Trends in Survival and Mortality of Adult CHD

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- Changing profile of ACHD
- Life expectancy of ACHD
- Changing mortality in ACHD
- Cohort study
- After Pediatric Cardiac Surgery
- Survival and mortality after heart transplantation

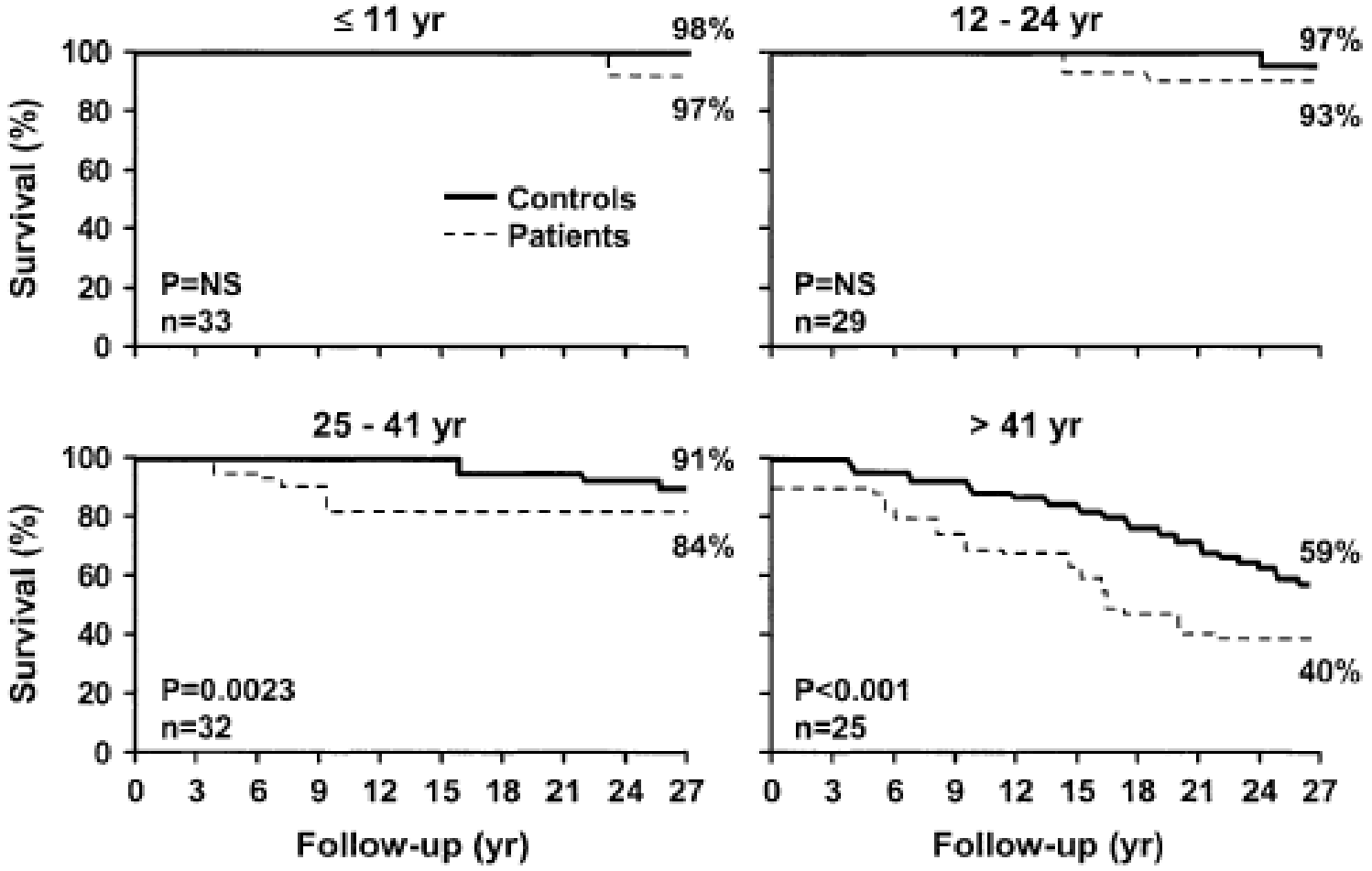
Misconception of Cure

- The majority may consider themselves **"cured".**
- Fostered by the surgical description, **"total correction"**
- In reality, there is almost no surgical cure for CHD.
- Has potentially serious consequences

- Cardiac surgery is **Palliative** rather than curative
- Require **Life long FU** at center, available to deal with their complex problems.

Long-term outcome of patients surviving the perioperative period according to age at operative closure of ASD

Murphy JG, et al. NEJM 1990



Changing profile of CHD in adult life

Warnes CA, et al. JACC 2001

- Predict the need for FU of adults with CHD,
- >200cases per 100,000 live births
- >1600 cases every year

(a population of 50 million)

England

- Korea
- 1,000 cases every year in South Korea (500,000 live birth)
- US
- 16,000 cases every year in US (4 million live birth)

Korea and US

Types of adult patient with CHD

Conduits, valved or nonvalved
Cyanotic congenital heart (all forms)
Double-outlet ventricle
Eisenmenger syndrome
Fontan procedure
Mitral atresia
Single ventricle (also called double inlet or outlet, common or primitive)
Pulmonary atresia (all forms)
Pulmonary vascular obstructive diseases
Transposition of the great arteries
Tricuspid atresia
Truncus arteriosus/hemitruncus
Other abnormalities of atrioventricular or ventriculoarterial connection not included above (i.e., crisscross heart, isomerism, heterotaxy syndromes, ventricular inversion)

Aorto-left ventricular fistulae
Anomalous pulmonary venous drainage, partial or total
Atrioventricular canal defects (partial or complete)
Coarctation of the aorta
Ebstein's anomaly
Infundibular right ventricular outflow obstruction of significance
Ostium primum atrial septal defect
Patent ductus arteriosus (not closed)
Pulmonary valve regurgitation (moderate to severe)
Pulmonic valve stenosis (moderate to severe)
Sinus of Valsalva fistula/aneurysm
Sinus venosus atrial septal defect
Subvalvar or supravalvar aortic stenosis (except HOCM)
Tetralogy of Fallot
Ventricular septal defect with
- Absent valve or valves
- Aortic regurgitation
- Coarctation of the aorta
- Mitral disease
- Right ventricular outflow tract obstruction
- Straddling tricuspid/mitral valve
- Subaortic stenosis

Great Complexity

Moderate Severity

Life expectancy by adolescents and young adult with CHD

Reid GJ,et al. JACC 2006

- Older Adolescents and Young adults with moderate or complex CHD (n=296)
- Patients with CHD expected to liver to age 75 ±11years, only 4 year less than healthy peers
- >85% of patients expected to live longer than estimates of their life

Mode of Death in ACHD, Toronto '81-96

Cross sectional study 2,609 adults with CHD. Oechslin N et al. Am J Card. 2000

Diagnosis	Population (definitive surgery)	All-cause Mortality	Cardiovascular Mortality	Age at Death (years ± 1 SD) (range)
Pulmonary valve stenosis	167 (49%)	1 (0.6%)	0	26 (n = 1)
Ductus arteriosus	98 (81%)	4 (4%)	3 (3%)	53 ± 21 (28–80)
Aortic coarctation	171 (98%)	4 (2%)	4 (2%)	29 ± 6 (23–36)
Ebstein's anomaly	58 (22%)	6 (10%)	5 (9%)	36 ± 15 (18–62)
Pulmonary atresia	27 (63%)	3 (11%)	3 (11%)	27 ± 6 (22–33)
Atrioventricular septal defect	128 (73%)	15 (12%)	9 (7%)	35 ± 14 (21–69)
Univentricular connection	108 (64%)	25 (23%)	13 (12%)	31 ± 10 (20–61)
Tricuspid atresia	48 (69%)	12 (25%)	5 (10%)	27 ± 5 (22–39)
Congenitally corrected TGA	57 (63%)	15 (26%)	11 (19%)	37 ± 13 (21–61)

A Clinic- based study of patients with moderate to complex CHD: Died so at a mean age of 37± 15 years (range 18-80years)

Table 1. Estimates of Self and Peer Life Expectancies in Years for Patients With Congenital Heart Disease (CHD) and a Comparison Sample of Undergraduates

Sample	Mean ± SD	Median	Mode	Range
CHD				
Self	75*† ± 11.2	75	80	30 to 120
Peer	79* ± 7.5	80	80	60 to 120
Self-Peer	−4 ± 9.4	0	0	−60 to +24
Undergraduates				
Self	81†‡ ± 9.9	80	80	50 to 100
Peer	78‡ ± 6.4	80	80	60 to 100
Self-Peer	3 ± 8.3	0	0	−35 to +25

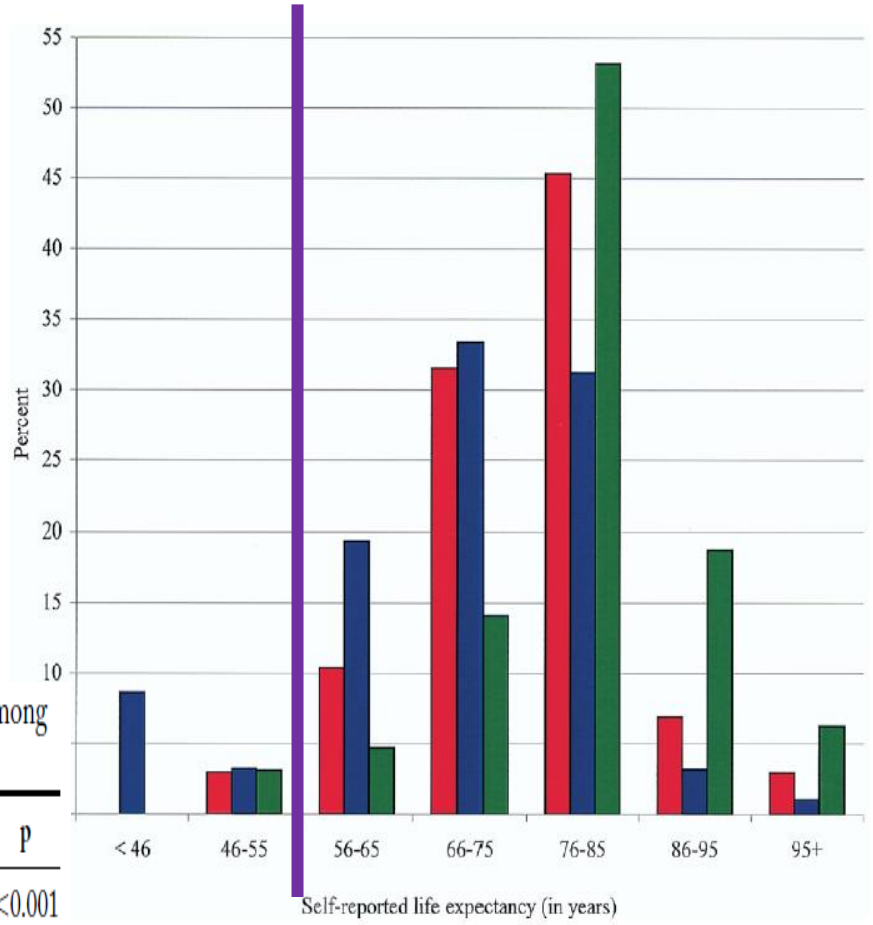


Table 3. Multivariate Logistic Regression Predicting Shorter Perceived Life Expectancy Among Patients With Congenital Heart Disease (CHD)

Predictor Variables	OR	95% CI	p
Diagnosis with higher risk of early death*	3.08	1.66–5.70	<0.001
Fair or poor overall health status†	2.70	1.13–6.47	0.026
Increasing perceptions of risk for CHD complications‡	1.76	1.16–2.66	0.008

68% in complex CHD & 87% in moderate CHD expected to live past age 55 years

vs. 35–40 years complex & 55 years moderate in current status

Implication of Unrealistic or Optimistic life expectancy

- Lead to avoidance of appropriate health care
- Acute and sudden onset of adverse events ranging from arrhythmia to HF or SCD
- Fairly realistic views had an element of hopeless
- Rarely based on discussion with their health professionals

- Patients Diagnosis, surgical History, current Complication
- Ongoing improvement in medical & surgical care
- Variability in outcome
- Uncertainty in current estimate

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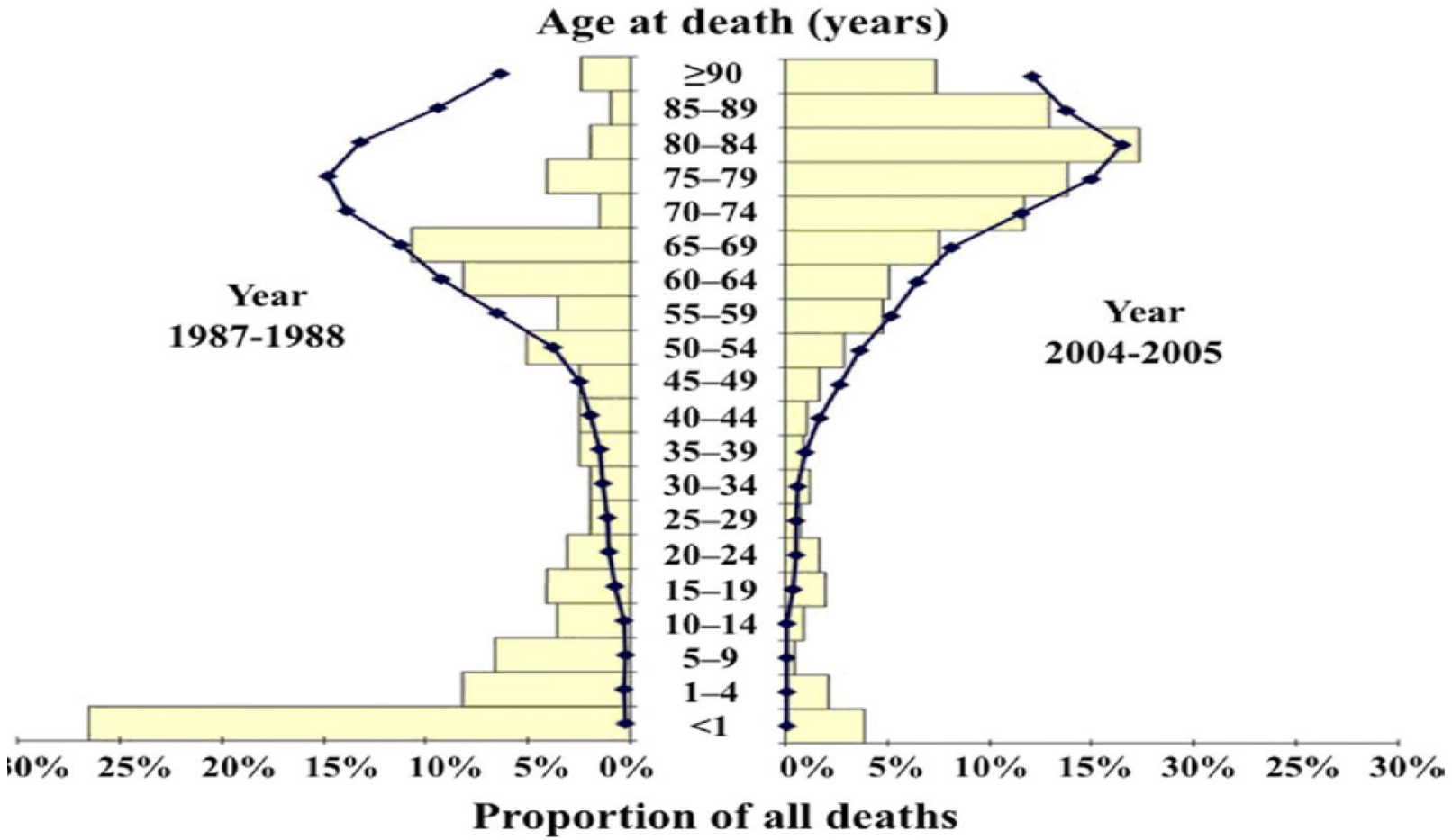
Changing mortality in CHD

Khairy QP, et al. JACC 2010, Quebec, Canada

- Population based cohort study of patient with CHD in Quebec, Canada from 1987-2005
- A total of 8,561 deaths occurred in 71,686 patients with CHD followed for 982,363 patients-years
- Quebec population 6.8~ 7.5 million people (1987-2005)

Distribution of age at death in patients with CHD in 1987to 1988 and 2004-2005

Khairy QP, et al. JACC 2010, Quebec, Canada



Deaths in the 6 Restricted cohorts of patients with CHD

Khairy QP, et al. JACC 2010, Quebec, Canada

	1987-1990	1990-1993	1993-1996	1996-1999	1999-2002	2002-2005
Total population with CHD						
Number of deaths	303	591	927	1,176	1,425	1,545
Number of patients	13,772	22,652	30,886	38,372	45,747	53,241
Severe vs. other forms of CHD						
Number of deaths in severe CHD	61 (20)	78 (13)	77 (8)	105 (9)	89 (6)	84 (5)
Number of patients with severe CHD	2,387	2,994	3,426	3,958	4,410	4,887
Number of deaths in other forms of CHD	242 (80)	513 (87)	850 (82)	1,071 (91)	1,336 (94)	1,461 (95)
Number of patients with other forms of CHD	11,385	19,658	27,460	34,414	41,337	48,354
Children vs. adults with CHD						
Number of deaths in children with CHD	89 (29)	78 (13)	95 (10)	78 (7)	79 (5)	62 (4)
Number of children with CHD*	7,568	10,943	14,087	16,392	19,566	22,228
Number of deaths in adults with CHD	214 (71)	513 (87)	832 (90)	1,098 (93)	1,346 (95)	1,483 (96)
Number of adults with CHD*	6,204	11,709	16,799	21,980	26,181	31,013

Adjusted Mortality Ratios in subtypes of CHD in 2002 to 2005 relative to 1987 to 1990

Type of Congenital Heart Disease	All Patients		Children (Age <18 yrs)		Adults (Age 18–64 yrs)	
	Adjusted Mortality Ratio* (95% CI)	p Value	Adjusted Mortality Ratio* (95% CI)	p Value	Adjusted Mortality Ratio* (95% CI)	p Value
All types of congenital heart disease	0.69 (0.61–0.79)	<0.001	0.41 (0.29–0.56)	<0.001	0.84 (0.73–0.97)	0.02
Severe congenital heart disease	0.51 (0.37–0.72)	<0.001	0.33 (0.19–0.60)	<0.001	0.67 (0.39–1.14)	0.14
Endocardial cushion defect	0.52 (0.26–1.02)	0.06	0.37 (0.12–1.15)	0.09	1.02 (0.23–4.48)	0.98
Tetralogy of Fallot	0.54 (0.31–0.95)	0.03	0.45 (0.19–1.07)	0.07	0.58 (0.26–1.32)	0.20
Transposition of the great arteries	0.39 (0.17–0.89)	0.03	0.14 (0.03–0.67)	0.01	0.88 (0.19–4.03)	0.87
Univentricular hearts†	0.52 (0.22–1.25)	0.15	0.21 (0.04–1.02)	0.05	0.75 (0.17–3.38)	0.71
Other forms of congenital heart disease						
Atrial septal defect	0.79 (0.57–1.11)	0.17	1.14 (0.34–3.84)	0.84	0.77 (0.54–1.09)	0.14
Ventricular septal defect	0.40 (0.28–0.59)	<0.001	0.28 (0.13–0.60)	<0.001	0.54 (0.34–0.87)	0.01
Patent ductus arteriosus	0.90 (0.37–2.20)	0.82	NE		1.36 (0.47–3.94)	0.57

Khairy QP, et al. JACC 2010, Quebec, Canada

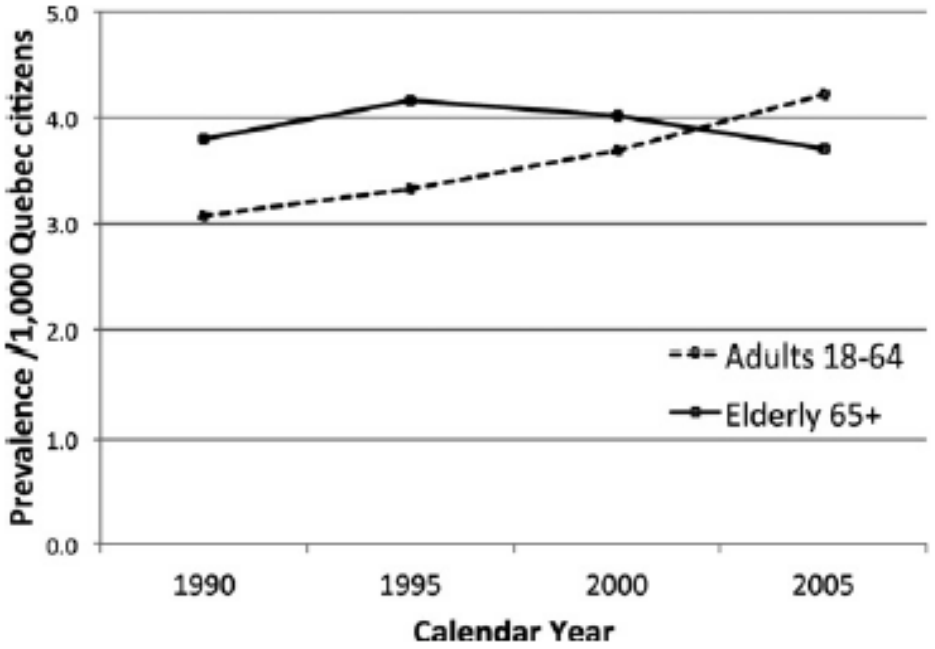
- Mortality rate decreased in all age groups below 65 years
- Largest reduction in infants (MR ratio 0.23)
- In adults 18-64 years, mortality reduction paralleled the general population
- Gains in survival were mostly driven by reduced mortality in severe form of CHD, particularly children

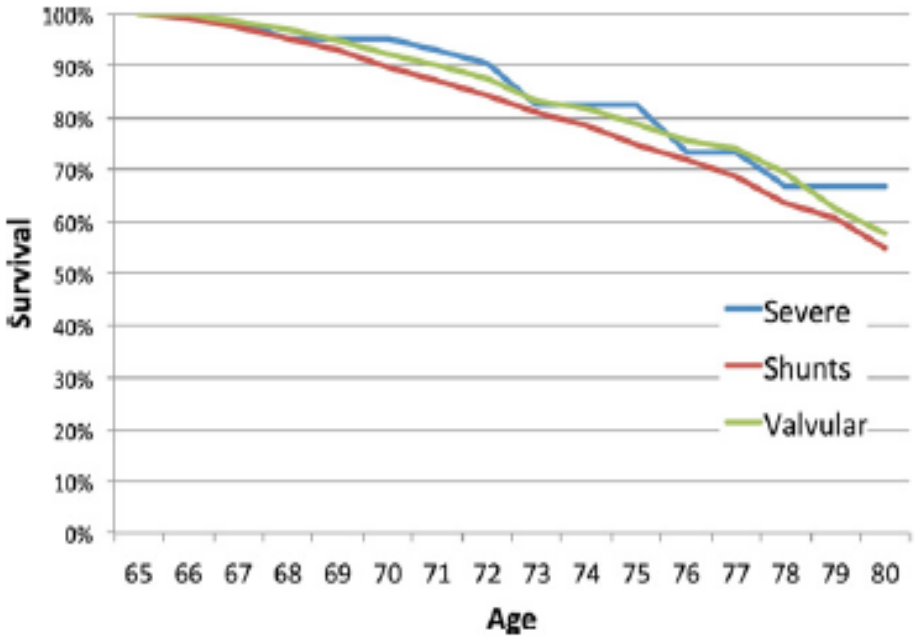
Geriatric Congeital Heart Disease

Afilado J, et al. JACC 2011, Quebec, Canada

The geriatric ACHD cohort consisted of 3,239 patients. From 1990 to 2005, the prevalence of ACHD in older adults remained constant from 3.8 to 3.7 per 1,000 indexed to the general population (prevalence odds ratio: 0.98; 95% confidence interval [CI]: 0.93 to 1.03). The age-stratified population prevalence of ACHD was similar in older and younger adults. The most common types of congenital heart disease lesions in older adults were shunt lesions (60%), followed by valvular lesions (37%) and severe congenital heart lesions (3%). Type of ACHD and ACHD-related complications had a minor impact on mortality, which was predominantly driven by acquired comorbid conditions. The most powerful predictors of mortality in the Cox proportional hazards model were: dementia (hazard ratio [HR]: 3.24; 95% CI: 1.53 to 6.85), gastrointestinal bleed (HR: 2.79; 95% CI: 1.66 to 4.69), and chronic kidney disease (HR: 2.50; 95% CI: 1.72 to 3.65).

- Prevalence 3.8~3.7 per 1,000 indexed to the general population
- Most common types were shunt lesions(60%), valvular lesions(31%), severe CHD(3%)
- Most powerful predictors of mortality – dementia, GI bleeding, Chronic renal disease





- Spectrum of disease that is transitioning toward more complex forms
- Neurocognitive impairment is well recognized in children with severe forms of CHD
- Implications for education, employability, insurability, more neurocognitive assessment and intervention
- Burden of health in CHD, shifting toward adult, Complication.

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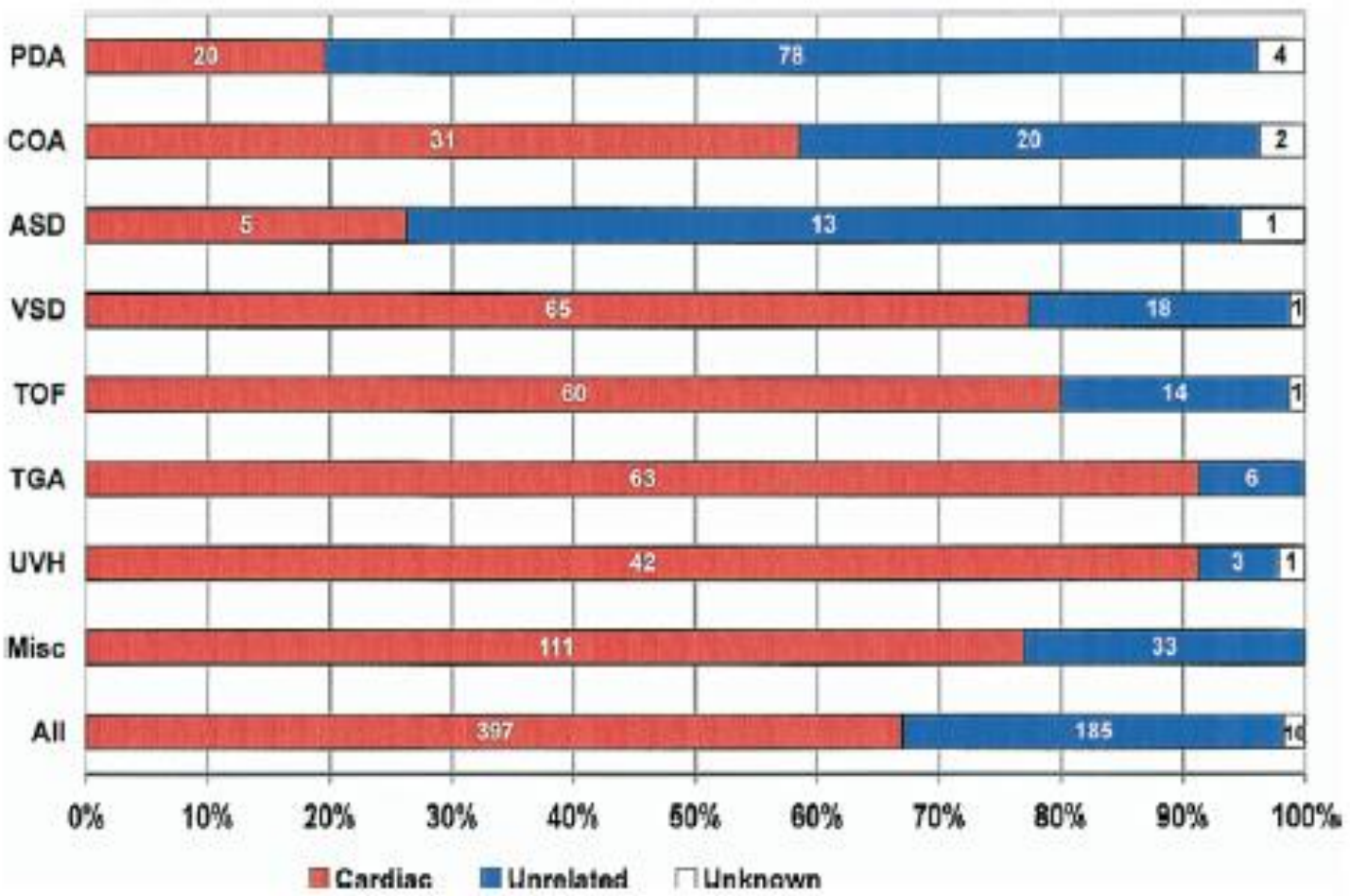
Cause of late deaths after Pediatric Cardiac Surgery

Nieminen HP, et al. JACC 2007. Helsinki, Finland

- All late deaths operated on for CHD in Finland, 1953-1989
- Survival of patients, causes of death, modes of CHD-related death
- Compare the survival and causes of non-CHD-related deaths to those of the general population
- 6,024 patients, survived after 1st Op.
- 592(9%) died during the 45year FU period.

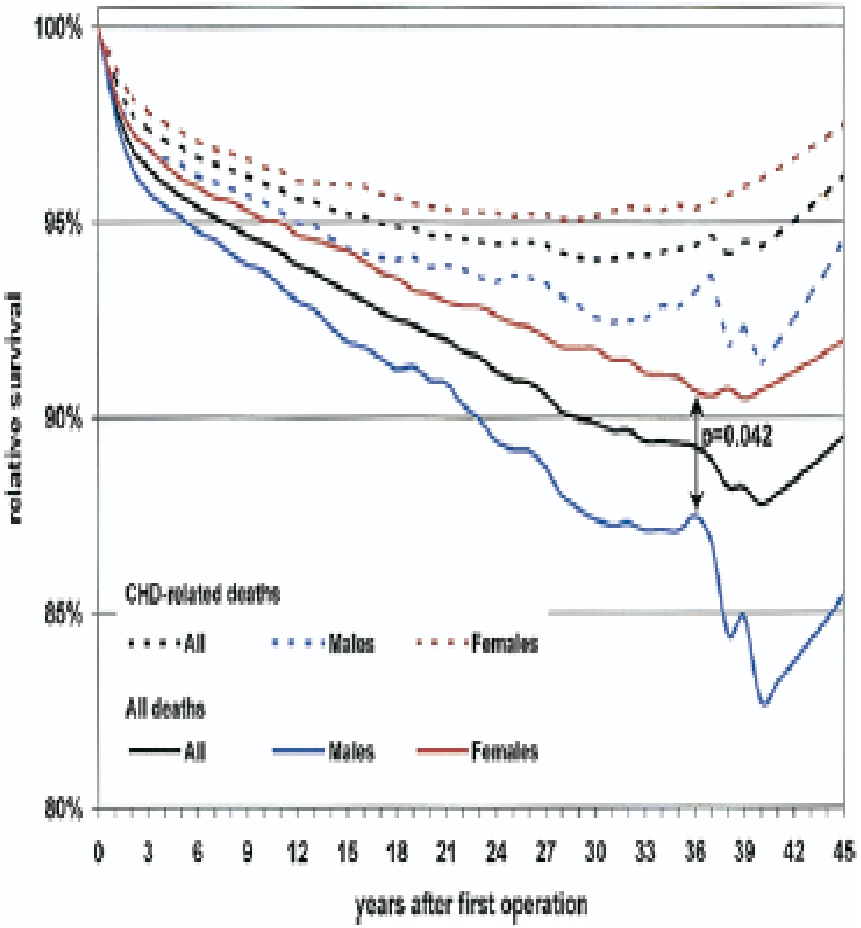
Proportion of Causes of Death



Nieminen HP, et al. JACC 2007.
Helsinki, Finland

Relative survival(Survival of patients/Survival of general population) of all patients

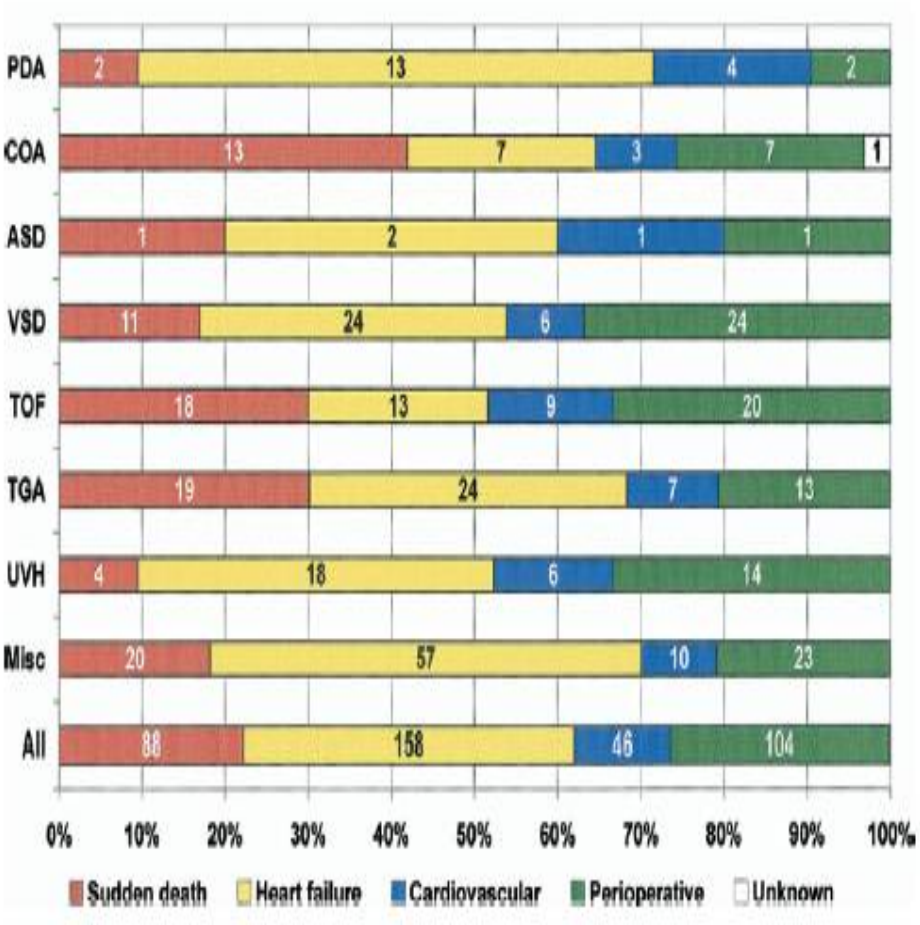
- Highest Mortality within the 1st year of FU
- Male patients with corrected TOF and TGA died suddenly more often than female.
- Seriousness of defect
- Male with CAD & male athletes died suddenly more
- Type of arrhythmia



Nieminen HP, et al. JACC 2007. Helsinki, Finland

Proportion of modes of CHD-related Death in different defect groups

- HF in 40%
  - ¼ previously Dx with PAH
- 26% in perioperatively, esp. early within 30days
- Surgery, main mode of death among patients with TOF
- 22% occurred suddenly



Nieminen HP, et al. JACC 2007. Helsinki, Finland

- Most patient due to pneumonia
- Mental retardation and seriously ill infants
- Neurological disease
- Other malformation and genetic syndromes
- Brain damage related to CHD or Op
- Accidental death was low
- The number suicide equal to the number expected.

	n
Cause of sudden death	
Arrhythmia/heart failure/unknown	73
Rupture of aorta	5
Pulmonary emboli	3
Myocardial infarct	2
Shunt occlusion	2
Rupture of an aneurysm of MPA	1
Subarchacnoidal bleeding	1
Pulmonary hemorrhage	1
All	88
Cardiovascular causes of death	
Stroke	11
Arrhythmia	6
Pulmonary emboli	6
Endocarditis	4
Brain abscess	4
Thrombosis	4
Myocardial infarct	3
Rupture of an aneurysm of PDA	2
Valve prothesis complication (aortic)	2
Pulmonary hemorrhage	2
Pericarditis	1
Myocarditis	1
All	46

Unrelated death

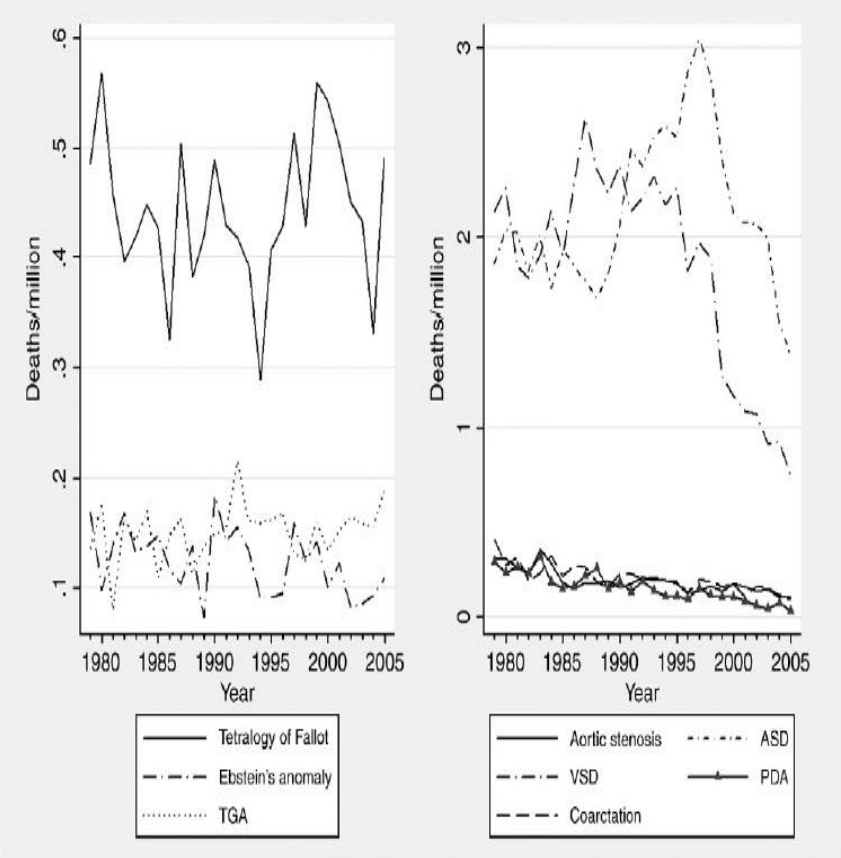
Sudden and CV deaths

Mortality asso. With ACHD: trends in the US population from 1979 to 2005. *P Pillutla, et al Am Hear J 2009*

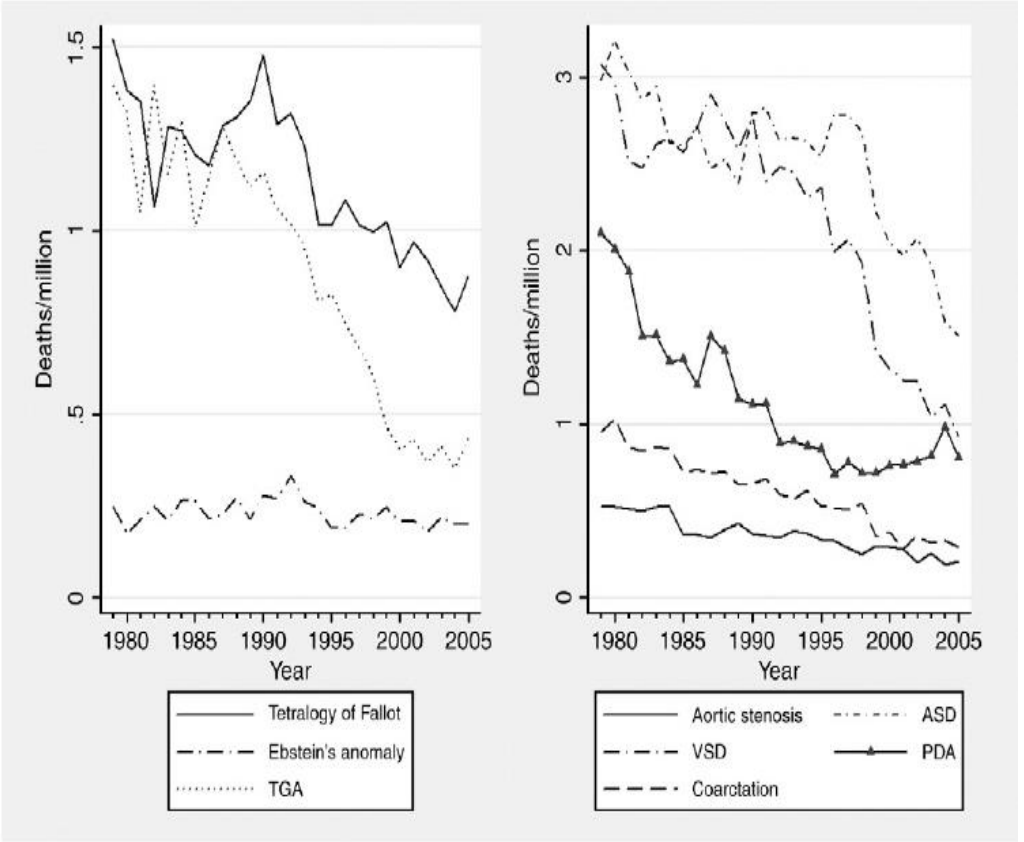
- CDC multiple cause of death registry 1979-2005 among individuals with CHD
- Significant reduction in death rate for ACHD
- 71% decline in TGA, 40% reduction in TOF
- Primary contributing cause of death

  Arrhythmia before 1990 vs. Myocardial infarction after 1990
- Overall decrease in the incidence of arrhythmia as the cause of death in all ages, particularly among children

Death rate for cyanotic and non-cyanotic CHD

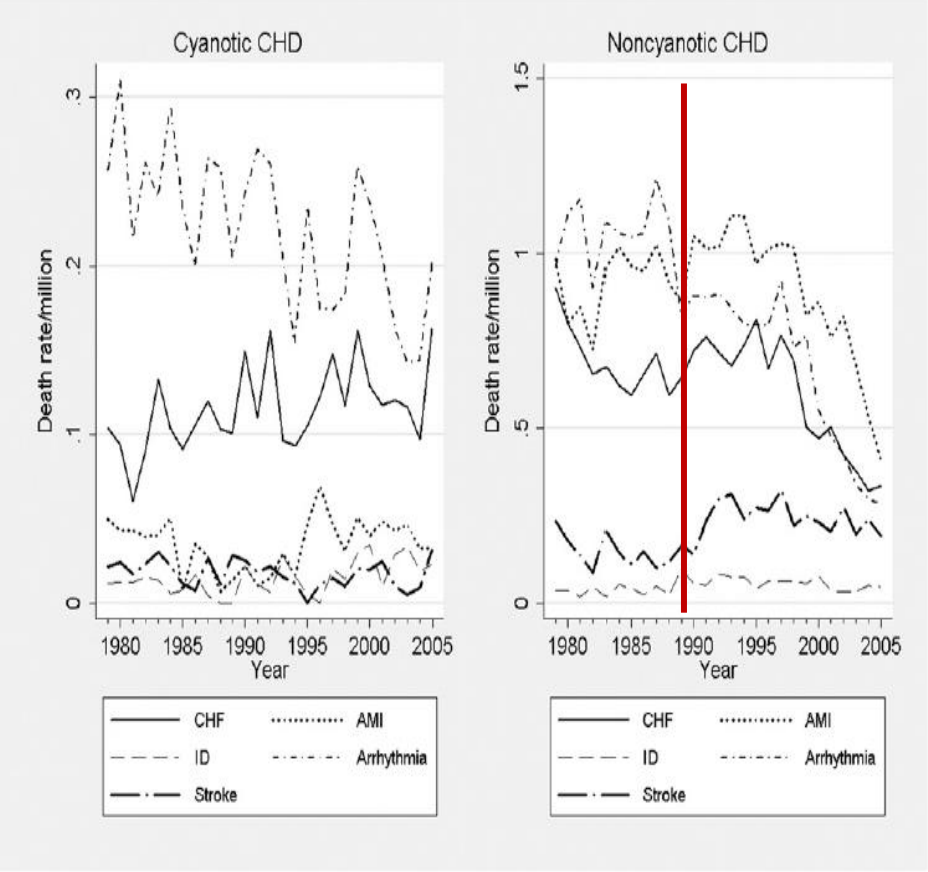


Death rates for cyanotic and noncyanotic CHD in adults.

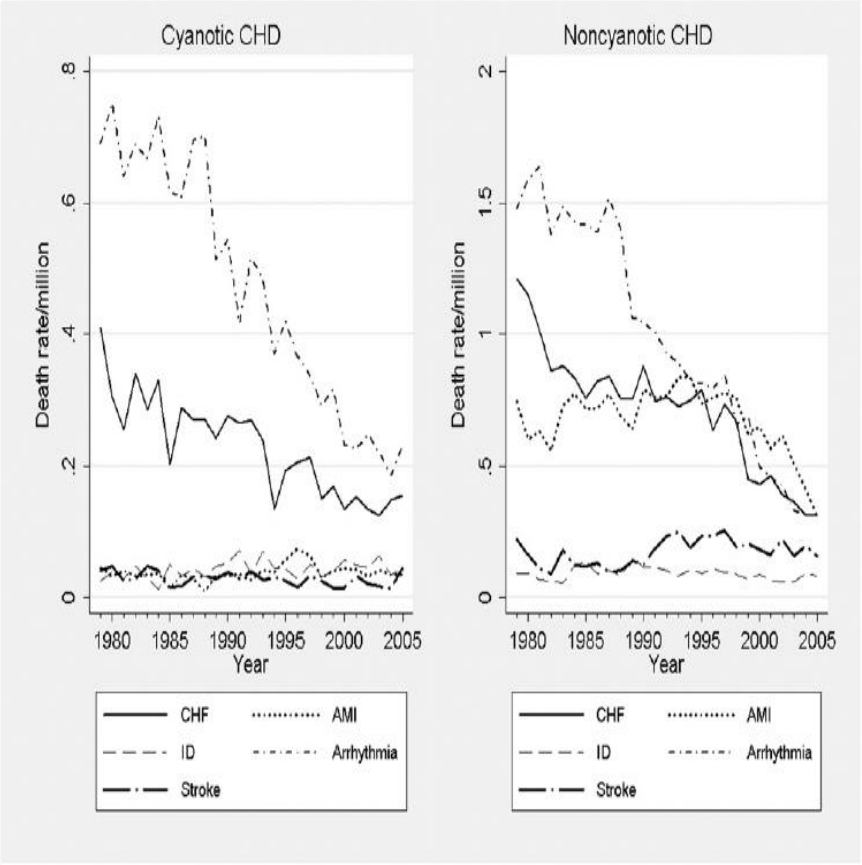


Death rates for cyanotic and noncyanotic CHD in all ages.

CHD in all and adult asso. Cause of death



CHD in adults-associated causes of death.



CHD in all ages-associated causes of death.

- A decline in age-adjusted mortality for almost every lesion.
- Mortality in patients of all ages with TOF & TGA was markedly decreased. Esp. primarily affected children
- A decline in incidence of arrhythmia and HF as Primary contributing cause of death
- Earlier recognition and Tx(reduced reliance on pro-arrhythmic medication and increased use of ICD) reduced mortality seen in TOF and TGA

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Impact of ACHD on survival and mortality after heart transplantation

BACKGROUND: Reduced early survival has been reported in adult congenital heart disease (ACHD) heart transplant (HTx) recipients, but little is known about late outcomes after HTx. The aim of this study was to examine survival; causes of death; and predictors of early (<1 year), mid-term (1 to 5 years) and late (>5 years) mortality in ACHD HTx recipients.

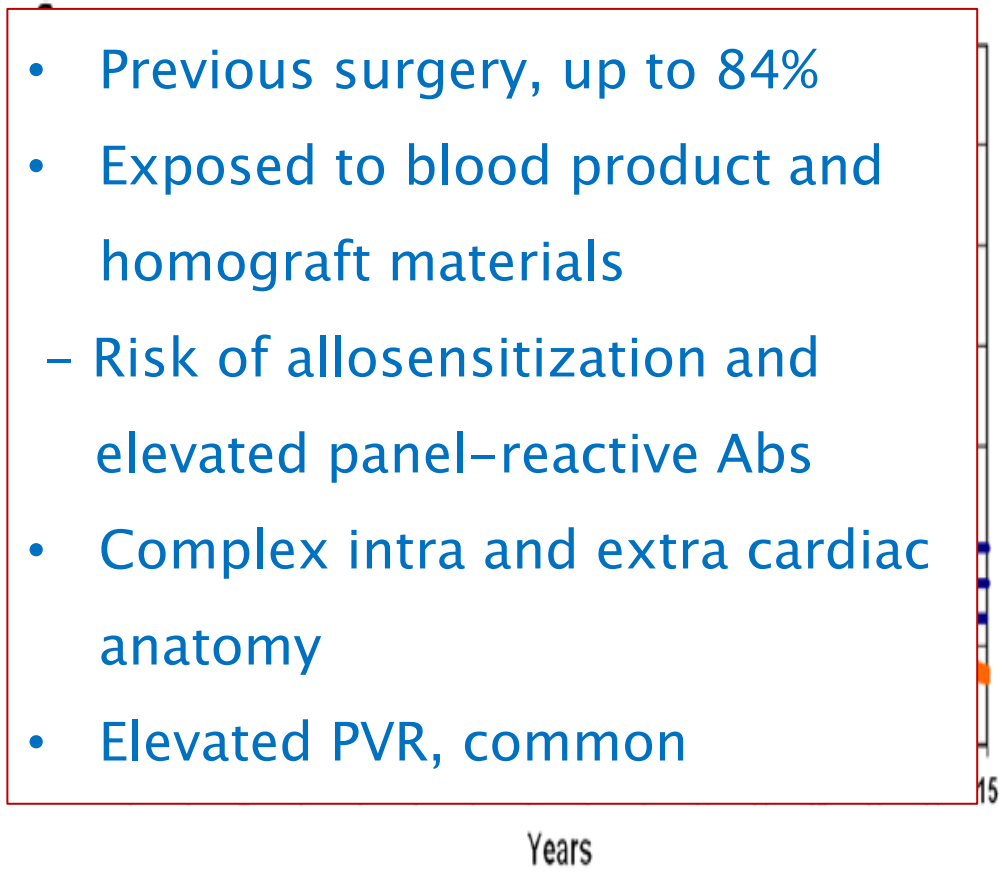
METHODS: ACHD patients undergoing HTx between 1985 and 2010 were identified in the transplant registry of the International Society for Heart and Lung Transplantation (ISHLT). Survival was compared between ACHD and other adult HTx recipients ("controls") using the Kaplan–Meier method. Factors associated with survival beyond 1 year were assessed using multivariable proportional hazards regression analysis.

RESULTS: Of 85,647 adults who underwent HTx, 1,851 (2.2%) were transplanted for ACHD. Early death secondary due to technical reasons was high among ACHD HTx recipients: 10% vs. 4% in controls ($p < 0.0001$). However, long-term survival of ACHD recipients who survived the early hazard phase was superior compared with controls ($p < 0.0001$). This was in part due to a lower infection ($p < 0.0001$) and malignancy-related ($p < 0.01$) mortality. Cardiac re-transplantation in ACHD HTx recipients was associated with a 2.75-fold increase in mortality.

Overall survival in ACHD HTx recipients and control

- "Survival Paradox"
- Advantage of Youth
- Low incidence of pre-transplant co-morbidities and lower infection and malignancy-related mortality after HTx

- Previous surgery, up to 84%
- Exposed to blood product and homograft materials
  - Risk of allosensitization and elevated panel-reactive Abs
- Complex intra and extra cardiac anatomy
- Elevated PVR, common



Summary I

- Marked reduction in infant mortality, decreasing MR in children and adolescents with CHD
- The burden of health is transitioning away from the child and toward the adult with CHD
- The patient with a cardiac lesion continues to require lifelong cardiology care, not only for the original defect but also for disease affecting the general population such as coronary artery disease.

Summary II

- The health community is challenged to meet these secular trend with appropriate allocation of resources.
- Future well provide a larger cohort from which more detailed prospective data can be obtained.


Thank You!