Recent Clinical Outcomes in Children with Acute Fulminant Myocarditis Treated with Mechanical Circulatory Support

Severance Cardiovascular Hospital

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Introduction

• The mortality rates for infants and children with myocarditis may be as high as 75% and 25%, respectively
  Freedman SB et al, Pediatrics 2007

• Outcomes of severe acute myocarditis in children who require mechanical circulatory support
  -> not well known
  -> scarce data
Between 2001 and 2009, 16 children required mechanical circulatory support for acute fulminant and persistent myocarditis. Survival rate was 75% (12/16), with 7 recovered ventricular function.

In children with acute fulminant and persistent myocarditis, MCS is a life-saving treatment strategy, particularly in the absence of viral infection.

- 6 Patients were placed on ECMO support:
  - Weaned (n=6)
  - Bio-Medicus (n=1)
    - ECMO (n=1)
    - CHT (n=1)
    - Died (n=1)

- 10 Patients were placed on VAD support:
  - TandemHeart (n=1)
  - Thoratec HeartMate II LVAS (n=1)
  - Bio-Medics LVAD (n=5)
  - Thoratec VAD (n=1)
  - Josta Rotabow (n=1)
  - MicroMed DeBakey VAD Child (n=1)
  - MicroMed (n=1)
  - HeartMate II (n=1)
    - OHT (n=1)
    - Died (n=1)
    - Weaned (n=1)
  - CHT (n=4)
    - Died (n=1)

ECMO Survival (4/6) 67%
VAD Survival (8/10) 40%
Overall Survival (12/16) 76%
• 1994 to 2009

• 75 pts (including 24 children)

• Survival to discharge 64% (n=48)
  
  61% in adult group
  70.8% in pediatric group

• Due to its simplicity and effectiveness, ECMO can be a first-line tool to rescue this group of patients
Extracorporeal membrane oxygenation for the support of infants, children, and young adults with acute myocarditis: A review of the Extracorporeal Life Support Organization registry*

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**Objective:** To describe survival outcomes for pediatric patients supported with extracorporeal membrane oxygenation for severe myocarditis and identify risk factors for in-hospital mortality.

**Design:** Retrospective review of Extracorporeal Life Support Organization registry database.

**Setting:** Data reported to Extracorporeal Life Support Organization from 116 extracorporeal membrane oxygenation centers.

**Patients:** Patients ≤18 yrs of age supported with extracorporeal membrane oxygenation for myocarditis during 1995 to 2006.

**Interventions:** None.

**Measurements and Main Results:** Of 19,348 reported pediatric extracorporeal membrane oxygenation uses from 1995 to 2006, 260 runs were for 255 patients with a diagnosis of myocarditis (1.3%). **Survival to hospital discharge was 61%**. Seven patients (3%) underwent heart transplantation and six patients survived to discharge. Of 100 patients not surviving to hospital discharge, extracorporeal membrane oxygenation support was withdrawn in 70 (70%) with multiple organ failure as the indication in 58 (83%) patients. In a multivariable model, female gender (adjusted odds ratio, 2.3, 95% confidence interval, 1.3–4.2), arrhythmia on extracorporeal membrane oxygenation (adjusted odds ratio, 2.7, 95% confidence interval, 1.5–5.1), and renal failure requiring dialysis (adjusted odds ratio, 5.1, 95% confidence interval, 2.3–11.4) were associated with increased odds of in-hospital mortality.

**Conclusion:** Extracorporeal membrane oxygenation is a valuable tool to rescue children with severe cardiorespiratory compromise related to myocarditis. Female gender, arrhythmia on extracorporeal membrane oxygenation, and need for dialysis during extracorporeal membrane oxygenation were associated with increased mortality. (Crit Care Med 2010; 38:382–387)

**Key Words:** myocarditis; pediatrics; extracorporeal membrane oxygenation
Acute Fulminant Myocarditis (2008-2013)  

17 pts  
Medical treatment: 4 pts  
ECMO: 13 pts  
Survival rate: 53.8%  

ECMO support was initiated >24 hours after admission in 4 of the 13 patients (30.7%), and 3 of those 4 patients (75%) died.

Fig. 1. Outcomes of pediatric patients with acute fulminant myocarditis. ECMO, extracorporeal membrane oxygenation; DCMP, dilated cardiomyopathy.
Purpose

• We studied the survival and clinical courses of patients with acute fulminant myocarditis who received extracorporeal membrane oxygenation (ECMO)
Materials and Methods

- Retrospective chart reviews
- Between April 2013 and April 2015
- 13 consecutive patients with acute fulminant myocarditis / DCMP who were treated with ECMO
Management strategies

- **Device**
  - Pre-assembled, simplified ECMO system
- **Vascular access**
  - Peripheral cannulation: preferred
- **Target ACT**
  - 160-180 sec using heparin
- **Left side decompression**
  - Atrial septostomy and LA vent via femoral vein
- **Oliguria**
  - CRRT connected to circuit of ECMO
Device
– Pre-assembled, simplified ECMO system

CAPIOX EBS®
TERUMO
N = 9

QUADROX PLS®
MAQUET
N = 4
Cervical approach: Semi-open technique
LA venting

- Pulmonary edema, increased LA pressure
- Catheter indwelling through created ASD or PFO by catheterization
F/ 7M, 7.3 kg, LVEF 10%
• CRRT
  – Prefer in-series connection with ECMO
Results

- Age -> 25.8 months (range, 2.9 mo to 11.5 yrs)
- Body weight -> 10.3 kg (range, 5.3 to 47.5 kg)
- ECMO duration was 140 hrs (range, 51 to 324 hrs)
- ICU stay was 16 days (range, 4 to 44 days)
- Viral pathogen -> detected in 7 patients
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<th>Age (Yr)</th>
<th>BW (Kg)</th>
<th>ECMO duration (day)</th>
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<th>IE (㎍/kg/min)</th>
<th>EF(%)</th>
<th>Indication</th>
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ECMO, n=13

Weaning, n=10

LT Drain, n=6
Atrial spatostomy & LA vent cannula

HT, n=2

Organ Donation after weaning, n=1

Enterovirus encephalitis

ECMO weaning rate 100% (Excluding HT)
Survival rate 92.3% (12/13)
EF, Inotropic changes

$P = 0.002$

$P = 0.002$
Complications

- Neurological – 2 cases (thromboembolism)
- Cannulation site bleeding – No
- Pulmonary – No
- Infection - No
- Gastrointestinal – 1 case required no tx.
- Hematuria – 1 case required no tx.
- Rt. IJV segmental obstruction - 1 case
Major complications

• Intracardiac thrombosis involving four chambers
  -> emergency thrombectomy
  -> multiple brain infarction without serious sequelae

• Left side weakness due to a right basal ganglia infarction
  -> motion weakness is becoming better
Thrombus in 4 chambers
Conclusion

• Myocarditis in children can be treated successfully using ECMO support
  1) Early administration of ECMO
  2) No cannulation site bleeding
  3) Timely attempt (e.g. left heart decompression by indwelling a catheter through the femoral vein)
  4) CRRT connected to the ECMO circuit

have contributed to improving the outcome
Conclusion

- In children with acute fulminant myocarditis, mechanical circulatory support using ECMO can be a first-line treatment with excellent results.
Thank You