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M E D I C I N E

# Sudden Death in Congenital Heart Disease:

## What do epidemiologic studies tell us?

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# Disclosures

- No financial conflicts
- Excessive fun dancing with Medtronic employee last night though

# Case study

- 22 yo medical student with repaired ASD, pacemaker for advanced 2<sup>nd</sup> degree AV block
- Family History: Father with heart block, 2 sisters with ASDs, cousin with tricuspid atresia
  - Sudden death in father after ENT surgery

# Case study

- Patient experienced sudden death
    - Autopsy showed no obvious cause
    - Pacemaker interrogation unrevealing, working properly, had been checked 2 months before
  - NKx2.5 mutation found in affected family
  - 3 more family members died suddenly
- ***Lesion: epidemiology informs our practice in part, Genetics in part***

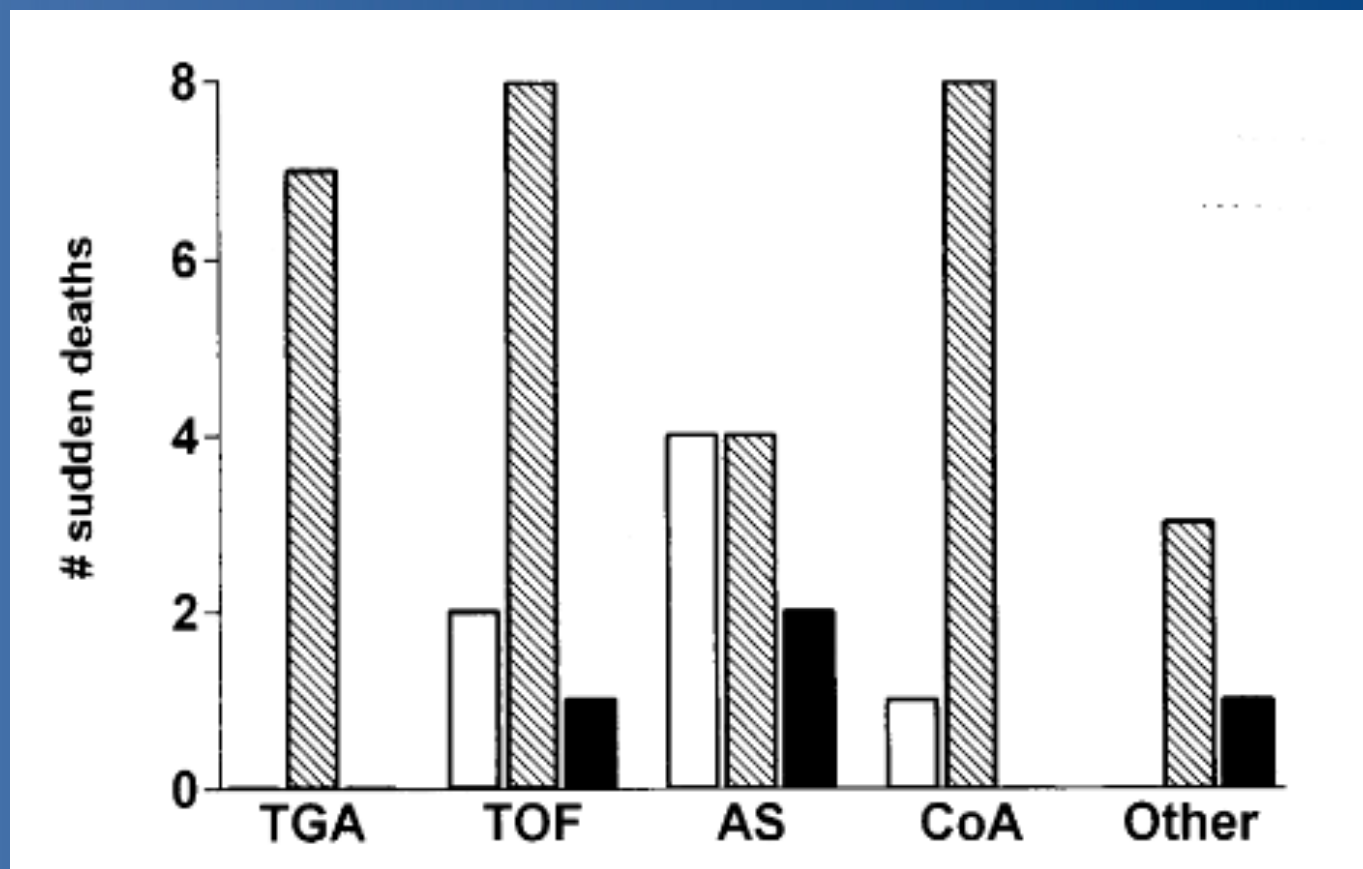
# Complexities of adult CHD that impact survival

- Initial anatomy and genetic make-up
  - eg ToF variants, NKx2.5
- Surgical history, quality of repair
  - eg scars that cause reentry tachycardia
- Late hemodynamic and arrhythmic effects
  - eg poor valve function resulting in ventricular dilation

# 1<sup>st</sup> big population-based study of survival after CHD surgery

- Silka, et al 1998: 3,589 patients s/p CHD surgery at <19 yo in single US state, 1958-1996
- 41 unexpected late deaths
  - ***Almost all*** in tetralogy, transposition, aortic stenosis, coarctation
    - Event rate 1/454 pt-years in these 4 dx
    - Event rate for all others 1/7174 pt-years

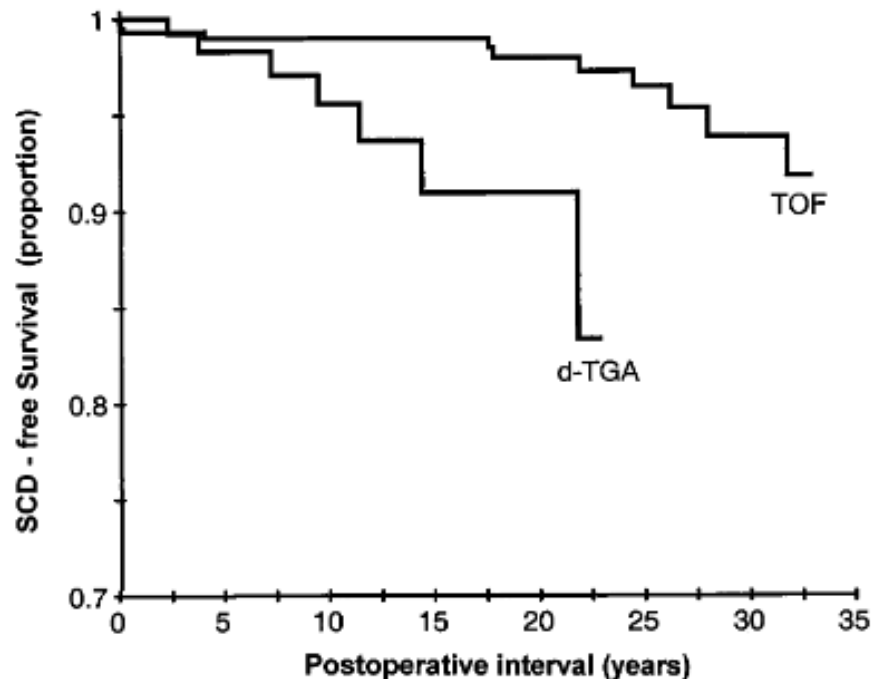
# Sudden death clustered



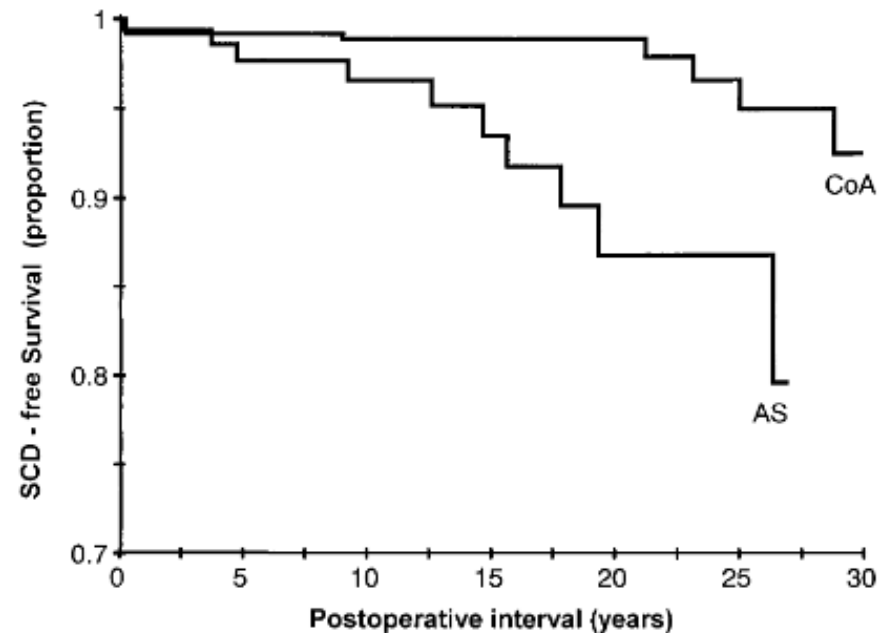
Hatched: arrhythmia, Open: circulatory, Dark: CHF

# Kaplan-Meier survival curves

## Cyanotic defects



## Left sided obstructive lesions



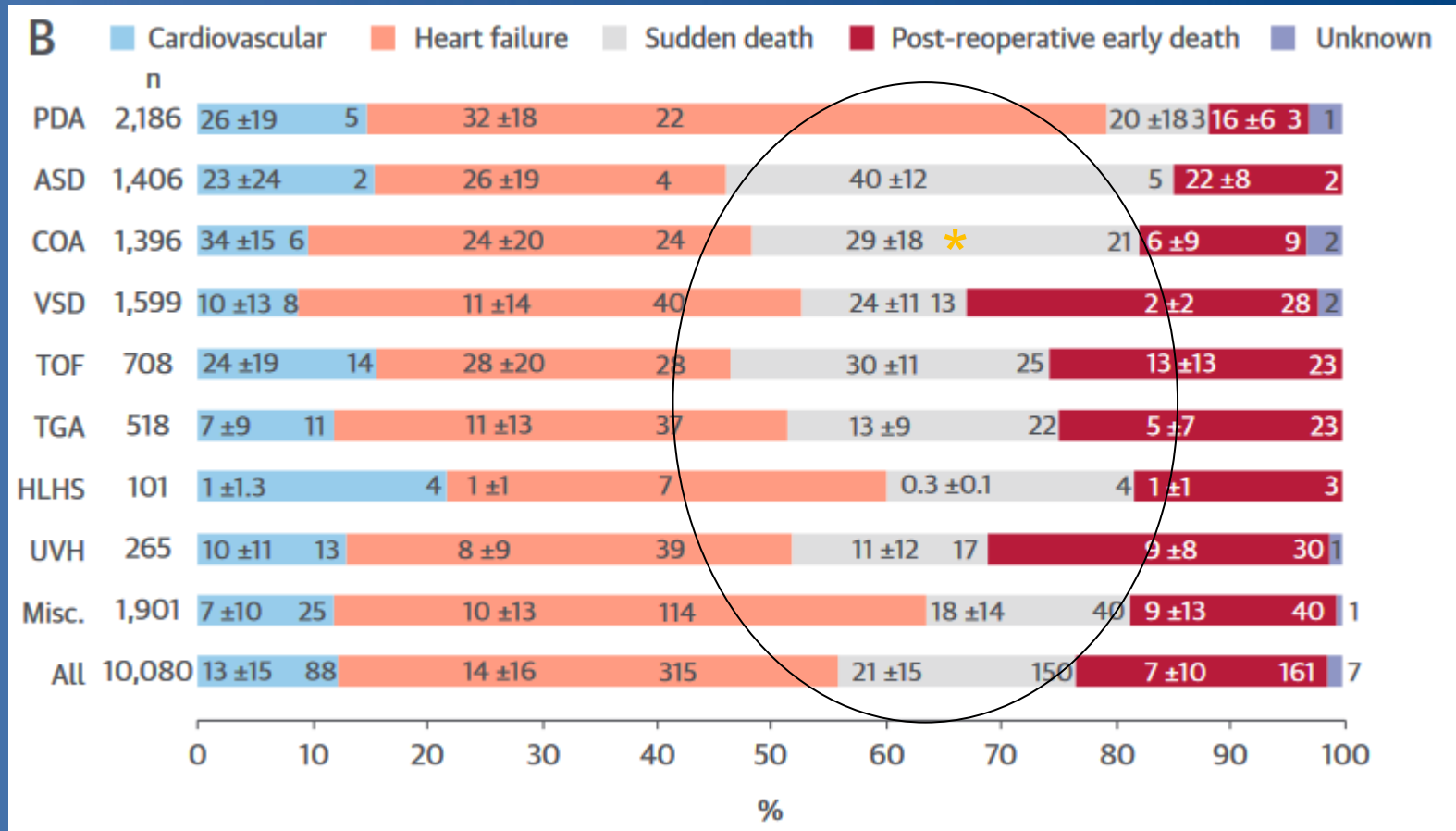


# Late Causes of Death After Pediatric Cardiac Surgery : A 60-Year Population-Based Study



- Survey of all late deaths following CHD surgery under 15 yo in Finland 1953-2009
- Total population 10,964 patients
  - All-cause late mortality 10%, cardiac 6.6%
  - **Sudden death in 1.5%**
    - 40 yr freedom from SCD 99% for simple defects, 91% for severe defects

# Same trends as Silka paper over the duration of the study



\* Includes untreated aortic stenosis

# Marked decrease in SCD in later cohort

**TABLE 3** Incidence of CHD-Related Deaths by Time Period of Operation

Defect	Cardiovascular Death Incidence/1,000 PY		Heart Failure Death Incidence/1,000 PY		Sudden Death Incidence/1,000 PY		Post-Reoperative Early Death Incidence/1,000 PY	
	1953 to 1989	1990 to 2009	1953 to 1989	1990 to 2009	1953 to 1989	1990 to 2009	1953 to 1989	1990 to 2009
PDA	0.07	0	0.31	0	0.03	0.13	0.04	0
ASD	0.08	0	0.15	0	0.23	0	0.04	0
COA	0.20	0	0.67	0.58	0.67 →	0.14	0.20	0.29
VSD	0.33	0.08*	1.42	0.84*	0.61 →	0†	1.13	0.34‡
TOF	0.85	0.78	1.94	0.78	1.94 →	0	1.55	0.78*
TGA	1.28	0.95	4.81	2.21†	3.53 →	0‡	2.41	2.52
UVH	3.50	3.47	11.51	9.26	4.50	4.63	9.01	6.95
Misc	0.62	0.83	3.10	2.95†	1.24	0.68	1.16	0.91*

\*p < 0.05. †p < 0.01. ‡p < 0.0001.

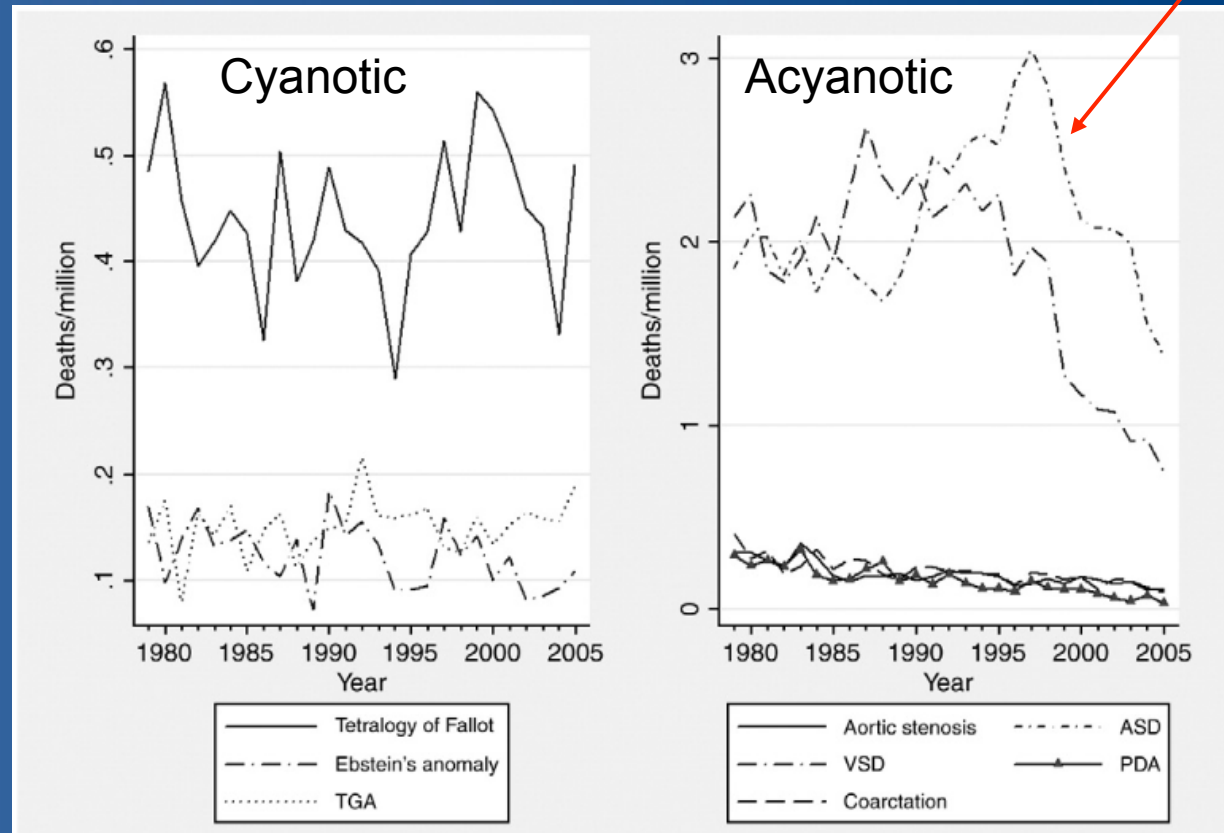
CHD = congenital heart defect; other abbreviations as in [Tables 1](#) and [2](#).

# Decreasing mortality associated with adult congenital heart disease

*Pillutla et al, Ann Thorac Surg, 2003*

- Looked at trends in the US population from 1979 to 2005

In adults, overall decline in death rates in VSD, Ebsteins, coarctation and aortic stenosis (not specific for SCD)



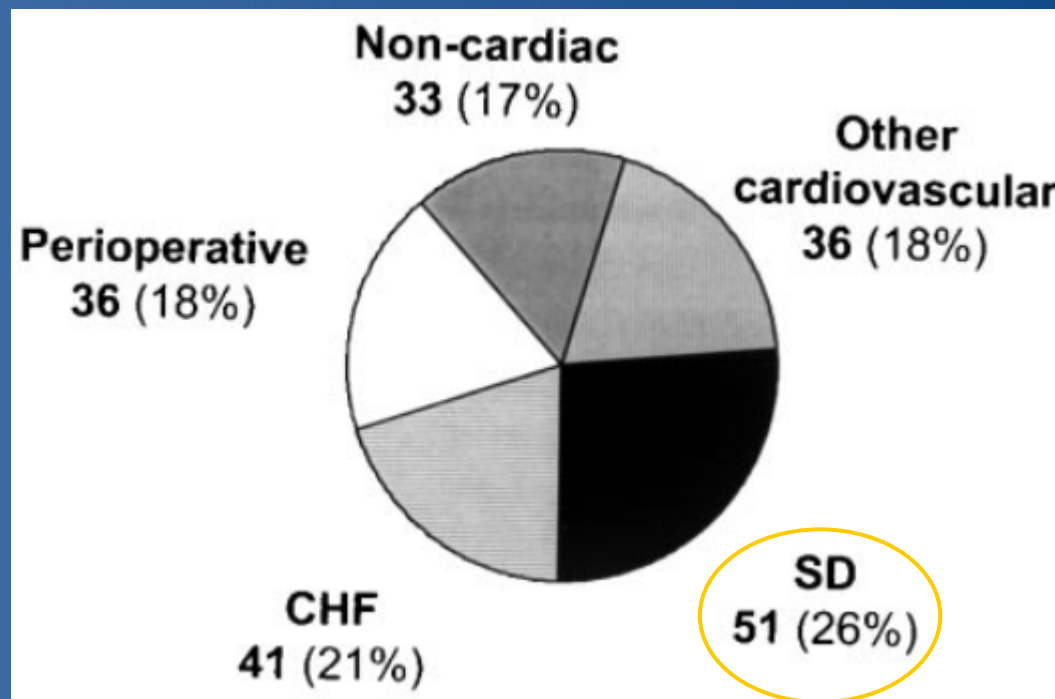
# Netherlands data

- 8595 ACHD patients, mean f/u 37 months
  - 2.7% mortality, mean age 48 years
    - 22% of deaths were sudden (<1% of population experienced SCD over this limited time frame)
      - 10% of these occurred during exercise
      - Ebsteins, DORV, TGA, VSD, aortic stenosis had more SCD than other lesions
  - (“vascular” deaths not included in SCD)

# Non-population based

- Toronto ACHD experience, 1981-1996
  - 2,609 patients
  - Data on 197/199 patients who died
    - 65% of deaths were cardiac
      - 26% sudden deaths (~2% of entire population)
      - New groups emerge in this older cohort:
        - » Ebstein's, L-TGA, as well as coarctation, AS and tetralogy

# Toronto series: mechanisms of sudden death in ACHD patients



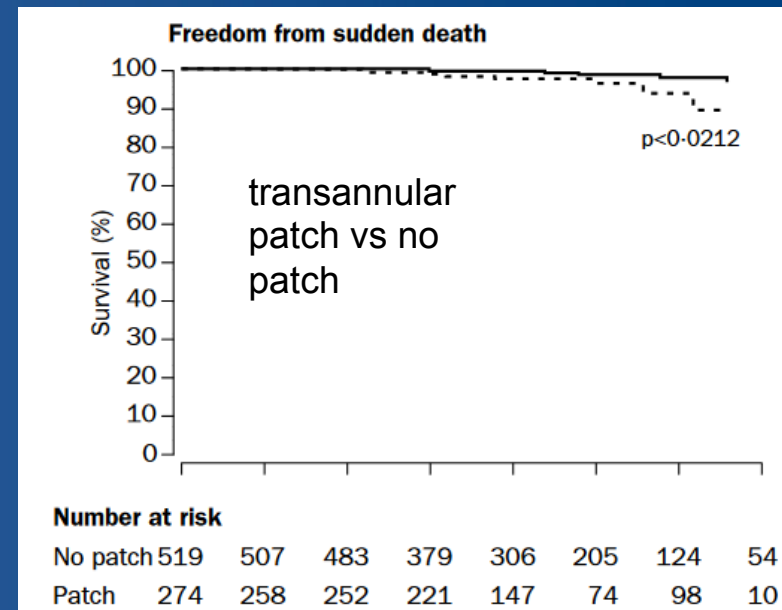
# Lesion specific: tetralogy of Fallot

- Ghai et al, 2002: 12 ToF pts with SCD compared with 125 without
  - Pts with SCD more likely to have:
    - Moderate to severe PR
    - History of sustained ventricular tachycardia
    - QRS duration >180 msec
    - Left ventricular dysfunction
- Combined positive predictive value 66%, negative predictive 93%



# Multicenter tetralogy of Fallot data

- Gatzoulis et al: 793 tetralogy pts with no heart block or clinical arrhythmias
  - Mean time from repair 21 years, 10 yr window 1985-1995
  - 16 pts (2%) died suddenly
  - **Risk factors for SCD**
    - Older age at repair
    - QRS duration >180 msec & increased rate of change in QRSd
    - Presence of tranannular patch



# Risk of sudden cardiac death in D-TGA with atrial switch surgery



## Overall SCD rates in adults ~5%

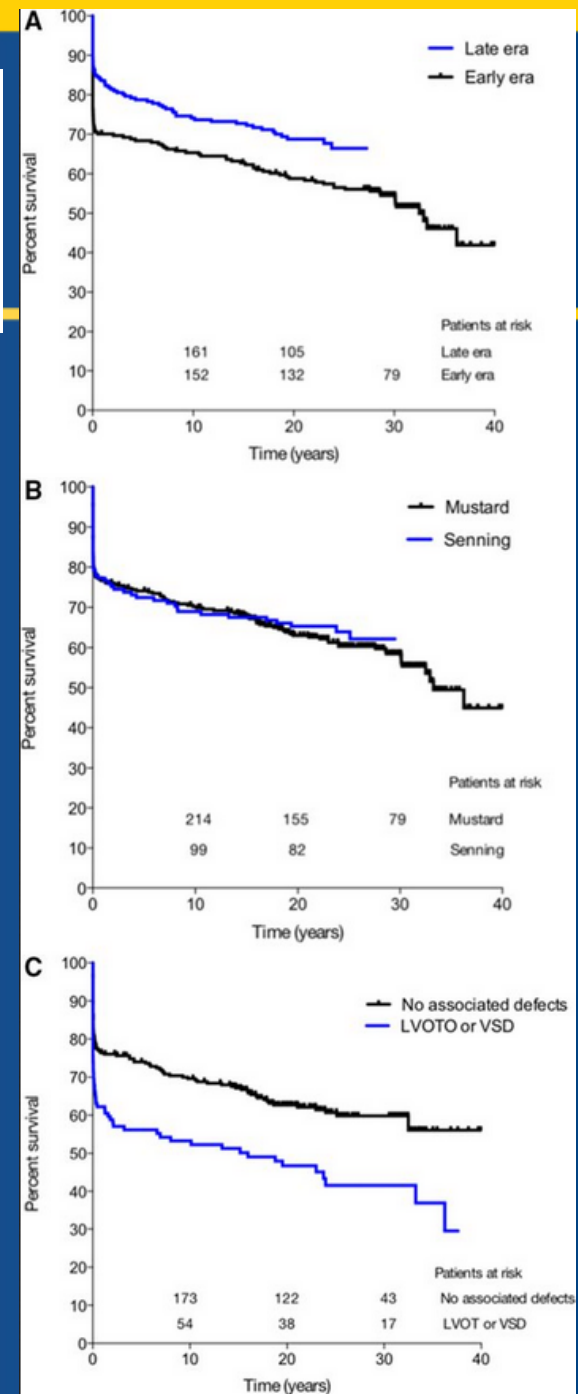
- Wheeler, et al 2014: 89 adult d-TGA
  - **5.6% sudden deaths, no therapies in 5 ICD pts**
- Roubertie et al 2011: 125 Senning survivors
  - **4% sudden deaths (4%)**
- Lange et al 2006: 417 pts: 329 Senning, 88 Mustard
  - **5% sudden late deaths, > late mortality in Mustard, VSD**

# Long-Term Outcome of Mustard/Senning Correction for Transposition of the Great Arteries in Sweden and Denmark

Niels Vejstrup, MD, PhD; Keld Sørensen, MD, DMSc; Eva Mattsson, MD, PhD;  
Ulf Thilén, MD, PhD; Per Kvidal, MD; Bengt Johansson, MD, PhD; Kasper Iversen, MD, DMSc;  
Lars Søndergaard, MD, DMSc; Mikael Dellborg, MD; Peter Eriksson, MD

## 468 Mustard/Senning patients, 1967-2003

- Follow-up in 2008
- After initial perioperative mortality, no significant differences in survival based on era of surgery, type of surgery, or associated defects



# Conclusions

- Epidemiology data suggests higher risk of SCD in coarctation, aortic stenosis, tetralogy of Fallot and transposition, probably Ebsteins', univentricular, L-TGA
- Death rates may be declining
- Some risk factors are apparent, best defined for tetralogy
- Constantly changing substrate

# Thank you very much!

