ECMO as bridge to lung transplantation is performed in case of respiratory failure with refractory hypoxaemia and/o hypercapnia despite optimal medical therapy and non-invasive ventilation.

Falcoz PE, Thorax 2009

ECMO as bridge to lung transplantation: phsyiotherapeutic intervention

Sara Mariani
Physiotherapist
Fondazione IRCCS Ospedale Maggiore Maggiore Roi Clino Milano

ECMO - ExtraCorporeal Membrane Oxygenation

a form of extracorporeal life support where an external artificial circuit carries venous blood from the patient to an oxygenator where blood is enriched with oxygen and has carbon dioxide removed. The blood is then returned to the patient via a vein or an artery.
1975-1st case of ECMO used as a bridge to lung transplant was performed

1991 Hannover group published the first report of long-term survival after using ECMO as bridge to re-do lung transplant

Mason 2010: 50% one year survival

Overall mortality following lung transplant is still notable, with one year survival is 80%.

Ecmo had been proven to be a strong risk factor for mortality after transplantation in multivariable analysis

Increased mortality in the early phase after LTX
Increased postoperative length of stay

EMOLISI related
CANNULA related
BLEEDING
TROMBOSIS
DISPLACEMENT
OBSTRUCTION

- HEMORRAGE
- CANNULATION SITE COMPLICATIONS
- RENAL FAILUR
- SEPSIS
- NEUROLOGIC COMPLICATIONS
- LEG HISCHEMIA

Fischel 2007
Kotta 1997
Lang 2012

V-V ECMO is preferred while HYPOXEMIA with PCO2 elevation occurs with stable hemodynamics (↓ risk from systemic embolization inherent with arterial cannula)

V-A ECMO is recommended when Hypoxemic respiratory failure and hemodinamic compromise (↑ risk of rates of neurological complications)
Now think about an ECMO patient...

Now think about an ECMO patient...

Now think about an ECMO patient...

News

2012

Thought an anaphylaxis ECMO patient has to lie calm in bed? – Wrong!

Even those patients can be mobilized under specific conditions, as this example from the University Hospital Regensburg, Germany, demonstrates.
**AWAKE vs INTUBATED**

Avoid drawbacks of endotracheal intubation, long term mechanical ventilation, sedation and bed rest

Prevent septic complications, diaphragmatic weakness, muscles deconditioning and critical illness myopathy

Chastre J AJRCCM 2002
Hermans G Crit Care 2008
Vassilakopoulos T AJRCCM 2004
Mason DP Cardiovasc Surg 2009

**IN CYSTIC FIBROSIS**

Poor prognoses and outcomes of patients with cystic fibrosis treated by MV.

Efraty O, Heart Lung 2010

To avoid the potential drawbacks of orotracheal intubation and long-term MV, particularly septic complications, in a cystic fibrosis patient,

VV ECMO is feasible in awake and non-intubated patients.

Bartosik ICVTS 2011
Olsson Am J Transplant 2010

<table>
<thead>
<tr>
<th>Study</th>
<th>Pts</th>
<th>Disease</th>
<th>Days</th>
<th>ECMO</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chason Am J Transplant 2010</td>
<td>5</td>
<td>Pulmonary Hypertension</td>
<td>16-35</td>
<td>V-A</td>
<td>Awake, spontaneously breathing, eat, drink, watching TV.</td>
</tr>
<tr>
<td>Nosotti Transplant Proc 2010</td>
<td>4</td>
<td>CF, PF</td>
<td>11-21</td>
<td>V-V</td>
<td>1 pt awake</td>
</tr>
<tr>
<td>Broomé Ann Thorac Surg 2008</td>
<td>1</td>
<td>alveolitis secondary to polymyositis</td>
<td>52</td>
<td>V-V Fem femoral</td>
<td>Kept awake most of the time, tracheostomy</td>
</tr>
<tr>
<td>Bartosik ICVTS 2011</td>
<td>2</td>
<td>bronchiolitis obliterans, BPCO</td>
<td>4-140</td>
<td>Novalung</td>
<td>Awake and spontaneously breathing patient</td>
</tr>
</tbody>
</table>
Several studies have suggested that early ambulation is advantageous for patients in the ICU.

This is particularly important for lung transplantation candidates, in whom there is a direct correlation between functional status and exercise capacity with outcomes.

Morris PE, Crit Care Med. 2008

- Physical and occupational therapy in the earliest days of critical illness was safe and well tolerated, and resulted in better functional outcomes at hospital discharge, a shorter duration of delirium, and more ventilator-free days compared with standard care.

104 patients

Schweickert WD, Lancet 2009

Risk factors associated with critical illness myopathy

- Severe systemic inflammation
- Corticosteroids
- Neuromuscular blocking agents
- Diabetes
- Immobility

Stevens R, Int Care Med 2007

Patients receive high doses of corticosteroids immediately after the lung transplantation. These relatively high doses of corticosteroids surely can induce steroid-induced myopathy.

Decramer M, Am J Respir Crit Care Med 1996

Role of ACTIVE MOBILIZATION in awake ECMO pts

This worsening weakness is known to play a substantial role in the outcome of critically ill patients undergoing lung transplantation.

Stevens R, Int Care Med 2007

Ambulation and preparation for lung transplant would normally be out of the question.

Fortenberry Crit Care Med 2011 (editorial)

Maximize muscle strength
Make the pt a "good candidate"
### AMBULATORY ECMO- out of bed physiotherapy

<table>
<thead>
<tr>
<th>Name</th>
<th>N</th>
<th>DRYS</th>
<th>V-V O-A</th>
<th>PT PROGRAM</th>
<th>RESPIRATION</th>
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<tr>
<td>Turner</td>
<td>2</td>
<td>7-14</td>
<td>I-V</td>
<td>Bilumen jugular</td>
<td>Tracheostomy</td>
</tr>
<tr>
<td>Mangi</td>
<td>3</td>
<td>7-14</td>
<td>I-V</td>
<td>Bilumen jugular</td>
<td>Ambulable</td>
</tr>
<tr>
<td>Garcia</td>
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<td>Jugular</td>
<td>2-H tracheostomy</td>
</tr>
<tr>
<td>Lowman JD</td>
<td>5</td>
<td>7-14</td>
<td>I-V</td>
<td>Jugular</td>
<td>Active and passive PT, Ambulable</td>
</tr>
<tr>
<td>Hayes</td>
<td>4</td>
<td>7-14</td>
<td>I-V</td>
<td>Bilumen jugular</td>
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AMBULATORY ECMO - out of bed physiotherapy

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<tr>
<th>Name</th>
<th>Age</th>
<th>CF</th>
<th>V-V/A</th>
<th>PT Program</th>
<th>Respiration</th>
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</thead>
<tbody>
<tr>
<td>Turner</td>
<td>16-24</td>
<td>CF</td>
<td>ILR</td>
<td>ilorusen jugular program</td>
<td>Tracheostomy</td>
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<tr>
<td>Mangi</td>
<td>34</td>
<td></td>
<td>U-A</td>
<td>ambulable</td>
<td>Stop to prevent infections</td>
</tr>
<tr>
<td>Garcia</td>
<td>34</td>
<td>CF</td>
<td>JL</td>
<td>ambulable</td>
<td>Tracheostomy</td>
</tr>
<tr>
<td>Lowman JD</td>
<td>16</td>
<td>CF</td>
<td>JL</td>
<td>passive and active exercises at bedside</td>
<td>Tracheostomy</td>
</tr>
<tr>
<td>Reeb</td>
<td>35</td>
<td>CF</td>
<td>JL</td>
<td>active and passive PT, ambulable</td>
<td>Nil</td>
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<td>Hayes</td>
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<td>CF</td>
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Patient ambulating on a treadmill while on single-venous ECMO.


Norwood Hospital, Norwood, MA

PT interventions, including out of bed mobility, can be safely provided to patient on portable ECMO (veno-venous ECMO) as a bridge to lung transplantation.

Bleeding and decannulation are the major concerns when mobilizing patients on ECMO.

PAY ATTENTION TO CANNULA!!
- Integrity of ECMO cannula
- Monitoring ECMO flow
- Signs and symptoms of poor cardiac output
- Trombosis?
Airway clearance techniques—chest pt is integral to the management of CF

Prevent atelectasis and infections
Avoid need for intubation

\[ \text{INTUBATION} = \text{Embed secreations, reduce FT intervention} \]

**ROLE OF NIV**

- During exacerbation need for NIV to assist FT
- Addition of NIV ACTB (Active cycle of breathing technique) resulted in preserved inspiratory muscle strength. It can safely be used.
  
  \[ \text{Holland, Thorax 2003} \]

Ventilator settings can enhance or hinder secretions clearance (embed mucus or expell it).

\[ \text{Volpe, Respir Care 2008} \]
\[ \text{Kim, J Appl Physiol 1998} \]
\[ \text{Ntoumenopoulou, Resp Care 2011} \]

- FBS - BLEEDING
CASE REPORT
Fondazione Ospedale Maggiore Policlinico Milano

FEMALE
AGE 43
CYSTIC FIBROSIS
INSULIN DEPENDANT DIABETES
Pseudomonas aeruginosa, stenotrophomonas maltophilia

DYSPEA, TACHYPNEA, HYPERCARBIA, ACIDOSIS non NIV respondent

OTLT, HOME NOCTURNAL NIV

26.11 PNX, WORSENING, INCREASING HYPERCARBIA
29.11 hospital ...

Dyspnea, Tachypnea, HYPERCARBIA, ACIDOSIS non NIV respondent

V-V ECMO (FEMOROFEMORAL) AS BRIDGE TO LUNG TRANSPLANTATION
GAS FLOW 2.5-6 L/min, BLOOD FLOW 2.3-3.3, FiO2 50-100%

Register the patient as high emergency on the TX waiting list.

GOAL
• PREVENT ATELECTASIS, INFECTIONS AND EI
• PREVENT DECONDITIONING

- Bronchodilators
- Heated humidification
- NIV
- Airway clearance with NIV assistance (autogenic drainage and cough)
- Seated with bed in "chair position" minimum 6 h/day
- Active exercises (isometric and isotonic) with or without NIV according to spiO2 and dyspnea (Borg scale)

RSI, RR 24, Borg DISPNEA3, respiratory accessary muscles recruitment
Cough and secretions thick and color brown.
ABO 7.405, PaCO2 63.6, PaO2 61.4, P/F 61, HCO3- 30 (RS FiO2 0.90 +ECMO)
Airleaks throught chest tube.
Muscles' straight MRC 5.

Central apnea associated with oxygen desaturation in sleep, (nadir SpO2 75%)

For the entire period of ECMO therapy, the patient was spontaneously breathing (alternating O2 reservoir and NIV), able to eat, drink, talk and have psychological support.
She was able to practice physiotherapy twice a day everyday.

PATIENT
WOB – RISPPOSTA VENTILATORIA lung gas exchange

GAS EXCHANGE RR
WOB

ECMO
GAS FLOW
BLOOD FLOW: FiO2

NIV
PS
PEEP
FiO2

FEMALE
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Respiratory deterioration, gas exchange worsening
Increased ECMO support and NIV time application
GAS FLOW 2.5-6 L/min, BLOOD FLOW 2.3-3.3, FiO2 90-100%

After 12 days: DOUBLE LUNG TRANSPLANTATION
• Weaning from ECMO was done in 1st postoperative day
• Extubation in 4th postoperative day
• Postoperative course was complicated by renal insufficiency
• Discharge at home 2 months after TX
IN CONCLUSION

- **Awake vs intubation**: ECMO as bridge to lung transplantation vs ECMO is feasible in patients with isolated and refractory respiratory failure
- Avoid **muscle deconditioning** and MV
- Importance of FT, **active rehabilitation** and ambulatory waiting for lung transplant
- Active rehabilitation can be **safely** provided in an ECMO pt (Attention to cannula!)
- Importance of **airway clearance techniques**, that requires patients cooperation, in order to avoid FBS and intubation
- **Role of NIV**
- Lack of evidence and need for further investigations