Persistent Pulmonary Hypertension of the Newborn (PPHN)

DEFINITION: PPHN is persistence after birth of the high pulmonary arterial pressure (P_{PA}), often suprasystemic, that is characteristic of the fetal circulation. PPHN may occur with or without apparent pulmonary disease.

PATHOPHYSIOLOGY: In fetal life, pulmonary blood flow (Qp) is low (5-10% of cardiac output [CO]) due to high pulmonary vascular resistance (PVR) and shunts (*i.e.*, foramen ovale, ductus arteriosus) which permit blood to bypass the pulmonary vascular bed. At birth, PVR normally falls dramatically (due to lung inflation and oxygenation), Qp increases to 100% of CO and, by 24 hours after birth, P_{PA} has fallen to about 50% of systemic arterial pressure.

When this normal transition fails, PVR and P_{PA} remain elevated, Qp stays low, right to left shunting occurs at the foramen ovale and ductus arteriosus, and hypoxemia results. Several factors influence PVR; among these, **acidosis and alveolar hypoxia are potent pulmonary vasoconstrictors.**

PPHN can result from abnormal pulmonary vascular development or with normal development of the pulmonary vasculature, when there is either failure of the normal pulmonary vasodilatation at birth or presence of powerful vasoconstrictive factors. Clinical scenarios associated with PPHN include:

- **Abnormal pulmonary vascular development** (*e.g.*, increased pulmonary vascular smooth muscle due to chronic fetal hypoxia, maternal diabetes, alveolar capillary dysplasia)
- **Pulmonary hypoplasia** with associated hypoplasia of pulmonary vasculature (*e.g.*, congenital diaphragmatic hernia, Potter's syndrome, prolonged oligohydramnios)
- **Postnatal elevation in pulmonary vasoconstrictors** (*e.g.*, sepsis, pneumonia, aspiration syndromes, perinatal asphyxia)
- **Congenital heart disease** (*e.g.*, total anomalous pulmonary venous return with obstruction). See section on Congenital Heart Disease, P. 95.

CLINICAL PRESENTATION:

- Term or post-term infant (In preterm infants, the pulmonary vasculature is rarely sufficiently developed to result in PPHN.)
- Onset at birth or within a few hours
- History or clinical findings consistent with condition associated with PPHN
- Cyanosis, often with pre-ductal (right upper extremity) O_2 saturation >post-ductal
- Respiratory distress is common
- Chest radiograph clear (idiopathic PPHN) or abnormal due to associated condition

EVALUATION and DIFFERENTIAL DIAGNOSIS:

- Begin O2 therapy, assisted ventilation if needed, blood culture and antibiotics immediately as you evaluate the infant.
- Chest radiograph

-Pre-ductal and post-ductal pulse O_2 saturation (SpO_2) monitors (to detect R → L shunting at ductus arteriosus). A difference of ≥10% suggests marked pulmonary hypertension.
-Cardiology consultation and echocardiogram to R/O congenital heart disease.
-Other abnormalities that can elevate PVR and require treatment include: acidosis, polycythemia, hypothermia, hypoglycemia, hypomagnesemia.

TREATMENT: Early treatment is important. The primary therapy is supplemental **oxygen.** Consider intubation and mechanical ventilation in infants who have significant respiratory distress or CO_2 retention. The aim is reduction of PVR through pulmonary vasodilator therapy, including the following as needed:

-High inspired oxygen concentration. Start with **100% O_2**. Maintain pre-ductal PaO_2 at 90 to 100 mmHg.
-**Correct metabolic acidosis** ($NaHCO_3$, THAM). **Do not administer alkali unless the patient is receiving adequate assisted ventilation.** With inadequate alveolar ventilation, $NaHCO_3$ will cause hypercarbia and worsen acidosis. THAM can cause apnea (due to rapid fall in CO_2).
-**Correct respiratory acidosis** with assisted ventilation. **Mild hyperventilation** (pH 7.40 to 7.45) may be helpful. (Do not hyperventilate to compensate for metabolic acidosis; this will reduce cardiac output.)
-**Assisted ventilation.** Use lowest effective mean airway pressure, especially in infants without significant parenchymal disease. High frequency ventilation may be effective in those with severe lung disease.
-Inhaled **nitric oxide** (iNO): dose is 20 ppm (see section on Nitric Oxide, P. 89).
-Maintain **adequate systemic blood pressure**. Keep mean arterial blood pressure in upper range for infant's weight (see graphs on P. 36). Use **dopamine**; begin at dose of 5 mcg/kg per min IV and increase as necessary. Dobutamine is less effective in newborns and may lower blood pressure.
-**Adequate sedation**, pharmacologic paralysis, as needed. Minimize handling.
-**ECMO** is needed for those in whom less invasive therapy is not effective in maintaining oxygenation, normal acid-base status or hemodynamic stability.

As patient improves with treatment, **wean oxygen and ventilatory support slowly**. Frequently in infants with PPHN, oxygenation will decrease suddenly and dramatically after small decreases in FIO_2 or ventilator pressures, or with airway suctioning, and it may take several hours for oxygenation to recover.