Rapid Mobile Cardiopulmonary Support
22 Years Later
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Overview
Our experience
Current system & practice

Pediatric ECLS Support 1995

ECMO Disadvantages
- Procedural setup time
- 2 cannulae
- Large priming volume
- ECMO
- Difficult patient transport
- Requires Heparinization pump

ECMO and ELSO* Survival Statistics
- Neonatal 80%
- Pediatric 53%
- Overall 61%
- Cardiac 38%

*ELSO = Extracorporeal life support organization (1995)
Literature Review

- Children’s Hospital Pittsburgh (1981-1994)
  - (N=68) survival to discharge = 38%
  - < 1 month = (27%)
  - > 1 month = (42%)
  - Mean CPR duration 65 minutes
  - 100% survival if CPR <15 minutes
  - 55% survival if CPR >42 minutes
  - Length of CPR adverse predictor of outcome

- Children’s Hospital Michigan (1984-1994)
  - (N=73) survival to discharge = 58%
  - 23.5% in OR, 69% post-op, 57% pre-op
  - RBC requirements
  - 24 ml/m2/h survivors
  - 88 ml/m2/h non-survivor
  - Post-op bleeding adverse predictor of outcome

Rapid Cardiopulmonary Support (CPS) 1995

- Increased
  - Neonatal open heart surgery
  - Interventional procedures

- Objectives
  - Reduce setup time
  - Reduce priming volume
  - Facilitate patient transport
  - Minimize need for blood products
Rapid Cardiopulmonary Support (CPS) 1995

Advantages

- Rapid setup (less than 5 minutes)
- Lower priming volume (250cc)
- Bloodless prime even in Neonates
- Complete Carmeda coating
  - Reducing the need for Heparin
- Drainage not gravity dependent
- Remote transport possible

Increase in the Number of High Risk Transportation

Problem:
- We were not a birthing or transplant center
- Delayed patient transfer
- Expansion in the use of nitric oxide / oscillators
- Increase in the number of pediatric hospitals

Solutions:
- Miniaturized / simplified ECLS systems
- Community CPS transport service

NCH Survival stats 1995-1997

Results:
- Overall survival to discharge was 48% (11 of 23 patients)
- Survival to discharge was 80% (4 of 5) in the preoperative support group
- 50% (2 of 4 patients) in the nonoperative group
- 44% (4 of 9) in the group placed on support postoperatively in ICU
- 20% (4 of 5) in the postoperative failure to wean from cardiopulmonary bypass group
- Neonatal cardiopulmonary support survival to discharge was 46% (6 of 13 patients)

ECPR International Annual Volume (ELSO)
NCH Transport CPS Design & Experience

**F.A.A. Regulations**
- Portable Electronic Medical Equipment
- Cart Tie Downs
- FAA regulations (1998)

NCH Transport CPS Design & Experience (1998)
Sikorsky S76 C
Range 300 Miles (167 mph)

Learjet 35 A
Range 2000 Miles (525 mph)
NCH Transport CPS Design & Experience

- Total 27
- Survival to DC 13 (48%)
- Median age 5 years (0-65 yrs.)
- Median Weight 16.3 kg (2.1-80 kg)
- Longest distance 1,358 miles
- 6 Transported for HX (50% SD)

NCH interventional CPS Experience 1995 - 2001

- 62 postoperative patients
- 56% Interventions
- Median Post-Op day 9
- 9 on support (56% SD)
- Early (< 24 h) catheterization

<table>
<thead>
<tr>
<th>Diagnosis</th>
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NCH Interventional CPS Experience

- 62 postoperative patients
- 56% Interventions
- Median Post-Op day 9
- 9 on support (56% SD)
- Early (< 24 h) catheterization

Diagnosis

- Meconium Aspiration
- Ebstein’s
- Pneumonia
- Cardiomyopathy
- Pulmonary Hypertension
- Cardiomyopathy
- S/P Ross-Konno
- Arrhythmia
- Coarctation, PHT
- ARDS, Myocarditis

Literature Review

- 2005-2011
- Post-op ECMO (N=119)
- 28% residual lesions
- Early reintervention improved outcomes
Residual Lesion dx ≤ 3 days
No Residual Lesion
Residual Lesion dx > 3 days

2012 Cart Redesign

NCH CPS Outcomes Related to Days of Support 1995-2017

- 146 Survivors (50% survival rate)
- Median Age 19 days
  - 0 days-65 yrs
- Median Weight 3.3 kg
  - 1.5-111 kg
- Average Duration 63 hrs
- Longest run 30 days (resp. infection)
- Longest run survivor 8 days

N=301

Postop - Preop - Nonop - Transport

Survivor - Mortality — % survival

2012 Cart Redesign
Post 2000 The Modern Era

- POC labs
- Antigrade Cerebral perfusion
- Neuro monitoring
- Open shunt (SVF) management
- > HCT on CPB
- Coated circuits
- Early reintervention
- Hyper Oxygenation

Literature Review

- STS CHS Database 2000-2010

Mortality of MCS pts 53% vs. 2.9% of pts who did not require MCS

96,596 operations, MCS 2.4%

CPS Initiated in the CICU 2001-2017

126 patients

- 60 survived (48%)
- 82 Postop (45% survival rate)
- 33 Nonop (52% survival rate)
- 11 Preop (55% Survival)
- 26 Neonatal postop 50% survival
Postop CPS Initiation 2001 -2017

162 pts. (48% SHD)
- 82 in CICU (45% SHD)
- 69 in OR (55% SHD)
- 28 (17%) converted to VAD (54% SHD)
- 11 in the Cathlab 18% Survival

E-CPR Duration in Minutes vs Survival Hospital Discharge
N=30 SHD 47%

E-CPR Time of day vs Survival Hospital Discharge
(N=30) SHD = 47%

E-CPR week day vs Survival Hospital Discharge
(N=30) SHD=47%
NCH Postop CPS % Rate

NCH CPS % Survival Hospital Discharge

NCH CPS % Plasma leak / Circuit Change Rate

NCH CPS Average Support Days

CPS Circuit Changes

2009
- FX05 < 10 kg

2012
- FX15 > 10 kg
- X coated circuits
- Affinity pump

Baby FX Oxygenator Longevity

NCH CPS Circuit Components
NCH CPS System Components

- Bio-Console 560
  - External Drive (Affinity)
  - Handcrank
- CSZ ECMO heater / Micro-Temp LT
- Spectrum M4
- Cisco access point / wireless router
- Adjustable attachment arm
- Oxy/Air tank / Gas blender

NCH CPS Priming and Storage Practice

- Two primed systems
  - Stored in locked room
- FX15 Oxygenator
  - < 30 Kg ¼ X ¼ tubing
  - 300cc prime
  - > 30 Kg ⅜ X ⅜ tubing
  - 450cc prime
- Changed every two weeks