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Respiratory Distress in the Term Newborn

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Respiratory Distress in the Term Newborn

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Definition

Respiratory distress (RD) in newborn is characterized by increased work of breathing (WOB) in the form of tachypnea, grunting, chest retractions, and often associated with reduced air entry and cyanosis.

Incidence

Respiratory distress is common in the neonatal period. Incidence of RD is around 5% in term, 15% in late preterm, and >30% in infants with gestation <34 weeks.

Downes and Silverman Anderson Score (SAS) on the clinical evaluation, oxygen saturation (SpO_2) and fraction of inspired oxygen (FiO_2) requirement, oxygen saturation index (OSI), alveolar-arterial diffusion gradient of oxygen (A-aDO_2), oxygenation index (OI), and arterial blood gas parameters are useful in the assessment of severity of RD in a term infant.

There are various clinical scoring systems for assessing the severity of RD objectively, out of which Downes scoring **(Tables 1)** and Silverman Anderson **(Tables 2)** scoring systems are widely used. Downes scoring system is used for term neonates whereas SAS score is often used in preterm neonates.

A total score of 0 suggests no distress, score of 1–4 mild RD, score of 5–7 moderate RD, and score of >7 severe distress or impending respiratory failure.

TABLE 1: Downes score.

Score	*Respiratory rate*	*Cyanosis*	*Air entry*	*Grunt*	*Retraction*
0	<60 breaths/minute	Nil	Normal	None	Nil
1	60–80 breaths/minute	In room air	Mild decrease	Audible with stethoscope	Mild
2	>80 breaths/minute or apnea	In >40% oxygen	Marked decrease	Audible without stethoscope	Moderate-to-severe

TABLE 2: Silverman Anderson score (SAS).

Score	*Upper chest**	*Lower chest*#	*Xiphoid retractions*	*Nares dilatation*	*Grunting*
0	Synchronized	No retractions	None	None	None
1	Lag on inspiration	Just visible	Just visible	Minimal	Heard with stethoscope
2	Seesaw	Marked	Marked	Marked	Heard without stethoscope

*Part of the chest anterior to mid-axillary line.

#Part of the chest posterior to mid-axillary line.

Pulse Oximetry

- ☑ Noninvasive saturation monitoring by pulse oximetry helps in assessing the severity.
- ☑ Saturation level <95% indicates the need for intervention.
- ☑ Preductal saturation target for a sick newborn on respiratory support is 90–95%.
- ☑ Oxygen saturation index can be calculated for any neonate on invasive respiratory support. OSI value of <7 suggests mild hypoxic respiratory failure (HRF), 7–15 moderate HRF, and >15 severe HRF.
- ☑ Pulse oximetry screening is useful in early detection of critical congenital heart disease (CHD). All neonates must undergo preductal (right upper limb) and postductal (one of the lower limb) saturation check around or after 24 hours of life and saturation <95% or saturation difference between preductal and postductal of >3% is considered as screen positive and should undergo echocardiography.

Other Assessment Tools

Calculation of various formula

Saturation index = $(MAP \times FiO_2)/SpO_2$

$A\text{-}aDO_2$ = (700 × FiO_2) – ($PaCO_2$ + PaO_2) or
= (760* – Water vapor pressure × FiO_2) – ($PaCO_2$/0.8#) – PaO_2

PF ratio = PaO_2/FiO_2
Oxygenation index = $(MAP \times FiO_2)/PaO_2$

*760 denotes the atmospheric pressure at sea level
#0.8 denotes respiratory quotient

(MAP: mean airway pressure; FiO_2: fraction of inspired oxygen; PaO_2 and $PaCO_2$: calculated from arterial blood gas; SpO_2: saturation from pulse oximeter)

Alveolar–Arterial Diffusion Gradient of Oxygen

- ☑ $A\text{-}aDO_2$ is the difference between amount of oxygen in alveoli and the amount of oxygen dissolved in plasma (arterial oxygenation).
- ☑ $A\text{-}aDO_2$ values could reach up to 200–400 in severe RD syndrome, persistent pulmonary hypertension (PPHN) and severe meconium aspiration syndrome (MAS).

PF Ratio (PaO_2/FiO_2)

- ☑ This is one of the measures used in ventilated neonates. Ratio of <300 mm Hg indicates abnormal gas exchange.

Oxygenation Index

- ☑ This is commonly used in neonates to assess the severity and to guide on the timing of intervention.
- ☑ OI value of <15 suggest mild HRF; 15–25 suggests moderate HRF; values >25 suggest severe HRF, and the need for inhaled nitric oxide (iNO) therapy.
- ☑ A persistent value above 40 is an indication for extracorporeal membrane oxygenation (ECMO).

Blood Gas Analysis

- ☑ Arterial or capillary blood gas analysis helps in assessing the severity of RD and guiding the management.
- ☑ Normal range of blood gas values in neonates are:
  - pH 7.35–7.45, $PaCO_2$ 35–45 mm Hg, PaO_2 45–80 mm Hg, bicarbonate 20–24 mEq/L, and base deficit 3–7 mEq/L.

Causes of RD in term neonates are depicted in **Table 3**.

TABLE 3: Causes of respiratory distress.

Common causes	***Uncommon causes***
☑ Transient tachypnea of the newborn (TTN) ☑ Meconium aspiration syndrome (MAS) ☑ Respiratory distress syndrome (RDS) ☑ Congenital pneumonia/sepsis ☑ Persistent pulmonary hypertension (PPHN) ☑ Perinatal asphyxia ☑ Critical congenital heart disease ☑ Congenital diaphragmatic hernia (CDH) ☑ Air leak syndrome: Pneumothorax	☑ Inborn errors of metabolism ☑ Anemia/high output failure ☑ Acidosis, hypoglycemia, hypothermia, and hyperthermia ☑ *Cardiac*: Arrhythmias and cardiomyopathy ☑ *Upper airway anomaly*: Choanal atresia, micrognathia, Pierre Robin sequence, laryngeal web, tracheal atresia, and vascular rings ☑ *Respiratory*: Alveolar capillary dysplasia, surfactant protein deficiency, pulmonary lymphangiectasis, and pulmonary alveolar proteinosis ☑ *Thoracic*: Chest wall deformities, skeletal dysplasia, hydrops fetalis, and phrenic nerve palsy ☑ *Neuromuscular*: Neuromuscular disorders, cerebral malformations, maternal sedation, and birth injury

Etiology

History, onset of RD, and clinical evaluation are useful in identifying the etiology of RD in term infant **(Tables 4 and 5)**.

TABLE 4: Etiology according to the onset of respiratory distress.

Onset	***Etiology***
<6 hours of life	☑ Transient tachypnea of newborn (TTN) ☑ Early-onset pneumonia/sepsis ☑ Meconium aspiration syndrome (MAS) ☑ Perinatal asphyxia ☑ Congenital diaphragmatic hernia (CDH)
>6–12 hours of life	☑ Sepsis ☑ Pneumonia ☑ Critical congenital heart disease (duct dependent systemic and pulmonary) ☑ Hypothermia and hypoglycemia ☑ Inborn error of metabolism ☑ Congenital pulmonary airway malformation (CPAM)

Etiology

TABLE 5: Etiology based on history.	
History	***Presentation***
History of maternal diabetes	RDS, TTN, MAS, and asphyxia
History of maternal fever/PPROM/chorioamnionitis	Sepsis and pneumonia
Fetal distress/CTG abnormality	Asphyxia
Elective cesarean section without labor	TTN
Consanguinity/previous sibling death	Inborn errors of metabolism (IEM)
Antenatal scan abnormality: ☑ Polyhydramnios ☑ Oligohydramnios ☑ Specific scan abnormality	Tracheoesophageal fistula, CDH, and CPAM Pulmonary hypoplasia CDH, CPAM, pleural effusion/hydrops, and congenital heart disease

(CDH: congenital diaphragmatic hernia; CPAM: congenital pulmonary airway malformation; CTG: cardiotocography; MAS: meconium aspiration syndrome; PPROM: preterm premature rupture of membrane; RDS: respiratory distress syndrome; TTN: transient tachypnea of newborn)

Diagnosis

Chest X-ray, ultrasound lungs, and echocardiography helps in differentiating various etiology of RD in neonates apart from history and clinical examination **(Table 6)**.

TABLE 6: Chest X-ray and ultrasound findings in various conditions.		
Condition	***Chest X-ray***	***Ultrasound lung***
TTN	Sun burst appearance; fluid in minor fissure	Thickened pleural lines, B lines, double lung point
MAS	Hyperinflation with bilateral patchy lung opacities	Disappearance of A lines, scattered B lines
RDS	Reticulogranular opacities/ground glass appearance	B lines, white lungs
Pneumonia	Asymmetrical parenchymal infilterates	Nonspecific changes
Pneumothorax	Collapsed lung border with air in pleural space with mediastinal shift	Absence of sliding sign; Bar code sign

(RDS: respiratory distress syndrome; TTN: transient tachypnea of newborn; MAS: meconium aspiration syndrome)

Table 7 elucidates the differences between congenital heart disease (CHD) and pulmonary disease.

TABLE 7: Differences between CHD and pulmonary disease.

	Pulmonary disease	***Cyanotic heart disease***
Onset of respiratory distress	Since birth or within 6 hours of life	Usually after 24 hours, when the ductus arteriosus closes
History	Risk factors such as maternal fever, prolonged rupture of membranes, and meconium-stained amniotic fluid could be elicited	Family history of congenital heart disease may be seen
Antenatal scans	Could detect congenital malformations such as CDH, CPAM, tracheoesophageal fistula	Structural heart conditions could have been detected in antenatal scans
Respiratory distress	Usually moderate to severe distress associated with chest retractions	Silent tachypnea in cardiac conditions with reduced pulmonary flow; mild-to-moderate distress in conditions with increased pulmonary blood flow
Other signs	Scaphoid abdomen and hyperinflated chest in CDH; copious secretion in TEF; septic shock can be present in pneumonia; barrel-shaped chest in MAS; labile saturations; and hypoxia during handling in PPHN	Cyanosis, murmur, signs of cardiac failure (gallop rhythm, and hepatomegaly), prominent precordial pulsations, single second heart sound, and feeble femoral pulses
Pulse oximetry screening	Occasionally positive (false positive in PPHN and certain respiratory conditions)	Positive with greater accuracy
Arterial blood gas	Hypoxia (PaO_2 low) Hypercapnia ($PaCO_2$ high)	Hypoxia (PaO_2 low) Hypocarbia or normocarbia ($PaCO_2$ normal or low)
*Hyperoxia test**	PaO_2 > 150 mm Hg	PaO_2 < 150 mm Hg
Chest X-ray	No cardiomegaly Patchy consolidation in pneumonia; bilateral patchy infiltrates with hyperinflation-MAS; prominent bronchovascular marking and fluid in minor fissure TTN; normal lungs in PPHN; ground glass appearance in RDS	Egg on side appearance in TGA; normal or small heart with pulmonary edema in obstructive TAPVC; box-shaped heart in Ebstein anomaly
Echocardiography	Structurally normal heart; could show features of PPHN	Confirms the diagnosis

*Limited value with advent of echocardiography; also it carries risk of oxygen toxicity.
(CDH: congenital diaphragmatic hernia; CHD: congenital heart disease; CPAM: congenital pulmonary airway malformation; MAS: meconium aspiration syndrome; PPHN: persistent pulmonary hypertension; RDS: respiratory distress syndrome; TAPVC: total anomalous pulmonary venous connection; TEF: tracheo-esophageal fistula; TGA: transposition of the great arteries; TTN: transient tachypnea of the newborn)

Differential Diagnosis

Other Differentials

Metabolic Acidosis

Metabolic acidosis causes deep and high rate of breathing as a compensatory mechanism to wash out the partial pressure of carbon dioxide (pCO_2). Air entry would remain good and characterized by absence of associated finding such as grunting or cyanosis. SpO_2 is normal and above 95%.

Anemia

Anemia results in tachypnea as a part of high output cardiac failure. History of antepartum hemorrhage or Rh incompatibility along with clinical examination showing pallor should rise the suspicion of anemia and appropriate evaluation should be carried out.

Treatment

General Therapy

- ☑ *TABC*: Maintain thermoneutral zone, clear the airway, and ensuring adequate breathing and circulation. Maintain skin temperature between 36°C and 37°C. RDS and PPHN are aggravated by hypothermia.
- ☑ Continuous clinical and pulse oximeter monitoring to be done to determine the requirement for respiratory support (including escalation and de-escalation of support and type).
- ☑ Maintain euglycemia, normal fluid and electrolyte balance. Ensure a minimum glucose infusion rate of about 4 mg/kg/min for adequate glucose homeostasis. In at risk newborns, 6–8 mL/kg/day of calcium gluconate to be added to the fluid. Enteral feeding should be started as soon as the infant is clinically stable and escalated to full feeds.
- ☑ Maintenance of adequate and age-appropriate hematocrit.
- ☑ Antibiotics are usually not required. Decision to start antibiotics would depend on the clinical situation, but the threshold should be low.
- ☑ Warm, humidified oxygen should be given with soft nasal cannula preferably with an FiO_2 meter and pulse oximeter monitoring to titrate the concentration of oxygen needed. Avoid using hood oxygen. When on any respiratory support maintain SpO_2 between 90 and 95%.
- ☑ When low flow nasal oxygen (<2 L/min) with nasal cannula fail to maintain target oxygen saturation (just above 94%) and PaO_2 of 50–80 mm Hg, heated humidified high-flow nasal cannula (HHHFNC) may be tried first. Begin with a flow of 4–6 L/min and increase @ 0.5–1 L/min as required [suggested by increasing respiratory rate (RR), WOB, and FiO_2 requirement) till a maximum of 8 L/min.

General Therapy

- ☑ If target saturation (90–95%) are not maintained or in those with increased WOB, noninvasive respiratory support by either continuous positive airway pressure (CPAP) or nasal intermittent positive pressure ventilation (NIPPV) should be started. Indications for starting CPAP are a Downes or Silverman score of ≥5 or an FiO_2 requirement of >0.3 to maintain an acceptable saturation on pulse oximeter. CPAP is started with a positive end-expiratory pressure (PEEP) of 5 cmH_2O, FiO_2 of 0.3 and titrated to maximum of 8 cmH_2O and 0.6 FiO_2, respectively. NIPPV is started with initial settings of PEEP of 5 cmH_2O, peak inspiratory pressure (PIP) of 14 cmH_2O, rate of 30 bpm, Ti of 0.50 second, FiO_2 of 0.3 and titrated to a maximum PEEP of 8 cmH_2O, PIP 25 cmH_2O, rate 50 bpm, Ti 0.5 second and FiO_2 0.6, respectively.
- ☑ When noninvasive ventilation (NIV) fails, intubate and switch to invasive mechanical ventilation (IMV). Ventilation mode should depend on infant's clinical condition, type of ventilator, and clinician's preference. Patient triggered ventilation with volume guarantee (4 mL/kg) is considered the best. For best outcomes this should be given to babies in impending respiratory failure or failed CPAP rather than in complete respiratory failure. Indications for IMV are FiO_2 requirement >0.6 to maintain target SpO_2, respiratory acidosis ($PaCO_2$ > 60 mm Hg), pH <7.2, or recurrent apnea. CPAP is said to have failed when the FiO_2 requirement is >0.6 or the CPAP required to maintain oxygenation exceeds 8 cmH_2O. Respiratory failure is defined a $PaCO_2$ > 60 mm Hg or PaO_2 < 50 mm Hg, or saturation < 85% in 100% O_2 with or without a pH of <7.25. If conventional IMV fails, especially in MAS with PPHN, consider switching to high-frequency oscillatory ventilation (HFOV), if available. Indications for HFOV are requirement of PIP > 28 cmH_2O, FiO_2 > 0.6, respiratory acidosis with pH < 7.2 on conventional IMV.
- ☑ *ECMO:* ECMO is a life-saving therapy in neonates with severe hypoxic failure not responding to conventional therapy and acts as a bridge to recovery.

Specific Therapy

Surfactants

- ☑ Surfactant is the drug of choice in babies with RDS/hyaline membrane disease (HMD) (term born babies >37 weeks account for 7.8% of total RDS cases in newborns, more common among early term infants of 37–38 weeks and in infants of diabetic mother).
- ☑ It is given as early rescue therapy within the first few hours of birth when newborn is on CPAP or NIV or MV and has FiO_2 requirement of >0.40 and chest X-ray is suggestive of RDS.

Specific Therapy

- ☑ Natural surfactants are preferred. Poractant alpha at an initial dose of 200 mg/kg or beractant at a dose of 100 mg/kg administered by intubation-surfactant-extubation (INSURE), less invasive surfactant administration (LISA), or minimally invasive surfactant therapy (MIST) methods of surfactant administration.
- ☑ Surfactants are also beneficial in MAS and/or PPHN management.

Antibiotics

- ☑ Antibiotics should be started early in case of congenital pneumonia after collecting blood for culture and sensitivity.
- ☑ Usually, unit-specific first-line antibiotics are started and adjusted later as per culture and sensitivity report. In certain situations, MAS and RDS may mimic pneumonia. In such situations, antibiotics are started and can be stopped early when clinical and laboratory parameters points toward alternative diagnoses.

Inotropes

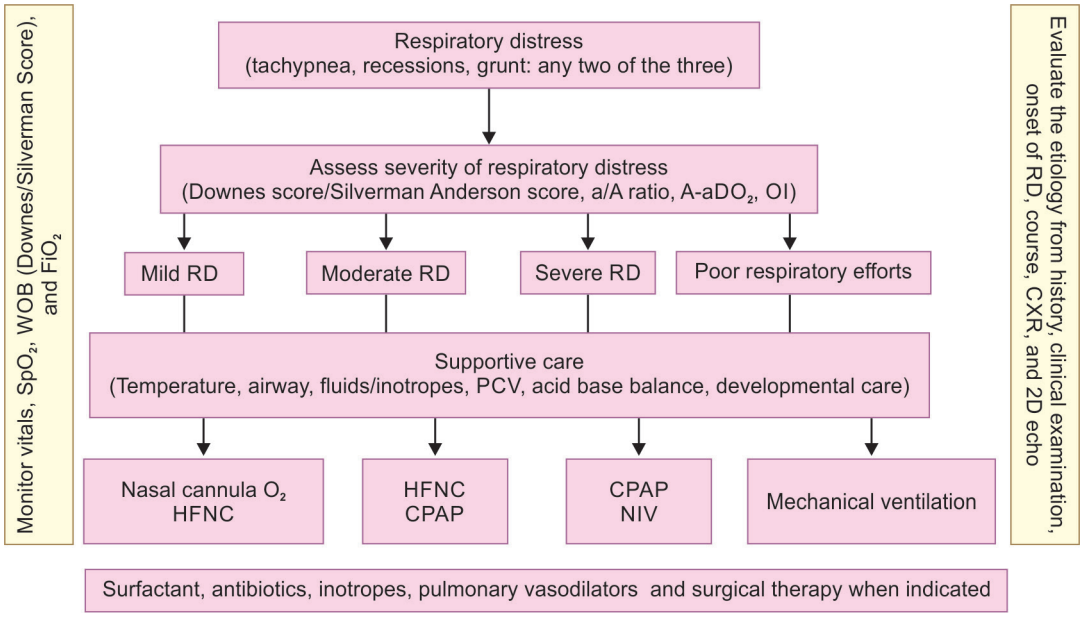
- ☑ Ensure adequate perfusion of organs with fluid boluses [0.9% normal saline (NS) 10 mL/kg over 20–30 minutes] and then add inotropes, if required.
- ☑ Choice of inotropes, if needed, depends on etiology and evaluation of circulation, blood pressures (systolic/diastolic/MAP) assisted by functional echocardiography. Dobutamine is preferred in conditions associated with left ventricular (LV) dysfunction for its inotropic action. Milrinone has inotropic and lusitropic actions and also is a pulmonary vasodilator, so preferred in PPHN. Low-dose epinephrine has inotropic effects. Vasopressors such as dopamine, vasopressin, epinephrine (high dose), or norepinephrine are used to maintain normal blood pressure.

Pulmonary Vasodilators

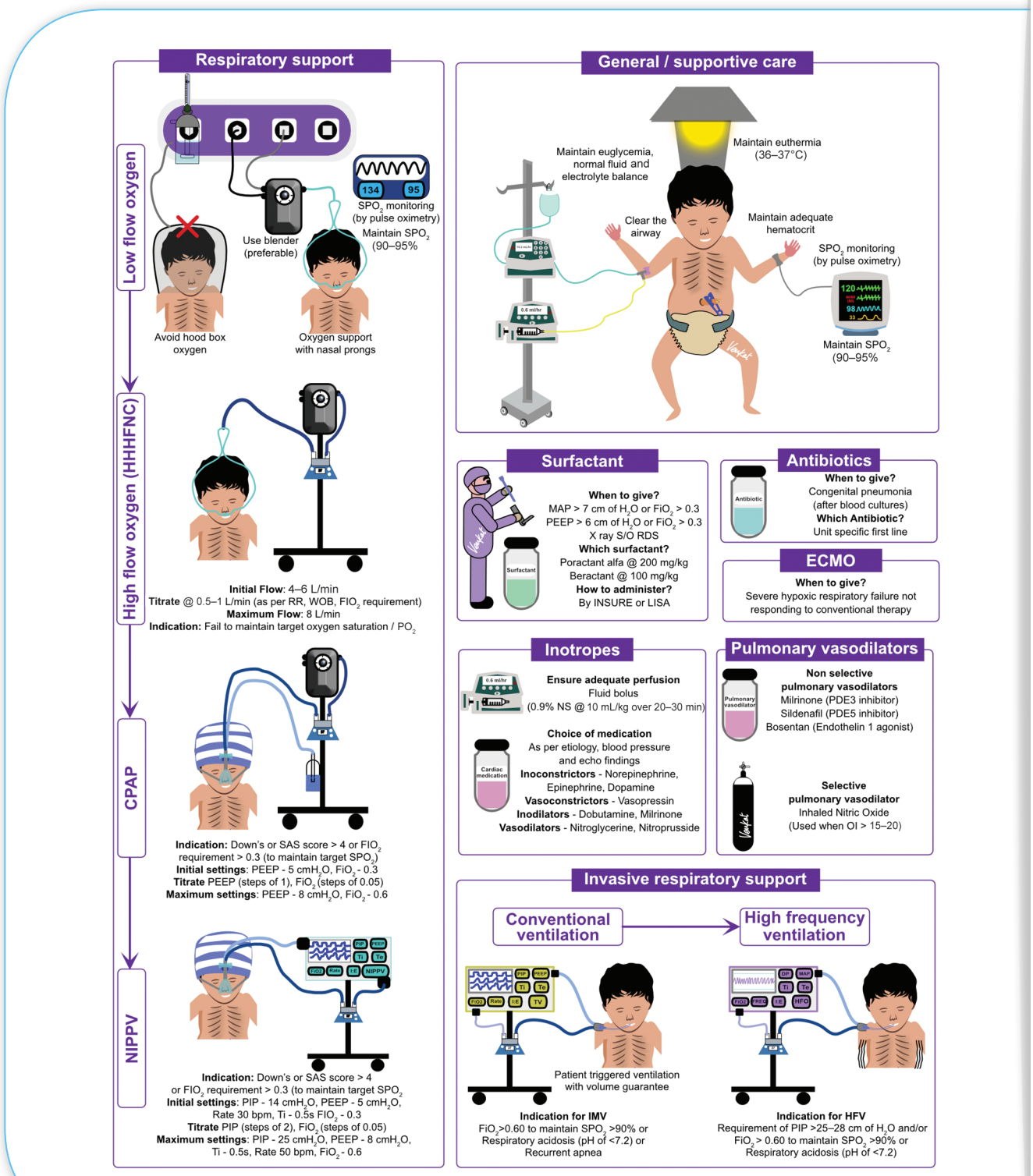
- ☑ In case of PPHN, after supportive care and lung recruitment strategies such as ventilation/surfactant, selective pulmonary vasodilator, and iNO are used when OI is >15–20. If iNO is not available or is ineffective, alternative nonselective pulmonary vasodilators, sildenafil [phosphodiesterase-5 (PDE5) inhibitor] or bosentan (endothelin-1 agonist) may be tried with an aim to reduce pulmonary pressure and improve oxygenation.

Treatment

Flowchart 1: Approach to respiratory distress in a term newborn.



(A-aDO_2: alveolar-arterial diffusion gradient of oxygen; CPAP: continuous positive airway pressure; CXR: chest X-ray; FiO_2: fraction of inspired oxygen; HFNC: high-flow nasal cannula; NIV: noninvasive ventilation; OI: oxygenation index; PCV: packed cell volume; RD: respiratory distress; SpO_2: oxygen saturation; WOB: work of breathing)



Infographics Courtesy: Dr Venkat Reddy Kallem.

Further Reading

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