GUIDELINE FOR THE MANAGEMENT OF ECMO REFERRALS IN CHILDREN AND NEONATES

1. SCOPE

For use within the Paediatric and Neonatal Decision Support and Retrieval Service (PaNDR) for the East of England.

2. PURPOSE

To outline the key points for the management of newborns and children who are referred for extracorporeal life support for acute-refractory respiratory and / or circulatory failure.

3. DEFINITIONS AND ABBREVIATIONS

PPHN	Persistent Pulmonary Hypertension of the Newborn
PDA	Patent Ductus Arteriosus
PFO	Patent Foramen Ovale
ASD	Atrial septal defect
SVR	Systemic vascular resistance
PVR	Pulmonary vascular resistance
HFOV	High Frequency Oscillatory Ventilation
MAP	Mean Arterial Blood pressure
ECMO	Extracorporeal Membrane Oxygenation
OI	Oxygenation index = (mean airway pressure x Fi02x 100)/Pa02 (in mmHg)
MAS	Meconium Aspiration Syndrome
ARDS	Acute Respiratory distress syndrome
DCM	Dilated cardiomyopathy
ELSO	Extracorporeal Life Support Organisation
PaO2	Arterial oxygen partial pressure
NOi	Inhaled Nitric Oxide

CXR	Chest X-ray
EXIT to ECMO	Ex utero intrapartum treatment

4. INTRODUCTION

Extracorporeal Membrane Oxygenation provides a potential lifesaving support for neonates and children with severe respiratory and/or cardiovascular failure refractory to conventional therapy and caused by a reversible pathology.

There are six national paediatric designated ECMO providers for respiratory and cardiac support in the UK: Great Ormond Street Hospital in London, Glenfield in Leicester, Freeman Hospital in Newcastle, Yorkhill in Glasgow, Alder Hey Hospital in Liverpool and Birmingham Children´s Hospital.

The ECMO retrieval process is undertaken in patients with severe respiratory and/or cardiac failure nonresponding to conventional medical therapies, and it is considered an emergency situation. The risk of significant morbidity and mortality is high and therefore the therapy needs to be provided in one of the designated centers. A significant proportion of complications are related to bleeding events during cannula positioning or whilst on ECMO due to systemic anticoagulation.

All paediatric and neonatal referrals for respiratory (and/or cardiac) ECMO in the East of England should be made through PaNDR EBS, who will organise a conference call through CATS (when GOSH is the destination center). This conference call will be arranged between the PaNDR Paediatric Consultant, the ECMO Consultant and the referring hospital in order to establish the eligibility of the patient to undergo extracorporeal life support and to facilitate transfer to the appropriate center should the patient require it.

5. INDICATIONS FOR ECMO

ECMO is indicated in cases of severe respiratory and/or cardiovascular failure when all other conventional therapies have been exhausted or the interventions to maintain the patient clinically stable are inherently damaging (such as high airway pressures either on conventional ventilation or HFOV, high FiO_2, high doses of vasoactive drugs).

ECMO should be considered in the following conditions, considering that there is a high likelihood of mortality and potential reversible aetiology:

- Meconium Aspiration Syndrome (MAS)
- PPHN

- Pneumonia / ARDS
- Severe sepsis or septic shock
- CDH with severe barotrauma or air leak
- Paediatric or neonatal cardiac patients (such as DCM or acute myocarditis) that requires assessment by the Heart Failure / Transplant teams

Criteria for ECMO

According to the ELSO, a patient with any of the above-mentioned conditions should be considered for ECMO if one or more of these criteria are met:

I. Inadequate tissue oxygen delivery despite maximal medical therapy (rising lactate, worsening metabolic acidosis, signs of end-organ dysfunction)
II. Severe hypoxic respiratory failure with acute decompensation (PaO_2 < 40 mmHg or 8 kPa)
III. Oxygenation index > 25 with sustained elevation and no improvement
IV. Severe pulmonary hypertension with evidence of right ventricular dysfunction and/or left ventricular dysfunction
V. Children > 2 kg weight and/or > 34 weeks' gestational age
VI. Severe air leak syndrome despite appropriate chest drainage and likely to worsen with continued high levels of positive airway pressure and altitude

Absolute contraindications for ECMO

- Contraindication for systemic anticoagulation (such as intracranial haemorrhage)
- Lethal chromosomal disorders (including trisomy 13 and 18 but **not trisomy 21**)
- Irreversible organ dysfunction including severe brain damage
- Vessel too small for cannulation

Relative contraindications:

- Irreversible organ damage (unless considered for organ transplant)
- Less than 2 kg and/or less than 34 weeks gestation (consider vessel assessment using USS)

6. INITIAL MANAGEMENT

At the time of the ECMO referral, the referring unit should provide the following information in order to assess patient´s candidacy for ECMO:

- Age and weight of the patient

- If a newborn, gestational age, antenatal scans results and perinatal history (APGARs, type of delivery, condition at birth, etc)
- Previous episodes of hypoxemia, hypoxic – ischaemic insults, cardiac arrests, including duration and interventions performed
- Duration and type of respiratory support at referral (conventional ventilation or HFOV), settings (including PEEP, FiO_2, RR, Tidal volume), presence of air leak on CXR
- Oxygenation Index = (MAP x FiO_2 x 100) / PaO_2 (in mmHg)
- Serial blood gases (worst pH, highest lactate values, etc)
- Pre & Post ductal saturations
- Interventions and treatments so far (antibiotics, surfactant, NOi, magnesium)
- Cardiovascular status (HR, MAP, SBP, CRT, femoral pulses present?) and current vasoactive support
- Echocardiogram if local expertise available
- Cranial USS scan ideally performed locally to exclude acute bleeding
- End-organ function including renal (Creat, Urea, urine output), liver function (glucose, LFTs, coagulation profile)
- FBC and platelet count to address any issue prior to ECMO cannulation

Initial interventions and management:

- Administer 100% FiO_2 as oxygen is the most potent pulmonary vasodilator
- Handle the patient with full sedation and muscle relaxation
- Ensure ETT position is appropriate on CXR and there is no ETT leak – in a neonate, consider a cuffed ETT
- CXR to assess lung fields, position of ETT, presence of air leak
- Optimise ventilation & oxygenation – use optimal PEEP during conventional ventilation (8 to 10 cmH2O) or MAP while using HFOV, increase inspiratory time (Ti)
- Commence NOi when available if OI above 15 and/or very poor RV systolic function on Echo
- Monitor arterial blood gases 1 to 2 hourly, aim for pH > 7.35, using Sodium Bicarbonate or THAM after discussion with PaNDR and CICU Consultant
- Titrate inotropic and vasopressor drugs to maintain mean BP above the normal limits for age and weight (goal is to achieve mean BP equal or above pulmonary pressures)
- If BP stable, consider Magnesium Sulphate bolus at 40-50 mg/kg over 30-45 min (monitor for hypotension) aiming for a serum Magnesium above 1 mmol/L

7. CONSIDERATIONS FOR TRANSPORT

The first and most important aspect to consider prior to transporting a very sick child to an ECMO center, is to speak to the family about the clinical condition of the child, what is ECMO and how it can help their child. It is important to mention that ECMO is a form of support not a treatment. Additionally, give ECMO information leaflet if available and obtain verbal consent (surgical consent will be sought once at the ECMO center).

Other clinical considerations:

- Check the ETT position prior to departure and ensure there is no ETT leak
- Ensure adequate sedation, analgesia and muscle relaxation is provided by continuous infusion
- Continue NOi during transport at 20ppm and FiO_2 100%
- Any pneumothoraces must be drained prior to mobilising the patient
- Ensure all arterial lines, central lines and peripheral lines are well secured and delivery of the infusions is not compromised
- In neonates ideally use Umbilical Arterial Catheter (UAC) and Umbilical Venous Catheter (UVC)
- In older children, avoid if possible central venous catheters in the right or left internal Jugular territory (to discuss beforehand with PaNDR and CICU Consultant)
- Titrate inotropic/vasopressor support en-route to maintain blood pressure targets

8. SURVIVAL RATES & RISKS

Survival to hospital discharge figures (from ELSO registry, October 2020)

Neonatal ECMO

Condition	Survival at discharge
PPHN	73%
Meconium Aspiration	92%
Neonatal sepsis/pneumonia	46% (sepsis), 60% (pneumonia)
Congenital Diaphragmatic Hernia	50%

CHD, myocarditis, arrhythmias, Pulm Hypertension	35-45%
ECPR	40-50%
EXIT to ECMO	64%

Paediatric ECMO

Condition	Survival at discharge
Aspiration pneumonia	67%
Pneumonia (bacterial/viral)	55-65%
pARDS	55-65%

Risks associated with ECMO

Bleeding	5-10%
Brain injury – severe – Mild to moderate	5% 20-25%
Mechanical problems with ECMO circuit	5-10%
Infection	5-10%

9. REFERENCES

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Appendix 1: Monitoring compliance and effectiveness

Set out below are the issues which **must** be addressed when drawing up the monitoring section of a Trust document. It is important that a suitable process is chosen, one which will be followed through in practice and is appropriate for the document in question.

Note: It is not necessary to reproduce the questions below in the document but it is crucial that all the listed topics are covered. The questions and responses are for guidance only.

1. **What are the key standards of the document that will be monitored?**
   This should include the standards laid down in the document or any key performance indicators (KPIs), such as indicated by the NHS Litigation Authority or any other relevant external bodies (as appropriate).
2. **How will these standards or KPIs be monitored?**
   Consider what will be done in practice to monitor what is described in the document. The following is a list of suggestions which may be useful:
   - a formal audit (internal or external)
   - quarterly spot checks
   - review of reported incidents
   - inspections
   - risk assessments or risk reviews
   - patient/staff surveys
   - complaints monitoring
   - sickness/ absenteeism levels
   - training records.

   An example of a KPI might be that '85% of all patient complaints are resolved within 14 days' or that '95% of patients surveyed are happy with the service received.' The KPI will vary according to the practice area and document type.
3. **Who will be responsible for conducting the monitoring?**
   Please state in the document, for each type of monitoring listed, whether it is an individual (no names needed, just the job title) or a group or committee who will be responsible.

4. **How frequently will the standards or KPIs be assessed?**
   Please state how often the monitoring will take place: eg daily, weekly, monthly, quarterly, annually or by spot checks.
5. **Who will review the results of the monitoring?**
   Please state who will be responsible for looking at the results of the monitoring; identifying any shortfalls which come to light, and most importantly, what will be done to address any shortfall.
6. **Responsibility for implementation of any actions needed**.
   Once actions have been identified as a result of (5) above, whose responsibility will it be to ensure any actions are followed through? Will it be an individual or a committee or group? – please state which. Please also state how the results of any implementation will be recorded or evidenced.