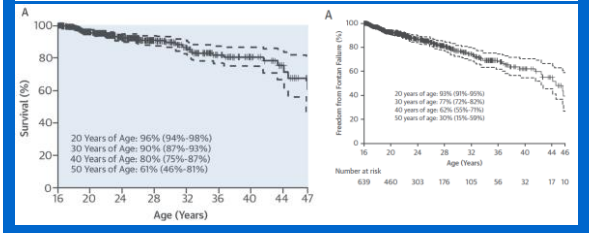
Failing Fontan

Clinical manifestations

- Cardiac (ventricular dysfunction, arrhythmias, exercise incapacity, thrombosis)
- Progressive hypoxaemia
- Hepatic complications (fibrosis, cirrhosis)
- Protein-losing enteropathy
- Plastic bronchitis
- Renal complications

Clinical Outcomes in Adolescents and Adults After the Fontan Procedure

Mark Dennis, MBBS HONS,[a,b] Diana Zannino, MSc,[c] Karin du Plessis, PHD,[c] Andrew Bullock, MBBS,[d] Patrick J.S. Disney, MBBS,[e] Dorothy J. Radford, MBBS, MD,[f] Tim Hornung, MD,[g] Leeanne Grigg, MBBS,[h] Rachael Cordina, MBBS, PHD,[a,b] Yves d'Udekem, MD, PHD,[c,i] David S. Celermajer, MBBS, PHD, DSC[a,b]



J Am Coll Cardiol 2018

Unknown	18 (29)
Heart failure	18 (29)
Arrhythmia	4 (6)
Post-transplant	4 (6)
Cardiac arrest	4 (6)
Cerebral event	3 (5)
Trauma or suicide	3 (5)
Sepsis or respiratory failure	3 (5)
Pulmonary embolism	2 (3)
Acute myocardial infarction	2 (3)
Systemic lupus erythematosus	1 (2)
Total	62 (100)

Dennis et al. J Am Coll Cardiol 2018

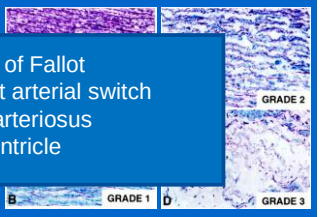
Specific Issues

Aortopathy

Niwa et al. Circulation 2001

- intraoperativ
  necropsy sp
  spectrum of
  disease
- medial abno
  found in the
  paracoarctat
  arteriosus, and pulmonary trunk

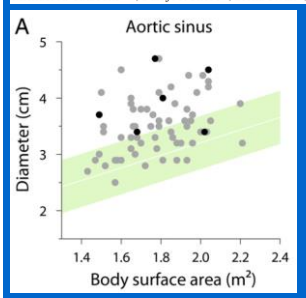
- tetralogy of Fallot
- TGA post arterial switch
- truncus arteriosus
- single ventricle



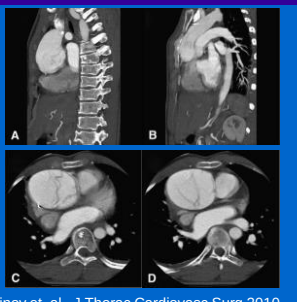
Outcome in adult patients after arterial switch operation for transposition of the great arteries

Aleksander Kempny [a,*], Kerstin Wustmann [a], Francesco Borgia [a], Konstantinos Dimopoulos [a,b], Anselm Uebing [a], Wei Li [a], Sylvia S. Chen [c], Adam Piorkowski [d], Rosemary Radley-Smith [e], Magdi H. Yacoub [f], Michael A. Gatzoulis [a,b], Darryl F. Shore [g], Lorna Swan [a], Gerhard-Paul Diller [a,b]

Int J Cardiol 2013



- aortic dissection in an 18-yr-old boy post TOF repair
- with 22q11 deletion
- aortic dilation 60 mm by 70 mm



Konstantinov et al . J Thorac Cardiovasc Surg 2010

ESC Guidelines for the management of grown-up congenital heart disease (new version 2010)

Table 17 Indications for intervention in transposition of the great arteries after arterial switch operation

Indications	Class[a]	Level[b]
Aortic root surgery should be considered when the (neo-)aortic root is >55 mm, providing average adult stature (for aortic valve replacement for severe AR see guidelines for AR[35])	IIa	C

Eur Heart J 2010

Canadian Cardiovascular Society 2009 Consensus Conference on the management of adults with congenital heart disease: Outflow tract obstruction, coarctation of the aorta, tetralogy of Fallot, Ebstein anomaly and Marfan's syndrome

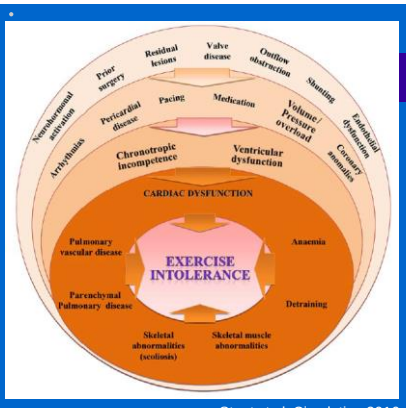
Candice K Silversides MD[1], Marla Kiess (Section Editor) MD[2], Luc Beauchesne MD[3], Timothy Bradley MBChB[4], Michael Connelly MBBS[5], Koichiro Niwa MD[6], Barbara Mulder MD[7], Gary Webb MD[8], Jack Colman MD[9], Judith Therrien MD[10]

- Significant aortic regurgitation associated with symptoms and/or progressive LV systolic dysfunction.
- Aortic root enlargement of at least 55 mm in diameter.
- A large RV outflow tract aneurysm or evidence of infection or false aneurysm.
- Sustained clinical arrhythmias, most commonly either atrial flutter or fibrillation, or sustained monomorphic ventricular tachycardia (VT). When any of these arrhythmias occur, the patient should also be evaluated for a treatable hemodynamic cause of the arrhythmia.
- The combination of residual VSD and/or residual pulmonary stenosis and regurgitation – all mild-moderate but leading to substantial RV enlargement, reduced RV function or symptoms.

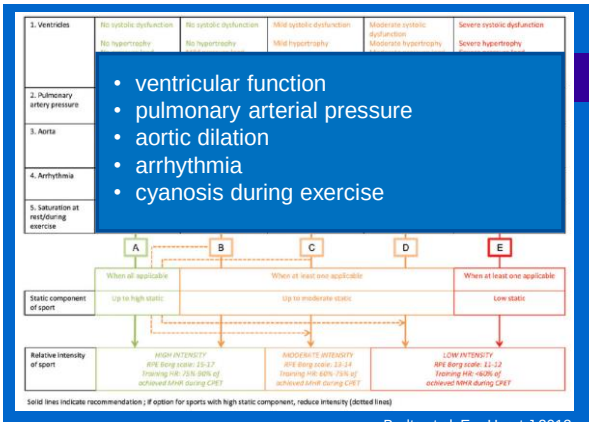
Class IIa, level C (79,95-100)

Can J Cardiol 2010

Exercise Incapacity



Stout et al. Circulation 2016



- ventricular function
- pulmonary arterial pressure
- aortic dilation
- arrhythmia
- cyanosis during exercise

Budts et al. Eur Heart J 2013

Infective Endocarditis

Prevention of Infective Endocarditis

Guidelines From the American Heart Association

A Guideline From the American Heart Association Rheumatic Fever, Endocarditis, and Kawasaki Disease Committee, Council on Cardiovascular Disease in the Young, and the Council on Clinical Cardiology, Council on Cardiovascular Surgery and Anesthesia, and the Quality of Care and Outcomes Research Interdisciplinary Working Group

Prosthetic cardiac valve or prosthetic material used for cardiac valve repair

Previous IE

Congenital heart disease (CHD)*

- Unrepaired cyanotic CHD, including palliative shunts and conduits
- Completely repaired congenital heart defect with prosthetic material or device, whether placed by surgery or by catheter intervention, during the first 6 months after the procedure†
- Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibit endothelialization)

Cardiac transplantation recipients who develop cardiac valvulopathy

Wilson et al. Circulation 2007

Situation	Agent	Regimen: Single Dose 30 to 60 min Before Procedure	
		Adults	Children
Oral	Amoxicillin	2 g	50 mg/kg
Unable to take oral medication	Ampicillin	2 g IM or IV	50 mg/kg IM or IV
	OR		
	Cefazolin or ceftriaxone	1 g IM or IV	50 mg/kg IM or IV
Allergic to penicillins or ampicillin—oral	Cephalexin*†	2 g	50 mg/kg
	OR		
	Clindamycin	600 mg	20 mg/kg
	OR		
	Azithromycin or clarithromycin	500 mg	15 mg/kg
Allergic to penicillins or ampicillin and unable to take oral medication	Cefazolin or ceftriaxone†	1 g IM or IV	50 mg/kg IM or IV
	OR		
	Clindamycin	600 mg IM or IV	20 mg/kg IM or IV

Wilson et al. Circulation 2007

2015 ESC Guidelines for the management of infective endocarditis

The Task Force for the Management of Infective Endocarditis of the European Society of Cardiology (ESC)

Recommendations

Antibiotic prophylaxis should be considered for patients at highest risk for IE:
(1) Patients with any prosthetic valve, including a transcatheter valve, or those in whom any prosthetic material was used for cardiac valve repair.
(2) Patients with a previous episode of IE.
(3) Patients with CHD:
(a) Any type of cyanotic CHD.
(b) Any type of CHD repaired with a prosthetic material, whether placed surgically or by percutaneous techniques, up to 6 months after the procedure or lifelong if residual shunt or valvular regurgitation remains.

Antibiotic prophylaxis is not recommended in other forms of valvular or CHD.

Recommendations	Class[a]	Level[b]
A. Dental procedures		
• Antibiotic prophylaxis should only be considered for dental procedures requiring manipulation of the gingival or periapical region of the teeth or perforation of the oral mucosa	IIa	C

Situation	Antibiotic	Single-dose 30–60 minutes before procedure	
		Adults	Children
No allergy to penicillin or ampicillin	Amoxicillin or ampicillin[a]	2 g orally or i.v.	50 mg/kg orally or i.v.
Allergy to penicillin or ampicillin	Clindamycin	600 mg orally or i.v.	20 mg/kg orally or i.v.

Habib et al. Eur Heart J 2015

These measures should ideally be applied to the general population and particularly reinforced in high-risk patients:

- Strict dental and cutaneous hygiene. Dental follow-up should be performed twice a year in high-risk patients and yearly in the others.
- Disinfection of wounds.
- Eradication or decrease of chronic bacterial carriage: skin, urine.
- Curative antibiotics for any focus of bacterial infection.
- No self-medication with antibiotics.
- Strict infection control measures for any at-risk procedure.
- Discourage piercing and tattooing.
- Limit the use of infusion catheters and invasive procedure when possible. Favour peripheral over central catheters, and systematic replacement of the peripheral catheter every 3–4 days. Strict adherence to care bundles for central and peripheral cannulae should be performed.

Habib et al. Eur Heart J 2015

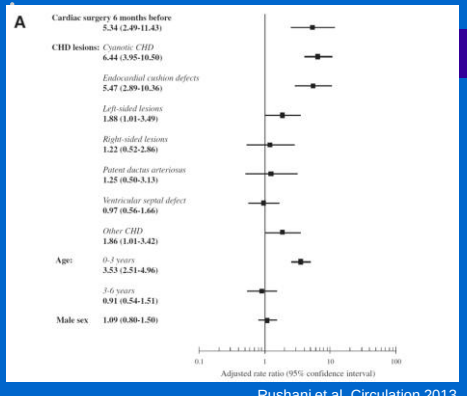
Infective Endocarditis in Children With Congenital Heart Disease

Cumulative Incidence and Predictors

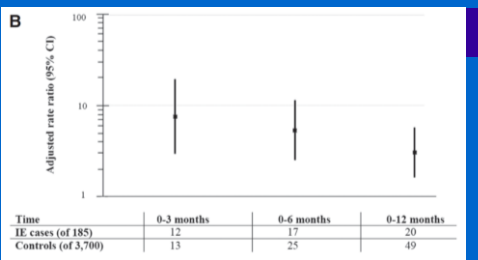
Dinela Rushani, MSc; Jay S. Kaufman, PhD; Raluca Ionescu-Ittu, PhD; Andrew S. Mackie, MD, SM; Louise Pilote, MD, MPH, PhD; Judith Therrien, MD; Ariane J. Marelli, MD, MPH

Methods and Results—We performed a population-based analysis to determine the cumulative incidence and predictors of IE in children (0–18 years) with CHD by the use of the Quebec CHD Database from 1988 to 2010. In 47 518 children with CHD followed for 458 109 patient-years, 185 cases of IE were observed. Cumulative incidence of IE was estimated in the subset of 34 279 children with CHD followed since birth, in whom the risk of IE up to 18 years of age was 6.1/1000 children (95% confidence interval, 5.0–7.5). In a nested case-control analysis, the following CHD lesions were at highest risk of IE in comparison with atrial septal defects (adjusted rate ratio, 95% confidence interval): cyanotic CHD (6.44, 3.95–10.50), endocardial cushion defects (5.47, 2.89–10.36), and left-sided lesions (1.88, 1.01–3.49). Cardiac surgery within 6 months (5.34, 2.49–11.43) and an age of <3 years (3.53, 2.51–4.96; reference, ages 6–18) also conferred an elevated risk of IE.

Circulation 2013



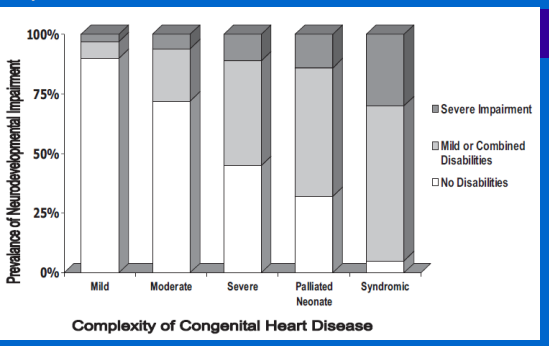
Rushani et al. Circulation 2013



Time	0-3 months	0-6 months	0-12 months
IE cases (of 185)	12	17	20
Controls (of 3,700)	13	25	49

Rushani et al. Circulation 2013

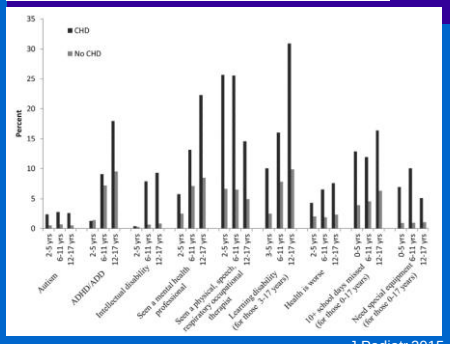
Neurodevelopmental Outcomes and Self Awareness



Marino et al. Circulation 2012

Long-Term Outcomes in Children with Congenital Heart Disease: National Health Interview Survey

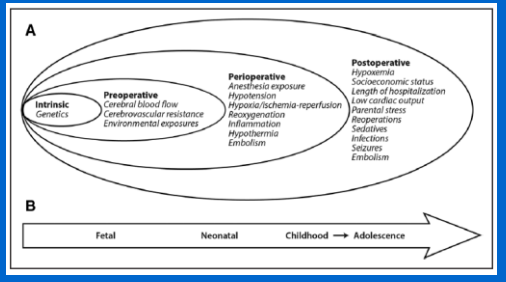
Hilda Razzaghi, PhD, MSPH[1,2], Matthew Oster, MD, MPH[1,2], and Jennita Reefhuis, PhD[1]



J Pediatr 2015

1. Neonates or infants requiring open heart surgery (cyanotic and acyanotic types), for example, HLHS, IAA, PA/IVS, TA, TAPVC, TGA, TOF, tricuspid atresia.
2. Children with other cyanotic heart lesions not requiring open heart surgery during the neonatal or infant period, for example, TOF with PA and MAPCA(s), TOF with shunt without use of CPB, Ebstein anomaly.
3. Any combination of CHD and the following comorbidities:
   - 3.1. Prematurity (<37 wk)
   - 3.2. Developmental delay recognized in infancy
   - 3.3. Suspected genetic abnormality or syndrome associated with DD
   - 3.4. History of mechanical support (ECMO or VAD use)
   - 3.5. Heart transplantation
   - 3.6. Cardiopulmonary resuscitation at any point
   - 3.7. Prolonged hospitalization (postoperative LOS >2-wk in the hospital)
   - 3.8. Perioperative seizures related to CHD surgery
   - 3.9. Significant abnormalities on neuroimaging or microcephaly*
4. Other conditions determined at the discretion of the medical home providers

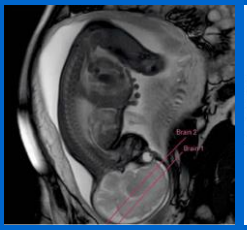
Marino et al. Circulation 2012

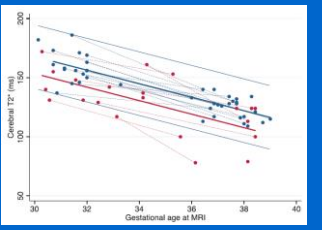


Morton et al. Circ Res 2017

Cerebral Oxygenation Measurements by Magnetic Resonance Imaging in Fetuses With and Without Heart Defects

Mette H. Lauridsen, MD; Niels Uldbjerg, MD, DMSc; Tine B. Henriksen, MD, PhD; Olav B. Petersen, MD, PhD; Brian Stausbøl-Grøn, MD, PhD; Niels B. Matthiesen, MD, PhD; David A. Peters, MSc, PhD; Steffen Ringgaard, PhD; Vibeke E. Hjortdal, MD, DMSc





Circ Cardiovasc Imaging 2017

De novo mutations in congenital heart disease with neurodevelopmental and other congenital anomalies

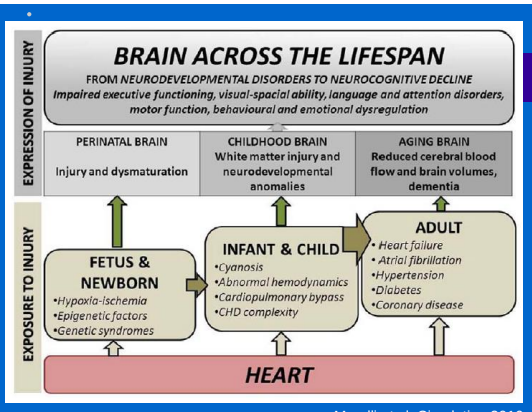
Congenital heart disease (CHD) patients have an increased prevalence of extracardiac congenital anomalies (CAs) and risk of neurodevelopmental disabilities (NDDs). Exome sequencing of 1213 CHD parent-offspring trios identified an excess of protein-damaging de novo mutations, especially in genes highly expressed in the developing heart and brain. These mutations accounted for 20% of patients with CHD, NDD, and CA but only 2% of patients with isolated CHD. Mutations altered genes involved in morphogenesis, chromatin modification, and transcriptional regulation, including multiple mutations in *RBFOX2*, a regulator of mRNA splicing. Genes mutated in other cohorts examined for NDD were enriched in CHD cases, particularly those with coexisting NDD. These findings reveal shared genetic contributions to CHD, NDD, and CA and provide opportunities for improved prognostic assessment and early therapeutic intervention in CHD patients.

Homsy et al. Science 2015

Contribution of rare inherited and *de novo* variants in 2,871 congenital heart disease probands

Congenital heart disease (CHD) is the leading cause of mortality from birth defects. Here, exome sequencing of a single cohort of 2,871 CHD probands, including 2,645 parent–offspring trios, implicated rare inherited mutations in 1.8%, including a recessive founder mutation in *GDF1* accounting for ~5% of severe CHD in Ashkenazim, recessive genotypes in *MYH6* accounting for ~11% of Shone complex, and dominant *FLT4* mutations accounting for 2.3% of Tetralogy of Fallot. *De novo* mutations (DNMs) accounted for 8% of cases, including ~3% of isolated CHD patients and ~28% with both neurodevelopmental and extra-cardiac congenital anomalies. Seven genes surpassed thresholds for genome-wide significance, and 12 genes not previously implicated in CHD had >70% probability of being disease related. DNMs in ~440 genes were inferred to contribute to CHD. Striking overlap between genes with damaging DNMs in probands with CHD and autism was also found.

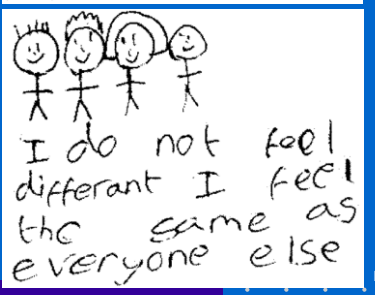
Jin et al. Nat Genet 2017



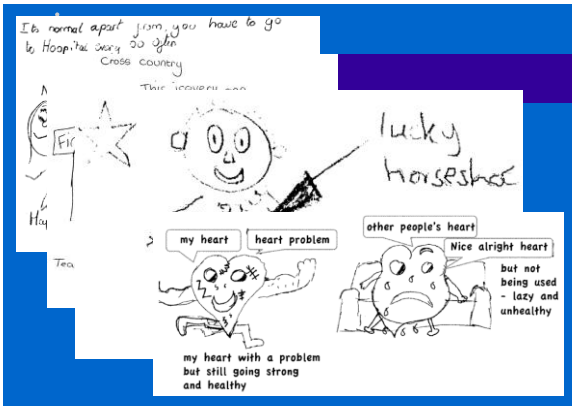
Marelli et al. Circulation 2016

Self-Reported Health Experiences of Children Living with Congenital Heart Defects: Including Patient-Reported Outcomes in a National Cohort Study

Rachel Louise Knowles[1]*, Valerija Tadic[1], Ailbhe Hogan[1], Catherine Bull[2], Jugnoo Sangeeta Rahi[1], Carol Dezateux[1], UK Collaborative Study of Congenital Heart Defects (UKCSCHD)[1]



PLoS One 2016



Knowles et al. PLoS One 2016

- '[I] get sick of people staring at my scar, asking questions all the time'
- 'I hate going to hospital because I hate needles and doctors/nurses'
- 'you cannot play sports and are weaker slower than everyone else. . .you can get left out a lot'
- '[I] feel alone because no one has been through what I've been through'
- 'I do get very annoyed sometimes because I can't keep up with my friends'
- 'I also would love to get my ears pierced but my heart doctor advised me not to because of maybe getting an infection'
- 'Being put onto Warfarin changes your life because you become scared of getting bumped, hurt, cut, because you bleed a lot or get blood clots'

Messages

- Significant improvement in survival of CHD patients
- Recognition of the needs for reinterventions
- Risk stratification of CHD for monitoring of long-term complications
- Identification and interventions for neurodevelopmental and psychological issues
- Monitoring of non-cardiac complications
- Education and transitional care of adolescent CHD patients