PERSISTENT PULMONARY HYPERTENSION OF THE NEWBORN (PPHN) ● 1/3

RECOGNITION AND ASSESSMENT

Definition

- Failure of normal postnatal drop in pulmonary vascular resistance
- Leads to hypoxia and right-to-left shunting
- Can be primary (idiopathic) or secondary
- Severe hypoxaemia
- Complex condition with varied causes and degrees of severity
- Echocardiogram: structurally normal heart – may be evidence of right or left ventricular dysfunction

Idiopathic

- Degree of hypoxia may be disproportionate to degree of hypercarbia
- Black lung on chest X-ray with no/minimal lung disease
- may be secondary to maternal drugs e.g. non-steroidal anti-inflammatory drugs or SSRIs
- Associated with polycythaemia

Secondary

- May be associated with:
- parenchymal lung disease e.g. meconium aspiration (MAS), surfactant deficiency, pneumonia/sepsis, broncho-pulmonary dysplasia
- structural abnormalities: pulmonary hypoplasia, congenital diaphragmatic hernia (CDH), A-V malformations, congenital cystic adenomatoid malformation
- perinatal asphyxia or severe anaemia
- Rare causes: alveolar capillary dysplasia, surfactant B deficiency

CLINICAL FEATURES

Usually present in first 12 hr of life

- Hypoxia with/without hypercarbia
- Mimics cyanotic heart disease
- CVS: tricuspid regurgitant murmur, right ventricular heave, loud second heart sound with/without systemic hypotension
- Idiopathic PPHN: minimal or no respiratory distress
- Secondary PPHN: moderate to significant respiratory distress

INVESTIGATIONS

- Blood gas shows hypoxaemia with rising oxygenation index, SpO_2 >10% difference in preductal (right hand) and postductal saturations (feet) (preductal saturations > postductal saturations)
- Hyperoxia test (100% oxygen for 5 min): SpO_2 may improve **or** may not respond in established PPHN (as in cyanotic heart disease)
- Chest X-ray: variable findings depending on underling diagnosis (normal or minimal changes in idiopathic PPHN)
- Echocardiogram (although not mandatory for initial diagnosis and management) is useful:
- to exclude cyanotic heart disease
- to assess pulmonary pressure
- to evaluate right and or left ventricular dysfunction
- Echocardiographic signs of PPHN in presence of normal cardiac anatomy:
- significant tricuspid regurgitation (TR)
- dilatation of right side of heart and/or hypertrophy of right ventricle
- right-to-left shunting across PFO and/or PDA
- pulmonary regurgitation
- bowing of interventricular septum to the left
- relatively small left ventricle (though apex forming)
- Pulmonary pressure is estimated from echocardiogram using:

  TR (systolic pulmonary pressure = 4 × $(VmaxTR)^2$ + usual right atrial pressure of 5). TR is not always present in presence of right heart dysfunction

MANAGEMENT

- If failed response to hyperoxia test and echocardiography not available to rule out duct dependent heart disease, start prostaglandin infusion IV (see **Prostaglandin infusion** guideline)
- Once PPHN suspected involve consultant neonatologist immediately

PERSISTENT PULMONARY HYPERTENSION OF THE NEWBORN (PPHN) ● 2/3

- Aims of management are to:
  - decrease pulmonary vascular resistance
  - maintain normal systemic blood pressure and end-organ perfusion
  - treat underlying condition, if known

General measures

- Minimal handling and noise
- Secure arterial and central venous access, (see **Arterial line insertion** guideline or **Umbilical artery catheterisation and removal** and **Umbilical venous catheterisation and removal** guidelines)
- Maintain normal temperature, biochemistry and fluid balance
- Keep ionised calcium >1 mmol/L
- Keep Hb ≥120 g/L
- Give antibiotics (infection is difficult to exclude at onset of disease process) (see **Infection in first 72 hours of life** guideline)
- Surfactant therapy may be beneficial in parenchymal lung diseases, e.g. MAS, pneumonia surfactant deficient lung disease – discuss with consultant
- If perfusion poor, fluid bolus [sodium chloride 0.9% 10 mL/kg or if coagulopathy, fresh frozen plasma (see **Coagulopathy** guideline)]. Do not give bolus >20 mL/kg without robust evidence of hypovolaemia

Ventilation and oxygenation

- Aim for preductal SpO_2 91–95% kPa. Do not attempt to reduce pre and postductal saturation difference as long as postductal SpO_2 >70%
- Avoid intermittent desaturations (preductal) <85% or preductal SpO_2 >97%
- Aim for preductal PaO_2 7.3–10.6 (if right radial arterial line) (tolerable hypoxaemia)
- Monitor oxygenation index (OI)

$$OI = \frac{\text{mean airway pressure (cm } H_2O) \times \text{ \% oxygen}}{\text{postductal } PaO_2 \text{ (kPa)} \times 7.5}$$

  - if umbilical arterial line OI will be higher as it is postductal OI and targeting lower postductal saturations
- Monitor OI trends
- Aim for disease specific ventilatory strategies: lung recruitment in parenchymal lung disease and discuss with consultant regarding surfactant therapy. In black lung PPHN and CDH aim for gentle ventilation
- Commence with conventional ventilation (targeted tidal volume)
  - high frequency oscillatory ventilation (HFOV) may be needed if requiring high pressures to deliver the set tidal volume [see **Ventilation: high frequency oscillatory ventilation (HFOV)** guideline]
- Aim for $PaCO_2$ 6–8 kPa, avoid hypocarbia
- Use sedation and muscle relaxation in babies with high ventilatory and oxygen requirements and/or ventilator asynchrony

Pulmonary vasodilatation

- If OI >20 or needs 100% oxygen, or significant PPHN on echo, use inhaled nitric oxide (NO) as a selective pulmonary vasodilator (see **Nitric oxide** guideline)
- If no response to NO or worsening PPHN, discuss with consultant regarding use of sildenafil. Liaise with KIDS NTS (see **Transport and retrieval** guideline)
- Magnesium sulphate may be used as a pulmonary vasodilator
  - side-effect is systemic hypotension
  - may require fluid bolus
- Babies with PPHN requiring NO should be referred to a NICU for ongoing management

Circulatory management

- Aim for normal gestation specific blood pressure
  - normal heart rate
  - urine output >1 mL/kg/day
  - lactate <3
- If hypotensive give inotropes judiciously:
  - adrenaline may be useful in increasing systemic blood pressure
  - if signs of right ventricular dysfunction consider milrinone
    - may need to add noradrenaline as milrinone may cause systemic vasodilatation
  - if milrinone not available dobutamine may be used as inodilator
- If hypotensive and not responding to inotropes, give hydrocortisone

PERSISTENT PULMONARY HYPERTENSION OF THE NEWBORN (PPHN) ● 3/3

- Monitor for side effects of treatment e.g. tachycardia, rising lactates

Severe and resistant PPHN not responding to conventional management
Baby born ≥34 weeks or ≥2 kg with PPHN

- Not responding or rising OI despite escalation of ventilation and NO therapy
- Recurrent pulmonary hypertensive episodes
- Hypotensive despite inotropes or worsening side effects of inotropic therapy
- No significant progression in 2–3 days
- Discuss with KIDS NTS team (see **Transport and retrieval** guideline) and conference call with ECMO centre

Criteria for ECMO

- Baby born ≥34 weeks or ≥2 kg with PPHN
- Rising preductal oxygenation index >40, despite medical management
- Reversible lung disease
- No lethal congenital malformation

Exclusion criteria (if in doubt, discuss with ECMO team)

- Major intracranial haemorrhage
- Lethal congenital or chromosomal anomalies
- Severe encephalopathy
- Major cardiac malformation

A baby accepted for transfer to ECMO centre will be retrieved by ECMO or PICU team

- ECMO centre will need:
  - cranial ultrasound scan
  - maternal blood for group and crossmatching (check with ECMO centre)
  - referral letter
  - copies of hospital notes/chest X-rays
- Outreach ECMO
  - ECMO team may decide to start outreach ECMO in NNU before transfer to ECMO unit. Check with ECMO team regarding diathermy unit and number of packed cell units needed for procedure

Referral for ECMO

- For West Midlands contact KIDS NTS team on 0300 200 1100
- KIDS NTS will liaise with ECMO centres to find a cot and/or give advice