

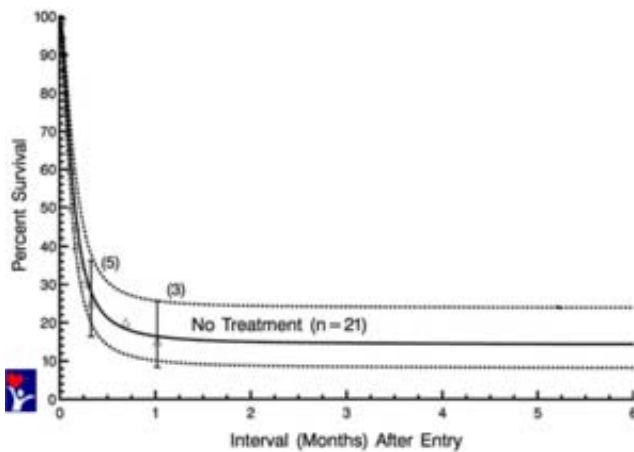
CONFERENCIAS MAGISTRALES  
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## Anesthesia for the child with congenital heart disease (CHD) for non-cardiac surgery

William J. Greeley, MD

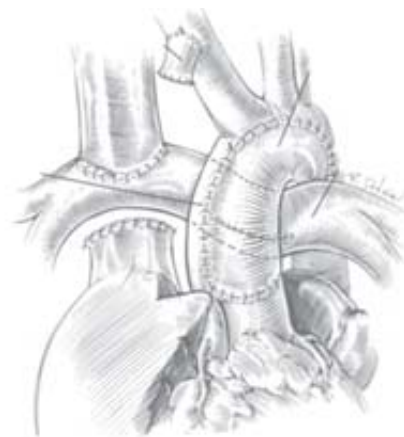
The Children's Hospital of Philadelphia  
Department of Anesthesia  
University of Pennsylvania School of Medicine

### HLHS - CIRCA 1980

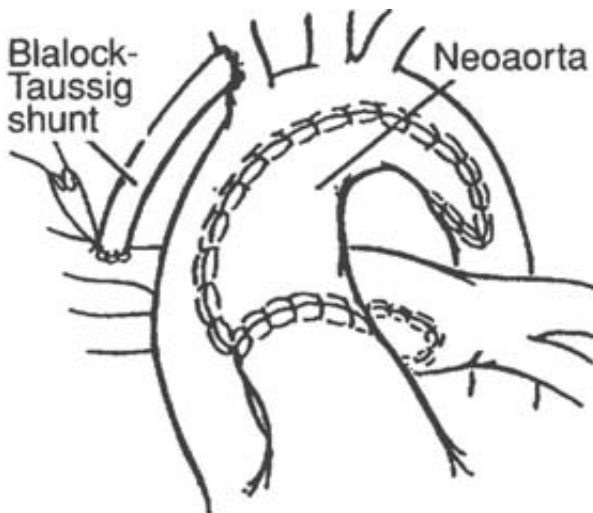


### STAGE II PROCEDURE

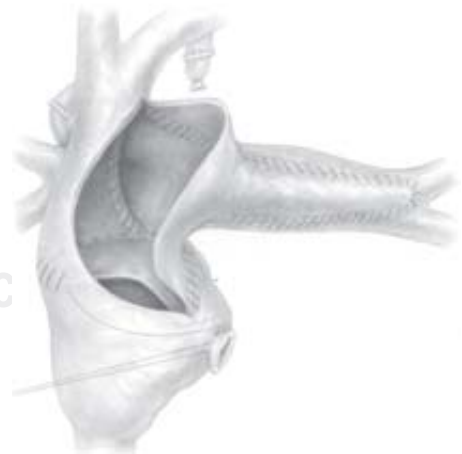
Superior Cavopulmonary Connection with Takedown of  
B-T Shunt Removes  
Volume Load on Single Ventricle



### STAGE I PROCEDURE

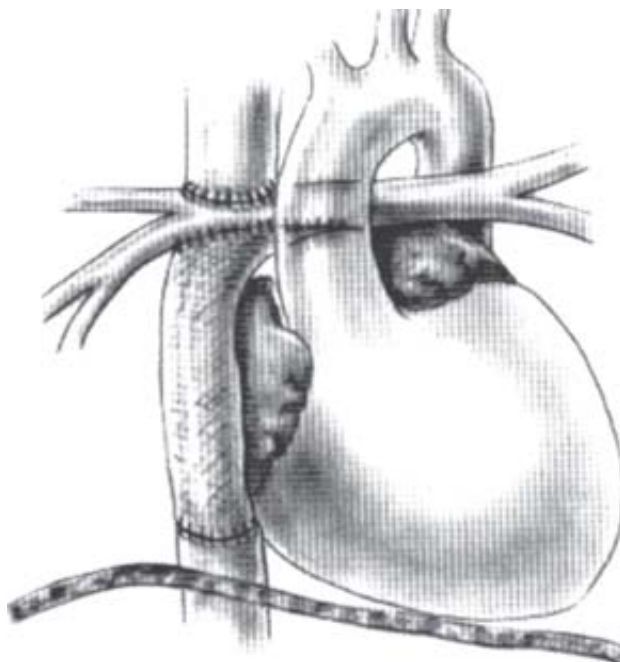


Bidirectional Glenn



Hemi-Fontan

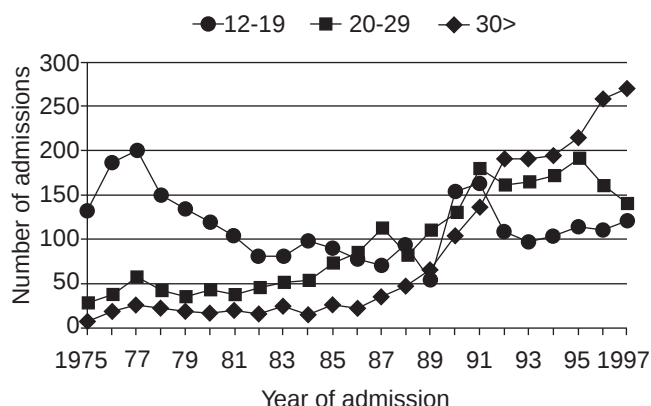
### STAGE III Extracardiac Fontan



### OBJECTIVES

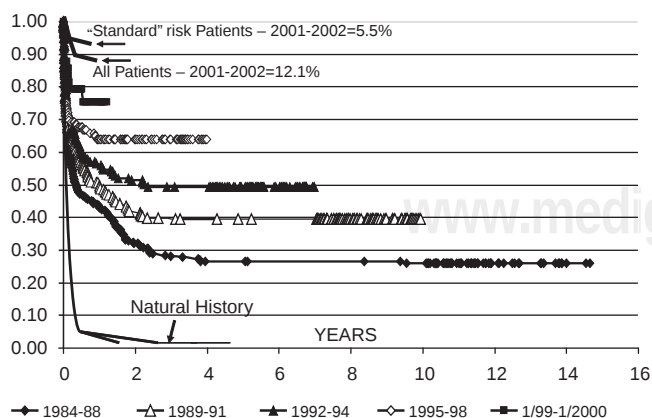
- Demographics
- Determinants of physiologic function
- Surgical procedures
- Anesthetic management

### HOSPITAL ADMISSION RATE-MAYO CLINIC



### HLHS- CUMULATIVE SURVIVAL - STAGED RECONSTRUCTION

N =1,056 Stage I Norwood Procedures



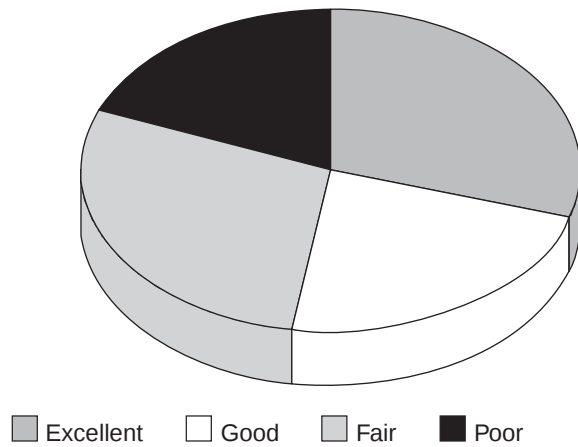
### DEMOGRAPHICS OF CHD IN USA

- 21,000-43,000 live births annually
- 20,000 cardiac surgical procedures
- Over 80% survival to third decade
- Prevalence 500,000-800,000
- Heterogeneous population

### PREVALENCE OF CONGENITAL HEART MALFORMATIONS

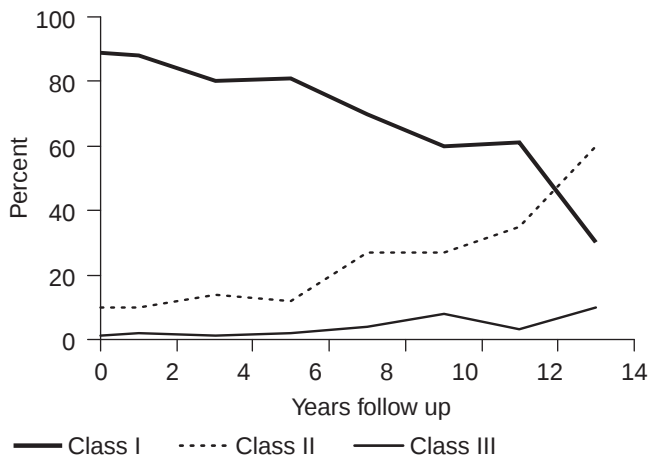
| Lesion                     | Infants (%) | Children (%) | Adults (%) |
|----------------------------|-------------|--------------|------------|
| Ventricular septal defect  | 28.3        | 24           | 15         |
| Patent ductus arteriosus   | 12.5        | 15           | 15.5       |
| Atrial septal defect       | 9.7         | 12           | 16         |
| Coarctation                | 8.8         | 4.5          | 8          |
| Transposition of great art | 8           | 4.5          | 2          |
| Hyoplastic left heart synd | 7.8         | —            | —          |
| Tetralogy of Fallot        | 7           | 11           | 15.5       |
| Pulmonary stenosis         | 6           | 11           | 15         |
| Aortic stenosis            | 3.5         | 6.5          | 5          |
| Truncus arteriosus         | 2.7         | 0.5          | —          |
| Tricuspid atresia          | 1           | 1.5          | 1          |

## AORTIC STENOSIS AFTER 25 YEARS



Keane *et al*, *Circulation* 1993;87(Suppl)I:16

## FONTAN NYHA CLASS



Fontan F, *et al*: *Circulation* 1990;81:1520

## OBJECTIVES

- Demographics
- Determinants of physiologic function
- Surgical procedures
- Anesthetic management

## DETERMINANTS OF PHYSIOLOGIC FUNCTION

- Sequelae
- Complications
- Palliation
- Correction

## COMMON SEQUELAE

- Arrhythmia
- Ventricular dysfunction
- Hemodynamic disturbance
- Pulmonary vascular disease

## DETERMINANTS OF PHYSIOLOGIC FUNCTION

- Sequelae
- Complications
  - CNS
  - Renal
  - Hematologic

## DETERMINANTS OF PHYSIOLOGIC FUNCTION

- Sequelae
- Complications
- Palliation
  - e.g. single ventricle & Fontan

## DETERMINANTS OF PHYSIOLOGIC FUNCTION

- Sequelae
- Complications
- Palliation
- Correction

## FONTAN OPERATION

- Functional level -NYHA
- Arrhythmia 20 – 30%
- Ventricular function 10 – 20%
- Pulmonary vascular disease 25%
- Hemodynamic sequelae 100%
- Protein losing enteropathy 5 – 10%
- Thromboembolism 15 – 20%

## OBJECTIVES

- Demographics
- Determinants of physiologic function
- Surgical procedures
- Anesthetic management

## SURGERY IN CHILDREN WITH CHD

- Dental procedures
- General surgery
- Urology
- Trauma
- Orthopedic surgery

**CHOP NON-CARDIAC SURGERY 2004**

- Requests 945/CVA 424
- PS II (154), PS III (195), PS IV (75)
- Elective (400), emergency (24)
- Day Surgery (274), overnight stay (150)
- Simple procedures (60%) – BMT, T/A, circumcision, hernia
- Complex procedures (40%) – TEF, brain tumor, tumor resection, transplant, etc.

**SURGERY IN ADULTS WITH CHD**

- Labor and delivery
- Trauma
- Orthopedic surgery
- General surgery
- Cardiac surgery

**OBJECTIVES**

- Demographics
- Determinants of physiologic function
- Surgical procedures
- Anesthetic management

**Table I.** Personnel and services recommended or required for regional ACHD centers.

| Type of service or personnel                            | Local care                                                                                                                                                                                      | Regional ACHD center                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pediatric ACHD cardiologist                             | Optional                                                                                                                                                                                        | One or several 24/7*                                                                                                                                                                                                                                                                                                          |
| Adult medical ACHD cardiologist                         | Optional                                                                                                                                                                                        | One or several 24/7*                                                                                                                                                                                                                                                                                                          |
| Mid-level practitioner                                  | Optional                                                                                                                                                                                        | Two/several                                                                                                                                                                                                                                                                                                                   |
| Congenital heart surgeon                                | No                                                                                                                                                                                              | Two/several 24/7*                                                                                                                                                                                                                                                                                                             |
| Cardiac anesthesia                                      | No                                                                                                                                                                                              | Several 24/7*                                                                                                                                                                                                                                                                                                                 |
| Echocardiography**                                      | Refer to regional ACHD center                                                                                                                                                                   | Two/several 24/7*                                                                                                                                                                                                                                                                                                             |
| Includes TEE, intraoperative TEE (required for surgery) |                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                               |
| Diagnostic catheterization**                            | Refer to regional ACHD center                                                                                                                                                                   | Yes 24/7*                                                                                                                                                                                                                                                                                                                     |
| Noncoronary                                             |                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                               |
| interventional catheterization**                        | Refer to regional ACHD center                                                                                                                                                                   | Yes 24/7*                                                                                                                                                                                                                                                                                                                     |
| Electrophysiology**                                     | Consult regional ACHD center unless unrelated to CHD                                                                                                                                            | Yes 24/7*                                                                                                                                                                                                                                                                                                                     |
| Exercise testing                                        | Standard                                                                                                                                                                                        | Echo, radionuclide, cardiopulmonary, metabolic                                                                                                                                                                                                                                                                                |
| Transplant                                              | Optional                                                                                                                                                                                        | Heart, lung, heart-lung desirable                                                                                                                                                                                                                                                                                             |
| Cardiac imaging/radiology services                      | Optional                                                                                                                                                                                        | CT scan, cardiac MRI with fast-pulse sequencing*, nuclear medicine                                                                                                                                                                                                                                                            |
| Cardiac pathology                                       | Optional                                                                                                                                                                                        | Yes                                                                                                                                                                                                                                                                                                                           |
| Information technology                                  | Optional                                                                                                                                                                                        | <ul style="list-style-type: none"> <li>• Data collection</li> <li>• Database support</li> <li>• Interface with local practitioners, including internet-based applications</li> <li>• Quality assessment review and protocols</li> </ul>                                                                                       |
| Other                                                   | <ul style="list-style-type: none"> <li>• Interface with regional ACHD center</li> <li>• Data collection</li> <li>• Participation in patient-care and best-practice guidelines review</li> </ul> | <ul style="list-style-type: none"> <li>• Optional development of best practice guidelines</li> <li>• Adolescent transitional unit</li> <li>• High risk obstetrics</li> <li>• Genetics</li> <li>• Rehabilitation services</li> <li>• Social services</li> <li>• Vocational services</li> <li>• Financial counselors</li> </ul> |

\*\* 24/7\* denotes availability 24 hours/day, 7 days/week. \*\* These modalities must be supervised/performed and interpreted by physicians with specific skills and knowledge in CHD, as outlined.

**DESIRABLE HEMODYNAMIC OBJECTIVES**

|                 | Preload | PVR | SVR | HR  | Contractility |
|-----------------|---------|-----|-----|-----|---------------|
| ASD (L→R)       | ↑       | ↑   | ↓   | N   | N             |
| PDA (L→R)       | ↑       | ↑   | ↓   | N   | N             |
| VSD (L→R)       | ↑       | ↑   | ↓   | N   | N             |
| VSD (R→L)       | N       | ↓   | ↑   | N   | N             |
| AS              | ↑       | N   | ↑*  | ↓*  | N-↑           |
| IHSS            | ↑       | N   | N-↑ | ↓*  | ↓*            |
| Valvar PS       | ↑       | ↓   | N   | ↓   | ↑             |
| Infundibular PS | ↑       | ↓   | N   | ↓   | ↓*            |
| Coarctation     | ↑       | N   | ↓   | N   | N             |
| MS              | ↑       | N-↓ | N   | ↓*  | N-↑           |
| MR              | ↑       | N-↓ | ↓   | N-↑ | N-↑           |
| AI              | ↑       | N   | ↓   | N-↑ | N-↑           |

\* Overriding consideration

**ANESTHETIC MANAGEMENT**

More important to be guided by a safe, familiar, established anesthetic technique than to have a detailed understanding of the specific pathophysiologic lesion

**ANESTHETIC MANAGEMENT**

- Patient evaluation
- Cardiologist communication
- Perioperative plan
  - Preoperative goals
  - Postoperative expectations
- Physiologic anesthetic

**EVALUATION OF CARDIAC STATUS**

- Activity tolerance
- Growth pattern
- Congestive heart failure
- Magnitude of cyanosis
- Medications
- Cardiologist evaluation

**FORMULATION OF AN ANESTHETIC PLAN**

- Patient considerations
- Operative considerations
- Postoperative considerations

**PATIENT CONSIDERATIONS**

- Associated conditions –e.g. Chr 22
- Airway –e.g. tracheal stenosis
- Psychosocial issues –e.g. depression
- Medications
- Hematocrit –e.g. cyanosis

**OPERATIVE CONSIDERATIONS**

- SBE prophylaxis –e.g. AHA
- Monitoring –e.g. BP, ECG, Pulse Ox
- Vascular access –e.g. CVP, A-line
- Positive pressure ventilation –e.g. VR
- Laparoscopy
  - Insufflation, Trendelenberg
  - VR & PBF, emboli & R→L shunts
- Single lung ventilation
  - Cyanosis, PBF, AV malformations

**POSTOPERATIVE CONSIDERATIONS**

- PACU vs ICU
- Patient comfort
  - Pain – SVR & PVR changes, neuraxial analgesia
  - N & V – fluids
- Fluid management

**CONCLUSIONS**

- Physiologic spectrum wide
- Expected outcome of a specific lesion and sequelae
  - (Arrhythmia, ventricular dysfunction, hemodynamic residua, pulmonary vascular disease)
- Formulation of anesthetic plan
- Response to provocative conditions
  - General
  - Specific
- Successes in surgery create later challenges for anesthesiology