Resuscitation in congenital heart disease

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Evolution of Congenital Heart Disease

Extraordinary success:
  Overall survival for initial hospitalization: 96-98%

Resuscitation:
  Infants & children post repair
  Adults with congenital heart disease (ACHD)
  Corrected not cured
Estimated clinical relevance of CHD in the next years

Patients

- Live births with CHD: 0.8% of all live births
- Children with CHD: 90% of live births with CHD
- 18-year-olds with CHD: 80% of children with CHD
- Adults with CHD

Image source: Competence Network for Congenital Heart Defects
ACC/AHA 2008 Guidelines for the Management of Adults With Congenital Heart Disease

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Develop Guidelines on the Management of Adults With Congenital Heart Disease)

Developed in Collaboration With the American Society of Echocardiography, Heart Rhythm Society, International Society for Adult Congenital Heart Disease, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons

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Delivery of Care

• Transitions
  - Patient Passport
  - Information & interpretation

• Regionalized ACHD centers of excellence
  - Different models: within an adult hospital or part of an expanded congenital heart center / institute
  - Expertise in cardiology, diagnostic and interventional catheterization, cardiac anesthesia
  - No recommendations re: surgeon, perfusion, critical care or nursing

• Resuscitation:
  - Consensus statement being prepared
There are hundreds of combinations and permutations of congenital cardiac lesions
Effective CPR

• Consistent & coordinated compressions
  – PALS guidelines

• Avoid overdosing with resuscitation drugs
  – Epinephrine, Bicarb and Ca++

• Induce hypothermia
  – Primary treatment, not post injury
Early Recognition & Prevention

Emphasize CPR quality:

- Push hard, fast, and allow full recoil
- 100 compressions/minute
- Minimize interruptions to compressions
- Rotate compressors
- Avoid excessive ventilation
<table>
<thead>
<tr>
<th></th>
<th>Surgical-Cardiac Group (n=640), % (n)</th>
<th>Medical-Cardiac Group (n=574), % (n)</th>
<th>Noncardiac (n=2109), % (n)</th>
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<tbody>
<tr>
<td><strong>CPR duration, min</strong></td>
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<tr>
<td>Mean</td>
<td>29.7</td>
<td>28.1</td>
<td>24.1*‡</td>
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<td>Interquartile range</td>
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<td>Alkalizing agents</td>
<td>70 (448)</td>
<td>64 (370)</td>
<td>59 (1245)*</td>
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<td>(sodium bicarbonate,</td>
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<td>THAM)</td>
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<tr>
<td>Atropine</td>
<td>30 (190)</td>
<td>42 (242)*</td>
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<td>Calcium</td>
<td>64 (409)</td>
<td>47 (271)*</td>
<td>41 (874)*‡</td>
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<td>Epinephrine</td>
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<td>87 (1845)</td>
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<td>Vasopressin†</td>
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<td>4 (18)</td>
<td>6 (102)</td>
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<tr>
<td>ECPR#</td>
<td>19 (117)</td>
<td>6 (34)*</td>
<td>2 (34)*‡</td>
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Effective CPR

- Consistent & coordinated compressions
- PALS guidelines
- Avoid overdosing with resuscitation drugs
- Epinephrine, Bicarb and Ca++
- Induce hypothermia
- Primary treatment, not post injury
Consideration in patients with CHD

• Principles of resuscitation the same:
  – Stroke volume with compression
  – Coronary perfusion
  – Pulmonary blood flow
  – Systemic perfusion: Cerebral
    • Run-off
    • CPP

• Complex anatomy and repairs

• Pathophysiology
Consideration in patients with CHD

- Principles of resuscitation the same
- **Complex anatomy and repairs**
- Pathophysiology
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<th>Vascular Access</th>
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<td></td>
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<td>Femoral Artery</td>
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<th>ANATOMY</th>
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<td>Aortic arch</td>
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- Diagram of defect & repair
- Access
- Compressions
- Defibrillation
Consideration in patients with CHD

- Principles of resuscitation the same
- Complex anatomy and repairs
- Pathophysiology
Transposition Great Arteries: Immediate post-operative resuscitation

- Arrhythmia with LCO = ischemia
- Coronary perfusion:
  - Usually mechanical
  - Pacing not effective: open chest ECMO
Arterial Switch Operation:
**Longer term**

Reconstructed RVOT  
5-10% stenosis

Pulmonary valve in the aortic position  
30% trivial AR

Coronary reimplantation  
up to 8% Occlusion

Aortic root dilation  
Uncertain

Arrhythmia  
Low risk

Functional class  
NYHA I / II
RVOT reconstruction

Restrictive RV physiology
- Elevated EDP, RVH
- RVOT & pulmonary stenosis
- Residual atrial defect

Systolic RV dysfunction
- Elevated ESV, RV dilation
- Pulmonary regurgitation

Arrhythmias
- Ventricular, risk for sudden death
- Risk higher with ↑EDv vs. Edp
- No recommendation for prophylaxis
Restrictive LV Physiology

- LVH with increased EDp, LAp & decreased ESv
  - Inadequate filling time
  - Elevated PAp
  - Limited ejection fraction
  - Ischemia
Functional repair: Cavo-Pulmonary connection

Fenestrated Fontan
Positive pressure ventilation

Fontan physiology

ECG

Pulmonary flow

resp

insp
Consideration in patients with CHD

• Limited stroke volume with compressions:
  - Impaired preload:
    Cavo-pulmonary connection
    Elevated PAP or PVR
  - Impaired ventricular filling:
    AVVR
    Ventricular hypertrophy and restrictive physiology
  - Impaired ejection fraction:
    Semilunar valve regurgitation
Consideration in patients with CHD

- Limited stroke volume with compressions:
  - RVOT obstruction
  - Elevated PVR
  - LA hypertension
  - Cavo-pulmonary connection

- Limited pulmonary blood flow & oxygenation

- Decreased cerebral perfusion
Consideration in patients with CHD

- Limited stroke volume with compressions:
- Limited pulmonary blood flow & oxygenation
- Decreased cerebral perfusion
  - Cavo-pulmonary connection
  - AoV regurgitation
CPR guidelines 2005, 2010
Recommend use of ECMO to support failed CPR

Extracorporeal Membrane Oxygenation
“Consider extracorporeal CPR for in-hospital cardiac arrest refractory to initial resuscitation attempts if the condition leading to cardiac arrest is reversible or amenable to heart transplantation, if excellent conventional CPR has been performed after no more than several minutes of no-flow cardiac arrest (arrest time without CPR), and if the institution is able to rapidly perform extracorporeal membrane oxygenation (Class IIb; LOE 561,62). Long-term survival is possible even after 50 minutes of CPR in selected patients.”
Outcomes among neonates, infants, and children after extracorporeal cardiopulmonary resuscitation for refractory inhospital pediatric cardiac arrest: A report from the National Registry of Cardiopulmonary Resuscitation*

Tia T. Raymond, MD; Christopher B. Cunyngham, MD; Marita T. Thompson, MD; James A. Thomas, MD; Heidi J. Dalton, MD; Vinay M. Nadkarni, MD; for the American Heart Association National Registry of CPR Investigators

*N = 199

PCCM 2010 11: 362 - 71
Pediatric Outcomes After Extracorporeal Membrane Oxygenation for Cardiac Disease and for Cardiac Arrest: A Review

ARI R. JOFFE,* LAURANCE LEQUIER, * and CHARLENE M.T. ROBERTSON†


• 2000-2011
• 45% cumulative survival (788/1735)
• Factors predicting non-survival:
  – Duration of ECMO
  – End organ injury
  – NOT ECPR
Improving the quality of CPR

• Leadership is key
• Control the chaos
  – Role assignment
  – Effective communication
• ICU structure / teams & training
  – Dedicated CICU, Cardiac Code team
  – Staffing levels & experience

REVIEW ARTICLE

The American Heart Association’s Recent Scientific Statement on Cardiac Critical Care: Implications for Pediatric Practice

Daniel J. Penny, MD, PhD, MHA,*‡ and Lara S. Shekerdemian, MD, FAAP, MHA†
Divisions of *Cardiology and †Critical Care, Texas Children’s Hospital, and †Department of Pediatrics, Baylor College of Medicine, Houston, Tex, USA

Congenit Heart Dis. 2013;8:3–19
Future

• Longer term outcomes
• Focus on ACHD risk & prevention
  – Passport and algorithm
• Reliable and actionable data