Exit on ECMO: When Do We Reach the End?

3rd Annual South and West Asia Chapters ELSO Conference

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Disclosures

• I do not have any relevant financial conflicts
• I chair the Extracorporeal Life Support Organization
• I chair the Critical Care Sub-board of the American Board of Pediatrics
“ECMO is easy to start and hard to stop”
It Can Be Difficult To Know When One is Ready to Come Off ECMO—Either For Good or For Bad
Providers Are Not Good at Predicting ECMO Outcomes

<table>
<thead>
<tr>
<th>Role</th>
<th>accuracy</th>
<th>PPV</th>
<th>NPV</th>
<th>sens</th>
<th>spec</th>
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<tbody>
<tr>
<td>CICU</td>
<td>0.71</td>
<td>0.67</td>
<td>0.83</td>
<td>0.91</td>
<td>0.5</td>
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<tr>
<td>PICU</td>
<td>0.79</td>
<td>0.78</td>
<td>0.8</td>
<td>0.88</td>
<td>0.67</td>
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<tr>
<td>NICU</td>
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<td>0.5</td>
<td>0.5</td>
<td>0.8</td>
<td>0.2</td>
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<td>CCMF</td>
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<td>0.59</td>
<td>0.75</td>
<td>0.88</td>
<td>0.38</td>
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<tr>
<td>CV SURG</td>
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<td>0.68</td>
<td>0.8</td>
<td>0.9</td>
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<td>RN</td>
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<td>0.61</td>
<td>0.73</td>
<td>0.85</td>
<td>0.42</td>
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<tr>
<td>CRN</td>
<td>0.67</td>
<td>0.64</td>
<td>0.71</td>
<td>0.82</td>
<td>0.5</td>
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<tr>
<td>SPEC</td>
<td>0.66</td>
<td>0.64</td>
<td>0.7</td>
<td>0.86</td>
<td>0.41</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>0.66</strong></td>
<td><strong>0.64</strong></td>
<td><strong>0.75</strong></td>
<td><strong>0.87</strong></td>
<td><strong>0.45</strong></td>
</tr>
</tbody>
</table>

-Mazor et al., Submitted 2015
Begin With the End in Mind

• Informed consent at outset of ECMO should clarify that ECMO can/will be withdrawn if it is not providing benefit to ultimate outcome
Frequently the Decision to Exit May Not Be Clear
Exiting ECMO to Conventional Support: Our Goal for All

• Improving compliance
• Improving gas exchange
• Chest radiograph improvement
• Improving cardiac function
“Take a Coffee”
Approach To ECMO Weaning

Weaning on ECMO?

YES
- Capping/Trial off
  - Successful
    - Decannulate
  - Unsuccessful
    - Unable to wean/trial off
      “Take more coffee!”
      Complication?
        - Intracranial Bleed, Severe Neuro Injury, Progressive Organ Failure
          - NO
            Futility/Withdrawal
          - YES
            Bridge to transplant
            Transplant Candidate?
              - YES
                Bridge to transplant
              - NO
                Futility/Withdrawal

NO
- “Take a Coffee”
  - Unsuccessful
    - Inability to wean/trial off
      “Take more coffee!”
      Complication?
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  - “Take more coffee!”
  - Complication?
    - Intracranial Bleed, Severe Neuro Injury, Progressive Organ Failure
  - Transplant Candidate?
    - YES: Bridge to transplant
    - NO: Futility/Withdrawal
What to Do While “Taking Coffee”

- Pulmonary toilet
- Therapeutic bronchoscopy
- Proning
- Medical interventions
- Improving fluid balance (diuresis, CRRT)
- Slow lung recruitment (if evidence of improvement in compliance, radiologic changes)
- Enhancing mobility
Positive Exit From ECMO: Weaning

• Neonate: decreasing to 40-50 cc/kg/min; shunt as needed due to low minimum flows vs. oxygenator
  – VA: Assessment of SvO2 maintenance (65-70%) with weaning of flow, trial off with clamping
  – VV: Weaning flow (vs. sweep gas) as native lung function returns, and “capping” trial

• Pediatric Respiratory:
  – VA
  – VV
  – Acceptable vent settings: “Less than you those would consider going on ECMO for” = Take a coffee!
Weaning From ECMO

• Pediatric Cardiac:
  – Assessment of adequate function, lactate, perfusion, pulsatile blood flow return
  – ECHO monitoring
  – Decreased flow
  – Presence of LV vent taken into account

• Adult Respiratory
  – Increasing off rest settings
  – Similar to pediatric respiratory

• Adult Cardiac
  – 3-5 days; ECLS < 30% of overall support
Exiting ECMO: Don’t Tweet Before You Succeed
Approach To ECMO Weaning

Weaning on ECMO?

YES → Capping/Trial off

NO

“Take a Coffee”

Successful → Decannulate

Unsuccessful

Unable to wean/trial off

“Take more coffee!”

Transplant Candidate?

YES → Bridge to transplant

NO → Complication?

Intracranial Bleed, Severe Neuro Injury, Progressive Organ Failure

Futility/Withdrawal
Possible Reasons to Consider Suboptimal Exit of ECMO

• Pre-ECMO conditions
• ECMO Duration
• Duration of CPR
• Lung biopsy
• ECMO Complications
  – Evidence of failure
  – Bleeding driving acute exit
  – Brain death
Do Pre-ECMO Predictions Help Decide?

• Pre-ECMO prediction scores describe the population and help provide some ante hoc assessment for prognosis with ECMO

• RESP Score (Schmidt et al., AJRCCM 2014)
  – ELSO Registry data on >2300 adults from 2000-12
  – Developed predictive score (AUC 0.76, external validation 0.92)

• PRESERVE Score (Schmidt et al., ICM 2013)
  – 3 French PICUs

• However, once on ECMO, every patient’s n = 1
RESP Predictive Score for Predicted ECMO Mortality Pre-Cannulation
Does Prolonged Duration of ECMO Inform Stopping?
Prolonged ECMO in Pediatric Respiratory Failure

- Survival by number of ECMO days:
  - < 21 days: 61%
  - > 21 days: 38% (p< .001)

-Brogan et al., PCCM, 2012
Prolonged Neonatal ECMO Duration Worsens Outcome – But Not To Zero

> 21 Days on ECMO: 24% survival

- Prodhan et al., ASAIO Journal 2014
“Duration of adult ECMO is a poor predictor of hospital survival”

-Staudacher JCC, 2015
Duration of ECMO Post-Pediatric Cardiac Surgery

2004-2013
998 Patients
PHIS Database

-Gupta et al., Minerva Anesth, 2015
Duration of ECMO and Death-Pediatric Cardiac Surgery

12% increase in odds of mortality for each 24 hour increase in ECMO duration

-Gupta et al., Minerva Anesth, 2015
Does E-CPR Impact Decision on ECMO Exit?

- Use of E-CPR associated with worse outcomes overall
- Duration of CPR prior to ECMO does correlate with outcome
90+ Minutes Of (Really Effective) CPR
Does Biopsy Help Determine Decision?

• Short answer: In general →, No

• Difficult to assess relation to rest of lung, correlation to outcome

• May be helpful in:
  – Neonates to determine lung dysplasia (alveolar-capillary dysplasia, surfactant protein deficiency)
  – Pertussis patients to determine level of necrosis
  – Inwald et al., Thorax 2004
Determination of Futility in Cardiac ECMO

• Native function has not returned in 3-5 days
• Patient is not a candidate for VAD or heart transplant
Determining Whether to Exit: Possibility of Bridge to Transplant

- Is transplant possible
- YES: IF cardiac alone, consideration of VAD
- NO: What is the likelihood of spontaneous recovery?
Exiting ECMO: Reaching the End…

- Most common driver to stop: the patient tells us it is time
- In general, indications for stopping ECMO are:
  - Development of irreversible multiple organ failure
  - Development of significant intracranial bleed with profound neurologic devastation
  - Evidence of profound neurologic hypoxic-ischemic injury (post E-CPR)
  - Progression to brain death
  - Failure of recovery of myocardial function in absence of bridge to transplant option
Technique for Neurologic Determination of Death on ECMO

- Apnea test can be done on ECMO
- Decrease sweep gas flow to allow increase in pCO2
- Maintain oxygenation with ETT/self-inflating bag at FiO2 1.0
- Demonstrated in 3 pediatric patients

-Jarrah et al., PCCM, 2014
Stopping ECMO Support Is A Group Effort

• Multidisciplinary decision
• Consensus from provider group is important-MDs, RNs, perfusionists
• Bringing a decision to family is key
  – Walking them through
  – Reminding them of commitment at the beginning to remove ECMO when it was not providing hope
  – Avoiding a “choice”-focus on other options around time, holding patient, non-resuscitation status
  – Orchestrate those hours of passing for the family
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      - “Taking more coffee!”
      - Complication?
        - Transplant Candidate?
          - YES
            - Bridge to transplant
          - NO
            - Futility/Withdrawal
          - Intracranial Bleed, Severe Neuro Injury, Progressive Organ Failure

Conclusions

• Most patients exit well off ECMO
• Patience is a virtue: Take a Coffee!
• Predicting inability to exit well is an inexact science
• Duration on ECMO does not predict exit
• The patient usually tells you if they won’t exit to success
George
Everything will be all right in the end. So if it is not all right, then it is not yet the end.
E-CPR Improved Outcome Vs. C-CPR
In Pediatric Patients

• GWTG Pediatric Cardiac Registry
• Pediatric patients receiving E-CPR vs. C-CPR

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Survival/with favorable outcome</th>
<th>Odds Ratio for favorable outcome</th>
<th>Odds Ratio (Propensity Matched)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-CPR</td>
<td>591</td>
<td>40%/27%</td>
<td>2.64 (2.13-3.07)</td>
<td>1.78 (1.31-2.41) p&lt;.0001</td>
</tr>
<tr>
<td>C-CPR</td>
<td>3165</td>
<td>27%/18%</td>
<td></td>
<td></td>
</tr>
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</table>

-Lasa et al., Circulation, 2015-
Table 4. Multivariable regression analysis identifying factors independently associated with survival to hospital discharge

<table>
<thead>
<tr>
<th>Pre-ECLS Variable Considered</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Pre-ECLS mechanical ventilation time</td>
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<td></td>
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<tr>
<td>&gt;7–10 days vs. 0–7 days</td>
<td>0.78</td>
<td>0.51–1.19</td>
<td>.25</td>
</tr>
<tr>
<td>&gt;10–14 days vs. 0–7 days</td>
<td>0.70</td>
<td>0.44–1.10</td>
<td>.12</td>
</tr>
<tr>
<td>&gt;14 days vs. 0–7 days</td>
<td>0.32</td>
<td>0.20–0.51</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pre-ECLS cardiac arrest</td>
<td>0.56</td>
<td>0.40–0.80</td>
<td>.001</td>
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<tr>
<td>Oxygenation index per 10 units</td>
<td>0.95</td>
<td>0.92–0.98</td>
<td>.002</td>
</tr>
<tr>
<td>pH per 0.1 units</td>
<td>1.15</td>
<td>1.09–1.23</td>
<td>&lt;.001</td>
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<tr>
<td>Diagnosis</td>
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<td></td>
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<tr>
<td>“Other” vs. sepsis</td>
<td>2.24</td>
<td>1.44–3.42</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Viral pneumonia vs. sepsis</td>
<td>3.14</td>
<td>1.92–5.14</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
Desperate but Reasonable?
We may be getting mixed direction on where to go next
Pediatric ECMO Outcomes and ECMO Duration

Days of Mechanical Ventilation Prior to ECMO Run

- 0-1 day: 58%
- >1-3 days: 61%
- >3-7 days: 59%
- >7-14 days: 56%
- >14 days: 38%*