Extracorporeal support in acute respiratory failure

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Objectives

By the end of this session, you will be able to:

• Describe different forms of respiratory extracorporeal support

• List indications and contraindications for extracorporeal support in respiratory failure

• Know when to consider referral for extracorporeal support for patients with severe acute respiratory failure

• Consider future applications for extracorporeal support in patients with respiratory failure
Clinical scenario #1

- 45 year old woman, previously well, depression

- Community acquired pneumonia – bibasal consolidation, WCC 3, CRP 135, severe sepsis, **CUB 65** – admitted to medical HDU

- Appropriate initial and ongoing medical management, deteriorated (hypotension, hypoxaemia)

- ICU admission, intubated, noradrenaline

- Next day – 100% oxygen, pO$_2$ 6.9, pCO$_2$ 8.4, pH 7.28, sats 85%

- Influenza A (H1N1)
Clinical scenario #2

- 68 year old man with GOLD stage 3 COPD, 2 exacerbations/year, 1 admission 4 months ago (NIV)

- Exercise tolerance 50m, lives with wife, independent for washing/dressing, help with shopping

- Stable ischaemic heart disease

- Exacerbation requiring hospital admission and NIV, all appropriate acute therapy given

- Deterioration despite NIV 2l/min O₂: pH 7.28, pCO₂ 8.5, pO₂ 7.9
Basic principles of extracorporeal support

- **CO₂ removal +/- oxygenation** performed by artificial lung (membrane) in circuit

- **Oxygenation determined by:**
  - Rate of blood flow through device
  - Configuration of circuit (veno-venous, arterio-venous)

- **CO₂ removal determined by:**
  - Rate of sweep gas flow

- Allows reduction in ventilator settings (‘lung rest’) and supports acceptable gas exchange
Circuit configuration

- Veno-venous
  - ‘Respiratory’ support (no cardiac support)
  - Pump (motor) required
  - Oxygenation (depending on blood flow rate) = ECMO
  - CO$_2$ removal

- Arterio-venous
  - Pumpless
  - CO$_2$ removal, little/no oxygenation
  - iLA (Novalung)

- Veno-arterial
  - Respiratory and cardiac support
  - Pumped
  - ECMO for cardiac failure
Gaffney et al. Extracorporeal life support. BMJ 2010; 341: c5317
Bi-Caval Dual Lumen Catheter
Heat exchanger

Oxygenator

Motor
Smaller venous catheters
Veno-venous ECLS

• Oxygenation determined by
  • blood flow rate
    e.g. 5.5L/min with 31F cannula, 600mL/min with 15F cannula
  • Relative proportions of oxygenated ECMO blood flow and
deoxygenated venous return
  • Recirculation
  • Oxygen concentration of sweep gas
  • Efficiency of membrane
  • Degree of pulmonary dysfunction, $FiO_2$

• Carbon dioxide removal determined by
  • Sweep gas flow rate
  • Mechanical ventilatory strategy
Arterio-venous CO$_2$ removal

• Little (if any) oxygenation
  • Low blood flow (1-1.5L/min)
  • Arterial blood passes through membrane

• Carbon dioxide removal determined by
  • Sweep gas flow rate
  • Mechanical ventilatory strategy
Interventional Lung Assist (iLA, Novalung)

Percutaneous (femoral) insertion

13-19F short cannulae
Arterio-venous CO$_2$ removal
Potential benefits of extracorporeal support

• Reduced ventilator-associated lung injury
  • Lower tidal volume/pressure
  • Lower fiO₂

• Support gas exchange
  • Allow acceptable oxygenation and carbon dioxide/pH

• Permit investigation for underlying diagnosis
  • Imaging (CT)
  • Bronchoscopy
Evidence for ECMO in severe acute respiratory failure

- Many case series
- One older randomised controlled trial (1970s)
- One recent randomised controlled trial (CESAR)
- One recent cohort study (H1N1)
- Randomised controlled trial currently underway (EOLIA, NCT01470703)
Conventional ventilatory support vs ECMO for Severe Adult Respiratory failure

Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial

Giles Peck, Miranda Mugford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Mariamna M Thakorani, Clare L Hibbert, Ann Truesdale, Felicity Clemens, Nicola Cooper, Richard K Firmin, Diana Ebourne, for the CESAR trial collaboration
180 randomised

90 ECMO
5 died
3 before transport
2 during transport
85 transferred
68 ECMO
43 survived
57/90 survived
63%
17 conventional
14 survived
57/90 survived without severe disability
63%

90 conventional
75 CTC
15 RH
11 transferred to CTC
4 not transferred to CTC
1 died
1 too unwell to move
1 family declined
14 survived
45/90 survived
50%
3 withdrew
1 severe disability
P=0.03
41/87 survived without severe disability
47%

6 months
Criticisms of CESAR trial

- No standard algorithm for conventional management (pragmatic approach)
- Not all patients randomised to ECMO group actually received ECMO
- Differences in other treatments
  - Steroids
- Influence of regionalisation of care (centre effect?)
Variation in referral for ECMO for patients with Influenza A(H1N1) SwiFT study (ICNARC) and data from 4 UK ECMO centres ECMO-referred and non-ECMO-referred patients matched Survival to hospital discharge

80 ECMO-referred, 69 (86%) of whom received ECMO
Approximately 50% lower mortality for ECMO-referred patients (from ~50% to ~25%)
Management during ECLS

- Investigate/treat underlying diagnosis
- Mechanical ventilation
  - ‘Protective’ strategy, minimise $\text{fiO}_2$
- Anticoagulation/bleeding
  - Heparin
  - Avoidance of invasive procedures where possible
- Daily assessment of need for extracorporeal support
- Other good ICU care...
  - Sedation and paralysis
  - Circulation/haemodynamics
  - Acute kidney injury
  - Drug therapy
  - Weaning from ventilation
  - End of life care
Complications of ECLS

• Cannulation
  • Pneumothorax (<1%, neck cannula)
  • Cardiac tamponade (<1%, bicaval cannula)
  • Arterial injury/ischaemia (up to 10%)

• Bleeding (mostly with pumped ECMO support)
  • Minor bleeding is almost universal
  • More serious associated with surgical sites, GI tract, intrapulmonary
  • Intracranial bleeding 5-10% (ELSO registry)

• Risks of transport to SARF/ECMO centre
ECMO in the UK

- Glenfield Hospital, Leicester (since 1989)
- Commissioning process led by NSCT in 2011
- 5 centres commissioned to provide VV ECMO for severe acute respiratory failure (December 2011)
- Geographical coverage based on critical care networks (England)

- Referral criteria similar to CESAR
- Collaboration between centres
Referral criteria

Indications
• Age ≥16 years
• Potentially reversible severe acute respiratory failure
• No limitation to ongoing life-sustaining treatment
• Murray score ≥3.0 (or ≥2.5 with rapid clinical deterioration)
• Uncompensated hypercapnic acidosis (pH < 7.20)

(Relative) contraindications
• Intracranial bleed (current or recent)
• Other contraindication to heparinisation
• High pressure / high FiO₂ ventilation (>7 days)
• Age (>65 years)
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COPD exacerbation

- Prevention, good COPD care
- QOL discussion before acute exacerbation
- Appropriateness of ICU admission/endotracheal intubation
- Early extubation to NIV
Extracorporeal support in COPD?

• Avoid intubation, support/avoid NIV?

• Allow earlier extubation?

• Mobility

• Which patients?
Evidence for ECCOR in COPD

- No RCTs
- Mainly single cases/case series
- 2 case-control studies
- 10 studies including 87 patients
- 5 ongoing studies identified (total target N=200)

Extracorporeal carbon dioxide removal in patients with chronic obstructive pulmonary disease: a systematic review
Evidence for ECCOR in COPD

- Avoidance of intubation 65/70 (93%)
- Assisted successful extubation 9/17 (53%)

- Complications
  - 11 major (8 bleeding, 3 cannulation)
  - 30 minor (13 bleeding, 9 device failure)
Extracorporeal CO\textsubscript{2} removal

• Technological advances

• Coming to (or already arrived at!) a hospital near you

• Careful patient selection...
Summary

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