Challenges and Lessons Learned from Transport ECMO.

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First successful ECLS patient, 1971

J Donald Hill MD and Maury Bramson BME, Santa Barbara, Ca, 1971. (Courtesy of Robert Bartlett, MD)
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These guidelines describe useful and safe practice for extracorporeal life support (ECLS), but these are not necessarily consensus recommendations. These guidelines are not intended as a standard of care, and are revised at regular intervals as new information, devices, and techniques become available. This talk is intended for educational use to build the knowledge of health care professionals in assessing the conditions and managing the treatment of patients requiring ECLS. These guidelines are not a substitute for a health-care provider’s professional judgement and must be interpreted with regard to specific information about the patient and in consultation with other medical authorities as appropriate.
ECMO INTER-FACILITY TRANSPORTS ARE DEFINED IN THE FOLLOWING MANNER:

Primary Transports

situations in which the transport team is required to perform cannulation for ECLS support at the referring facility and then transported to an ECMO facility.

Secondary Transports

situations in which the patient is already supported with ECLS at the referring facility and needs to be transported to another center for a variety of reason, or level of care provided.
REMOTE CANNULATION
ALL PATIENTS SHOULD HAVE A CAREFUL EVALUATION OF THEIR HEMODYNAMICALLY STATUS BEFORE CANNULATION, COMPRISING AN ECHOCARDIOGRAPHY TO ASSESS THEIR MYOCARDIAL FUNCTION AND EVALUATE THEIR CARDIO OUTPUT.

1. Venovenous (VV) ECMO may be used for transport of patients with severe respiratory failure who have clinical and echocardiographic evidence of adequate cardiac function at the time of transport.

2. Venoarterial (VA) ECMO should be considered for transport of hemodynamically unstable patients and/or in cases of significant cardiac dysfunction.
FACTORS IMPORTANT IN PLANNING FOR ECMO TRANSPORT

1. A major priority in planning a Primary Transport is expediting the arrival of the ECMO team at the referring facility.

2. For Secondary Transports the timeliness of the team’s at the referring facility may not be as critical.

3. The overriding priority in transporting the patient to the ECMO center is patient safety.
   * The time required for patient stabilization prior to moving (ground time) may be lengthy and is of secondary priority to patient safety during the transport
   * When a prolonged ground time at the referring facility is anticipated, additional supplies, personnel, and equipment may be required and must be available.
ADVERSE EVENTS DURING TRANSPORT

• January 2010 and June 2016 536 transports identified, in 163 of these (31.7%) 206 adverse events occurred

• 65% (134) of the complications were patient related

• In 34 transports, 2 or more events occurred

• Lack of control of equipment was the most common staff related flaw

• Transportation related complications were reported in 26 transfers

• From Ericsson, Frenckner, and Broman Pre Hospital Emergency care Feb. 2017
Distance between referral center and ECMO center, and therefore duration of the mission, plays a large role in dictating the mode of transportation. In each case, geographic considerations must be viewed in the context of clinical, weather, and resource priorities. If the duration of en route care is expected to exceed 3-4 hours by ground, then air transport should be considered
GEOGRAPHIC FACTORS

Ground ambulance feasible for distances < 250 miles (400 km).
Helicopter is feasible for distances < 400 miles (650 km).
Fixed wing aircraft is usually necessary for missions > 400 miles (650 km).
WEATHER-RELATED ISSUES

Great impact on air transport (helicopter and fixed wing).

Ice/snow or other hazardous road conditions may impact the feasibility of ground transport.

Some helicopters and all commercial fixed wing air ambulances are capable of flight in IFR (instrument flight rules) conditions.

IFR mission may necessitate arrival and departure from a local airport rather than a hospital to hospital direct.

The impact of weather on the suitability of air transport for a given mission should always be a pilot decision with no input from the medical team.
## AIRCRAFT/VEHICLE AVAILABILITY AND CAPABILITIES

<table>
<thead>
<tr>
<th></th>
<th>Ground Ambulance</th>
<th>Helicopter</th>
<th>Fixed Wing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space for team and equipment</td>
<td>Sufficient (3-4 team members)</td>
<td>Limited (3-4 team members)</td>
<td>Variable (&gt; 4 team members)</td>
</tr>
<tr>
<td>Noise</td>
<td>Relatively Little (can be ruff riding)</td>
<td>Very Loud (helmets with mics)</td>
<td>Load</td>
</tr>
<tr>
<td>Distance range for reasonable times</td>
<td>Up to 250-300 miles</td>
<td>Up to 300-400 miles Can be very fast &lt; 30 minutes (ECPR)</td>
<td>Any distance</td>
</tr>
<tr>
<td>Weight Limitations</td>
<td>Unlimited</td>
<td>Limited by aircraft, weather, distance,</td>
<td>Variable, depends on aircraft and conditions</td>
</tr>
<tr>
<td>Loading and securing equipment and ECMO circuit/patient</td>
<td>Relatively easy</td>
<td>Relatively easy</td>
<td>Variable, depends on equipment and aircraft model</td>
</tr>
<tr>
<td>Cost</td>
<td>++</td>
<td>+++</td>
<td>++++</td>
</tr>
</tbody>
</table>
Centrimag vs Cardiohelp vs Rotaflow
FOR TRANSPORT
AEROMEDICAL TRANSPORT AND HYPOXIA

- Pediatric patients have different anatomical and physical parameters when compared to the adult population.

- For fixed wing transport, at maximum altitude of 8,000 feet:
  - **Dalton’s Law** - states that each gas in a mixture exerts the same pressure as if it were present, alone, in the same volume. (decrease FiO2).
  - **Boyle’s Law** - the volume of a fixed gas is inversely proportional to the pressure to which it is subjected. (8,000 feet, volume increases by 40%)

- May need to consider lowering maximum cabin pressure (3700 feet), may have an effect on times, fuel, flight.
DRINK TIME!
CARDIOHELP HOLDERS
“Say ... what's a mountain goat doing way up here in a cloud bank?”
PERSONNEL/TEAM COMPOSITION

Cannulating Physician

- Surgical Assist
- ECMO Specialist
- Transport RN/RRT

ECMO Physician

- ECMO Specialist
- Transport RN/RRT
FIRST RULE IN ECMO, YOU HAVE TO HAVE A SENSE OF HUMOR!
<table>
<thead>
<tr>
<th>Feature</th>
<th>Centrimag</th>
<th>Cardiohelp</th>
<th>Rotaflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet pressure regulation</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Pre-ox pressure regulation</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Post-ox pressure regulation</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Venous temperature monitor</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Arterial temperature monitor</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>SvO2 monitor</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>HCT monitor</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Arterial bubble detection</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Venous bubble detection</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Hand crank</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Integral battery</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
• Gaseous micro emboli will enlarge during the decrease in cabin pressure with increased cabin elevation

  • Bubble detection
    • Arterial side to protect air from going forward
    • Venous side will protect circuit from IV air administered pre-transport
<table>
<thead>
<tr>
<th>Item</th>
<th>Centrimag</th>
<th>Cardiohelp</th>
<th>Rotaflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device (pump)</td>
<td>$45,000</td>
<td>$100,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>Disposables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifugal pump</td>
<td>$9,000 - $12,500</td>
<td>$12,000 - $15,000</td>
<td>$250</td>
</tr>
<tr>
<td>Oxygenator</td>
<td>$1,200</td>
<td>Included</td>
<td>$1,200</td>
</tr>
<tr>
<td>Tubing pack</td>
<td>$200 - $500</td>
<td>Included</td>
<td>$200 - $500</td>
</tr>
<tr>
<td>Per transport total</td>
<td>$10,400 - $14,200</td>
<td>$12,000 – $15,000</td>
<td>$1,650 - $1,950</td>
</tr>
</tbody>
</table>
ANY BAD DAY CAN BE FIXED BY DRIVING COUNTRY ROADS, WINDOWS DOWN AND COUNTRY MUSIC UP.
HEALTHCARE ADMINISTRATION

- I ❤️ PERFUSIONISTS
- FEEL SAFE AT NIGHT, SLEEP WITH A PERFUSIONIST
- KEEP CALM AND TRUST A PERFUSIONIST
THANK YOU