FIRST HOUR OF CARE: QUICK REFERENCE MANUAL

East of England Neonatal ODN
(Hosted by Cambridge University Hospitals)

Respiratory Care Bundle & Saturation Targeting

Comprehensive evidence based review: *Sweet et al. European Consensus Guidelines on the Management of Respiratory Distress Syndrome – 2016 Update. Neonatology 2019;* 115:432–450

East of England Neonatal Operational Delivery Network

Early Management of Respiratory Distress Syndrome (RDS):

Early administration of CPAP/PEEP *within delivery room*

The newborn resuscitation and support of transition of infants at birth algorithm (UK Resus Council, 2021) should be followed with a focus on non-invasive methods of respiratory support where possible.
Application of early PEEP/CPAP of at least 6cmH_2O maximises the infant's functional residual capacity, enhances endogenous surfactant production, & reduces the need for rescue surfactant and mechanical ventilation. Initiate early PEEP in the delivery room in infants at significant risk of RDS. Infants <30^{+0} weeks gestation are likely to require continuous PEEP ***even if*** they appear vigorous and initially maintain pulse-oximeter saturations in 21% O_2.

Stratify infant into *'Surfactant Prophylaxis'* or *'Early Rescue Surfactant'* protocol

SURFACTANT PROPHYLAXIS

Infants Eligible For Surfactant Prophylaxis:

Infants at risk of RDS requiring intubation for stabilisation or transfer (liaise with transport team if unsure)

EARLY RESCUE SURFACTANT

Optimise non-invasive respiratory support early

Early Rescue Surfactant – WHEN TO ACT:

Suspect RDS in all preterm infants with radiographic appearances of RDS, respiratory failure, respiratory acidosis, respiratory distress **OR** increasing FiO_2
Low threshold for early administration of surfactant is advised for RDS

Criteria for administration of rescue surfactant include:

- Increasing FiO_2 due to suspected RDS. A suggested protocol would treat < 26 week babies at FiO2 threshold of > 0.3 and > 26 week babies at FiO2 > 0.4.
- Significant & worsening respiratory acidosis **OR** Marked respiratory distress

*- Despite **adequate** non-invasive ventilatory support –*

If meets criteria: administer surfactant

If intubated, utilise ventilatory strategies which minimise volutrauma & extubate to non-invasive ventilation as soon as is safe & possible

Non-Invasive Respiratory Support & The Early Management of Respiratory Distress Syndrome (RDS)

Non-invasive respiratory support with early rescue surfactant, if required, should be considered the optimal management for infants with RDS.

However, there are multiple confounding factors to be considered in the management of a sick preterm infant. Variation in practice may exist with flexibility required in the implementation of this quick reference guide – in all cases ***individual clinical assessment is paramount***. Level 1 or small level 2 units may require a lower threshold for securing the infant's airway and delivering pro-active prophylactic surfactant in a very or extremely preterm infant, depending on availability of ***on-the-unit*** medical supervision. Evidence is not clear for the definitive management of infants ≤24 weeks.

Optimal Non-Invasive Respiratory Support

CPAP (Continuous Positive Airway Pressure)

- Delivers a mixture of heated & humidified medical gases to provide a continuous & controlled positive pressure & percentage of O_2
- If delivery room CPAP is not available, a continuous positive pressure and Peak End Expiratory Pressure (PEEP) can be administered temporarily using a controlled T-Piece device via a face-mask ***or*** a short ETT placed within the naso-pharynx

Modes of Action:
- PEEP optimises functional residual capacity, oxygenation, prevents alveoli collapse & enhances endogenous surfactant production
- Distending pressure augments venous return and thus improves cardiac output
- Humidified gases improve lung compliance

Risk of:
- Nasal obstruction & trauma: regularly assess area & rotate ***correctly*** sized mask/prongs
- Abdominal distention: gastric tube is required for decompression

Settings:
- CPAP should be delivered at **6-8 cmH_2O** using a total gas flow of **6 – 10 L/min** via short binasal prongs OR nasal mask

  Caution *using CPAP >7 cmH_2O if the preterm infant has* ***not*** *received surfactant – increased risk of air leak observed in COIN trial using 8 cmH_2O prior to surfactant dosage*

Adequate seal is paramount.

HHHFNC (Heated Humidified High-Flow Nasal Cannulae)

- Delivers a mixture of heated & humidified medical gases to a defined 'high' flow and percentage of O_2

Modes of Action:
- High flow flushes CO_2 from the upper airways dead-space
- Humidified gases Improve lung compliance
- Continuous positive distending pressure may prevent alveoli collapse (uncontrolled & flow dependent)

- ***Role in primary therapy of RDS in extreme prematurity is debated***
- ***It is broadly equivalent post extubation infants >28 weeks gestation***

Benefits:
- Reduced abdominal distention
- Reduced nasal trauma
- Improved access to the infant's cranium

Settings:
Nasal cannulae **must be ≤50%** of the diameter of the infant's nares
- Infants **≥1 Kg**: Start flow at **6 L/min**
- Infants **<1 Kg**: Start flow at **4 L/min**
  - Increase flow by 0.5 to 1 L/min according to response
  - *Maximum flow is 8 L/min (**Caution: >6 L/min if infant <1kg**)*

FHOC Reference: Clinical Guideline: Heated Humidified High Flow Nasal Cannula (HHHFNC) Guideline
FHOC Reference: Clinical Guideline: Management of a baby on CPAP

Early Management of RDS: *Surfactant Therapy, InSurE & Optimal Ventilation*

Surfactant Therapy:

Alternate Indications, LISA, & Repeat Doses

Rescue Surfactant may also be considered in the following instances (within 1st 48 hours of delivery):

- Severe meconium aspiration
- Group B Streptococcus pneumonia
- Pulmonary haemorrhage (not if haemorrhage secondary to previous surfactant instillation)
- Other sick infant requiring ventilation with increasing oxygen requirement OR chest X-ray consistent with RDS

LISA: *L*ess *I*nvasive *S*urfactant *A*dministration

- Administration of intra-tracheal surfactant via a fine catheter placed under laryngoscopic guidance
- Infants must be spontaneously breathing
- Surfactant is administered slowly with non-invasive respiratory support ongoing throughout the LISA procedure
- Clinicians should be trained and experienced in this technique
- Pre-optimise with caffeine (if possible)
- Local LISA comfort / sedation protocol should be followed
- Infants must be monitored throughout and the team ready to convert to intubation if required (e.g apnoea)

Cautions / Contra-indications:

- More mature grades of prematurity where alternative diagnoses other than RDS may be contributory
- Requires intubation & ventilation for stabilisation or transport
- Difficult Airway

Repeat Dosage

- Consider repeat doses of surfactant (up to a total of 3 doses) if persistently high oxygen requirement or significant ongoing ventilatory requirements (See 'Use of Surfactant' on Page 29)

Mechanical Ventilation (MV):

Volume Targeted Ventilation (VTV):

Optimal first-line MV strategy in the majority of infants

Where non-invasive support has failed or intubation required for general stabilization or transfer. Aim is to minimise duration of MV.

VTV: Ventilator parameters (Peak Inspiratory Pressure [PIP] and/or inspiratory time [Ti]) are automatically adjusted to deliver a **pre-set tidal volume (VT) (usually between 4 to 6ml/kg)**

A patient-triggered (synchronised) VTV mode is optimal
- *i.e **least** injurious to the infant's lung, least risk of hypocapnia*
- *All modes of MV induce lung injury and risk air leak*

Commonly available VTV- default modes:

- **Volume Guarantee** (VG): Adjusts PIP in response to previous expired VT (i.e. will auto-wean PIP as lung compliance⇧)
- **Volume Controlled/Volume Limited**: Adjust the inspiratory phase (Ti &/or flow) in accordance with inspired volume
- **Guarantee/Control Hybrid Modes**: E.g. TTV^{plus}

*Manufacturer terminology is discordant - **know your unit's ventilator***

Accuracy of VTV is optimised in ventilator circuits where the flow sensor is positioned at the wye piece

Initial Settings:

*Select a **patient-triggered** mode with back-up rate of **30 bpm** (caution; Hypercapnia or the Muscle relaxed infant)*

- ***VT:** 4 to 5 ml/kg | **Ti:** 0.3 to 0.36 seconds*
- ***Flow:** 6 to 8 L/min | **PEEP:** 5 cmH_2O*

***Stay with the infant; adjust settings according to pCO_2, FiO_2 & clinical response.** Term infants may require longer Ti, ELBW infants may not tolerate VT<4.5ml/kg due to deadspace of ETT & circuit*

Cautions: ET Leak >40 to 60% *(leads to erroneous VT measurement)* & Lung anomalies at risk of hyper-inflation (monitor for over-distention)

Early Management of RDS: *Planning for Early Extubation & Use of NIPPV*

All modes of mechanical ventilation (MV) induce lung injury & risk air leak. Infants with RDS on MV should be ventilated as 'gently' as possible, weaned as quickly as possible and extubated off MV as soon as is safe and possible. Maintaining a stable infant on minimal ventilator settings does not increase extubation success; prolonged MV does, however, increase rates of Chronic Lung Disease (CLD). An infant may be extubated to CPAP, HHHFNC, NIPPV, or air, depending on their condition and size. VLBW or very preterm infants are likely to require some form of initial respiratory support post-extubation (to prevent atelectasis and alveolar de-recruitment)

When to extubate?

Exercise caution when considering extubation for infants:

- Requiring definitive airway for transport (Liaise with Transport team)
- With a significant airway abnormality OR known difficult airway
- With recent significant pulmonary haemorrhage
- Who are unstable e.g. significant inotropic requirement

The following tools may inform extubation decisions in preterm infants:

Early Extubation Protocol (infants <30 weeks gestation or <1.5kg):	✓
Percentage inspired O_2 <30%	
Peak Inspiratory Pressure <16 cmH_2O	
Mean Airway Pressure ≤7 cmH_2O	
Ventilator Back-up Rate ≤35-40 bpm (Ensure baby is breathing above rate)	
pH>7.25	
pCO_2 <7.5 kPa	
Ensure appropriate caffeine loading	
Ensure muscle relaxant, sedative and opiate medication infusions have been appropriately weaned/discontinued	

**Hamlin et al. Predicting successful extubation of very low birthweight infants. ADC F&N 2006. 91:F180–F183*

FHOC Reference: Clinical Guideline: Management of a baby on CPAP

Pre-medication for Non-Emergency (Elective) Intubation:

Analgesic-Sedative-Hypnotic (Opiate)*

Fentanyl

*There are some concerns regarding chest wall rigidity with synthetic opioid use – however this can be reversed by naloxone use or more appropriately minimised by **slow administration**, and co-administration of a rapid acting muscle relaxant*

Intravenous access, continuous heart rate and oxygen saturation monitoring are pre-requisites for elective intubation

Intubation checklist available in appendix 1 of premedication clinical guideline

Use Neonatal Infant Pain Score during procedure

Vagolytic

Atropine

To prevent bradycardia during intubation and decrease airway secretions

Muscle Relaxant

Suxamethonium

Muscle relaxation to facilitate intubation minimises the rise in intracranial pressure that occurs during awake intubation.

The infant's airway must be maintainable prior to giving any muscle relaxant – Exercise extreme caution if anatomical airway malformation

Medication**	Dose
FENTANYL (Controlled Drug)	**2 micrograms/kg** (Range 1 – 4 micrograms/kg) IV **slowly over 1-2 minutes** followed by a **slow** 0.9% sodium chloride flush Repeat dose of 3 micrograms/kg can be given if required
ATROPINE	**20 micrograms/kg** stat rapid IV bolus
SUXAMETHONIUM	**2 mg/kg** stat IV bolus

FHOC Reference: Clinical Guideline: Premedication for non-emergency endotracheal intubation in the neonate

***See medication tables on **pages 7 to 8** for further details*

Pre-medication for Non-Emergency Intubation: (Page 1 of 2)

Medication	Preparation	Dose	Administration	Onset, peak and duration of action	Side effect
FENTANYL (Analgesic, Controlled Drug)	50 micrograms/ml 2ml size Diluent: 0.9% sodium chloride or 5% glucose	**2 micrograms/kg** (Range 1 – 4 micrograms/kg) IV **slowly over 1-2 minutes** followed by a slow 0.9% sodium chloride flush Repeat dose of 3 micrograms/kg can be given if required	Draw 0.2mls (10micrograms) and dilute to 1ml with glucose 5% in a 1ml syringe = 10micrograms/ml, then give 0.1- 0.4 mls for each Kg of baby's weight	Onset of action: IV- almost immediate Peak effect: 5- 15 minutes Duration of analgesic effect: 30 – 60 minutes	Chest wall rigidity (can be reversed with naloxone or muscle relaxant), seizure-like activity, respiratory depression, bradycardia
ATROPINE (Vagolytic)	600 micrograms/ml 1ml size Dilution not recommended	**20 micrograms/kg** stat rapid IV bolus	Draw up 0.033mls (20 micrograms) for each kg of baby's weight Alternatively, dilute to 60 micrograms/ml solution (0.1 ml from 600 micrograms/ml solution to 0.9 ml of 0.9% sodium chloride) & draw up 0.33 ml for each Kg of baby's weight	Onset of action: Immediate Peak effects: 12-16 min, Duration of action: 4-6 hrs	Tachycardia (self resolving)

FHOC Reference: Clinical Guideline: Premedication for non-emergency endotracheal intubation in the neonate

Pre-medication for Non-Emergency Intubation: (Page 2 of 2)

Medication	Preparation	Dose	Administration	Onset, peak and duration of action	Side effect
SUXAMETHONIUM (Muscle Relaxant)	50 mg/ml 2ml size **in fridge** 0.9% Sodium chloride or 5% glucose	**2 mg/kg** stat IV bolus	Draw 0.2ml (10mg) and dilute to 1ml with 5% glucose in a 1ml syringe = 10 mg/ml then draw up 0.2ml (2 mg of diluted solution) for each Kg of baby's weight	Onset of action: 1-2 minutes Duration of action: 5-10 minutes	Bradycardia especially after second dose of suxamethonium, transient hyperkalaemia, malignant hyperthermia
NALOXONE (Opioid Antagonist – to reverse Fentanyl related respiratory depression or chest wall rigidity)	400 micrograms/ml solution for injection OR Available as 400 micrograms/ml Minijets	**10 micrograms/kg** IV bolus Can be repeated every 2-3 minutes to a cumulative dose of 100 micrograms/kg if necessary BUT risks complete reversion of opioid analgesia	Draw 0.1 ml (40 micrograms) and dilute to 1 ml with 0.9% sodium chloride = 40 micrograms/ml then draw up 0.25 ml for each Kg of baby's weight	Onset of action: 1-2 minutes Duration 3-4 hours	Arrhythmias Hypertension Hypotension (rare)

FHOC Reference: Clinical Guideline: Premedication for non-emergency endotracheal intubation in the neonate

Use of Surfactant:

Medication	Preparation	Dose	Administration	Onset, Peak and duration of action	Side effect
PORACTANT ALFA (CUROSURF®) ('Surfactant' – Porcine lung phospholipid fraction)	80 mg/mL Suspension **in fridge** 1.5-mL vial = 120mg 3-mL vial = 240mg Gentle inversion may be required; Do not shake	Round doses to nearest whole vial First dose: 200 mg/kg Repeat doses of 100 mg/kg may be administered under senior advice. Timing of doses dependent on infant condition; max. total dose 300–400 mg/kg	Warm to room temperature Administer via Endotracheal Tube Flush ET administration set with 1ml of air after delivery of surfactant Deliver 5x breaths with inflation time of 2 to 3 seconds following administration of surfactant Continue IPPV until the surfactant is no longer visibly refluxing within the ETT	Rapid onset Observe closely and adjust ventilatory settings according to infant response – this is essential to prevent hyperoxia, hypocarbia and prevent use of excessively high peak inspiratory pressures	Obstruction of ETT by mucous sectretions. Uncommon/rare: intracranial haemorrhage, bradycardia, pulmonary haemorrhage, desaturation, hypotension

Click to return to Respiratory sub-menu

Endotracheal Intubation - Suggested Tube Sizes & Lengths:

*Tube size and length are dependent on the size of the infant's airway and will thus vary between infants of the same gestations and weights. For this reason, the tables below can **only be used for guidance**. As a general rule – secure the Endotracheal Tube (ETT) once the tip has passed 2cm beyond the vocal cords (use the black marker on the ETT as a guide). **X-Ray should confirm ETT position** after intubation (Optimal position is **above the carina** at **T1 – 2**).*

Tube Size (Internal Diameter - mm)	Weight (g)	Corrected Gestational Age (Weeks)	Corresponding Suction* Catheter (Fr) for ETT
2.5	<1000	<27	5
3.0	1000 - 2000	27 - 34	6
3.5	2000 - 3000	35 - 38	7
3.5 – 4.0	>3000	>38	8

**Suction pressure should be set no greater than 8 – 10 kPa*

Length by Table:

ETT Length at Lips (cm)	Weight (g)	Corrected Gestational Age (Weeks)
5.5	500 - 600	23 - 24
6.0	700 - 800	25 - 26
6.5	900 - 1000	27 - 29
7.0	1100 - 1400	30 - 32
7.5	1500 - 1800	33 - 34
8.0	1900 - 2400	35 - 37
8.5	2500 - 3100	38 - 40
9.0	3200 - 4200	41 - 43

Length by Formula:

Oral Intubation (*cm to lips*) = 6 + weight (**kg**)

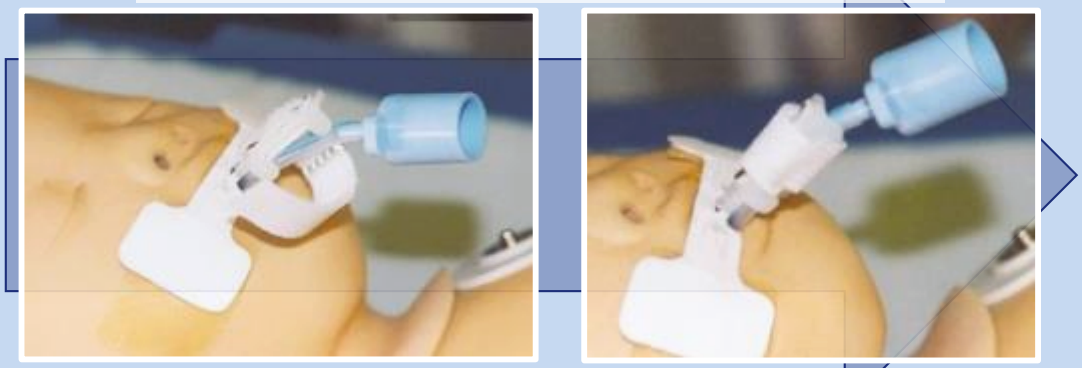
Nasal Intubation *(cm to nares)* = 6 + [weight (**kg**) x 1.5]

FHOC Reference: Clinical Procedure: Endotracheal Intubation

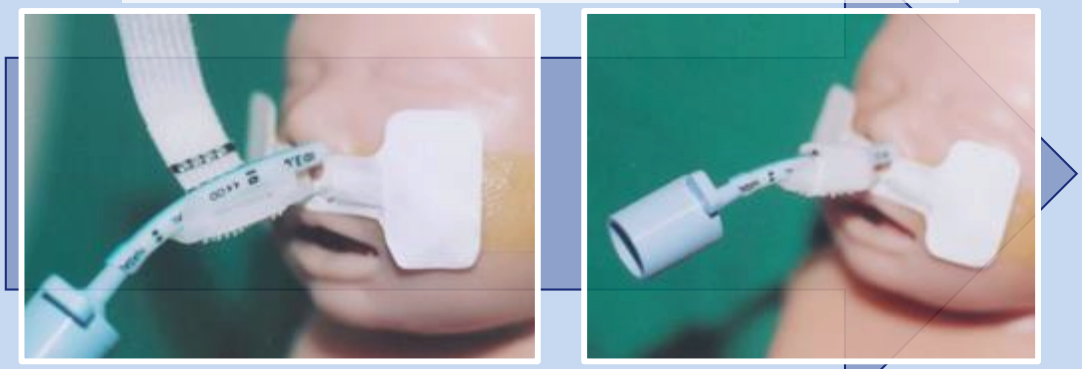
Endotracheal Intubation – Fixation:

- Ensure endotracheal tube (ETT) is held securely whilst fixation device is applied
  - *For oral fixation, the ETT may be held between the practitioner's finger and infant's hard palate*
  - *For nasal fixation the tube should be held in place with a pincer grip*
- Apply skin protectant (if used) and place a strip of colloid dressing to each cheek
- Attach the tube holder to the colloid dressing *(figures show orientation of tube holder for both oro- and naso- ETT fixation)*
- Wrap Velcro around the ETT to secure
  - *Apply 'lollipop' stickers across the bridge of the fixation device if required*
- Test security of ETT fixation by applying *downwards* pressure – *the ETT should* ***not*** *slip through the fixation device*

Fixation of Oro-Endotracheal Tube



Fixation of Naso-Endotracheal Tube



Use of an adjustable tube holder/fixation device facilitates ETT re-positioning with minimal infant handling, avoids the use of irritating tapes and allows for easier access the neonate's cranium (e.g. for CFM probes, scalp cannulae, or infant cares) compared with tape fixation or ribbon/hat systems.

FHOC Reference: Clinical Procedure: Endotracheal Intubation

Saturation Targeting at Delivery:

Time from Birth	Acceptable Pre-Ductal Saturation
2 minutes	65%
5 minutes	85%
10 minutes	90%

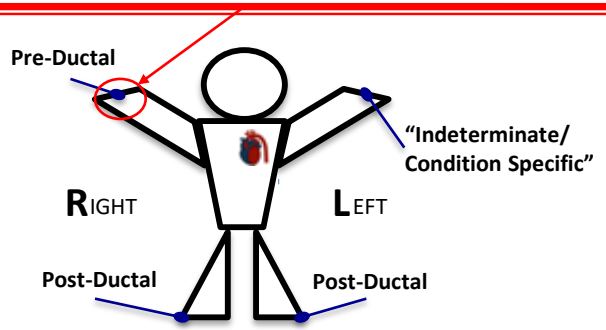
Tabulation of Resus Council UK (NLS 2021.) recommendations for acceptable pulse oximeter saturations at delivery, according to age..

Starting FiO_2 in the Delivery Room:
initiation of resuscitation/assisted transition

Gestation	Set FiO_2 (Percentage) to:
≥ 32 weeks	21% (Air)
28 to 31 weeks	21 to 30%
<28 weeks	30%

Titrate subsequent FiO_2 according to pre-ductal saturations

Use pre-ductal saturations (right hand/wrist) as preference within the delivery room



FHOC Reference: Clinical Guideline: Saturation targeting in the Infant admitted to the Neonatal Unit

Oxygen & Air Mixtures: Delivered Percentage of Oxygen

Total Flow: 8 Litres/Minute

Oxygen Percentage of Mixture	Air Flow (L/Min)	Oxygen Flow (L/Min)
21 %	8	0
30.9 %	7	1
40.8 %	6	2
50.6 %	5	3
60.5 %	4	4
70.4 %	3	5
80.3 %	2	6
90.1 %	1	7
100 %	0	8

Total Flow: 10 Litres/Minute

Oxygen Percentage of Mixture	Air Flow (L/Min)	Oxygen Flow (L/Min)
21 %	10	0
28.9 %	9	1
36.8 %	8	2
44.7 %	7	3
52.6 %	6	4
60.5 %	5	5
68.4 %	4	6
76.3 %	3	7
84.2 %	2	8
92.1 %	1	9
100 %	0	10

Saturation Targeting on the Neonatal Unit:

Gestation at Birth	Air/Oxygen	Target	Alarm Limits
Preterm <37 weeks Or Birth Weight <1.5kg	Oxygen	91 - 95%	90 - 96%*
	Air	91 - 95%	90 – 100%
Term Infant ≥37 weeks	Oxygen	≥95%	94 - 99%
	Air	≥95%	94 - 100%
Preterm Infant with corrected gestation ≥37 weeks	Oxygen	≥93%	92 - 99%
	Air	≥93%	92 – 100%

***Preterm infants with saturations >95% in oxygen are at significant risk of hyperoxia**

PaO_2 will be significantly elevated ➔ Act with the same urgency as a significant desaturation

FHOC Reference: Clinical Guideline: Saturation targeting in the Infant admitted to the Neonatal Unit

Saturation Targeting on the Neonatal Unit:

Special Circumstances

Circumstance	Air/Oxygen	Target	Alarm Limits
Risk of / Established PPNH**	Air/Oxygen	>95%	95% – 100%
Suspected or Confirmed Cyanotic Heart Disease	See CATS Clinical Guideline: "Duct Dependant Congenital Heart Disease"		
	*Avoid Hyperoxia – Particularly in duct-dependent lesions**** *Liaise with Specialist Cardiac Centre for Advice*		

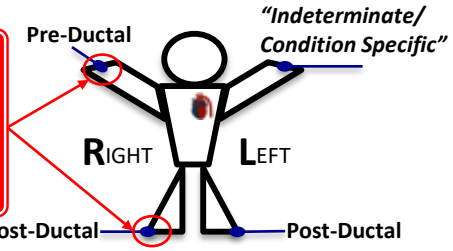
****Risk Factors for PPHN in Term or Near Term Infant:**

- Meconium Aspiration
- GBS sepsis or congenital pneumonia
- Severe perinatal Hypoxic Ischaemic Encephalopathy (HIE)
- Structural Lung Disease: *Pulmonary hypoplasia, congenital diaphragmatic hernia or congenital pulmonary malformation*
- Maternal Factors: *Aspirin / Non-Steroidal Anti-Inflammatory Drug (NSAID) / Selective Serotonin Receptor Inhibitor (SSRI) / Cigarette use, Ill-health through asthma / diabetes mellitus / raised BMI*

*****Limited evidence base for oxygen targeting in Cyanotic Heart Disease**

- Saturations >85% are unlikely to be achievable without significant hyperoxia (↑P_aO_2), due to the physiological effect of shunting/mixing
- Caution in duct dependent lesions: Hyperoxia may risk unintended ductal closure
- Saturations may be less than 75% in certain cyanotic cardiac lesions – liaison with cardiac specialists is imperative to guide optimal targeting

Consider dual pre- & post-ductal saturation monitoring in suspected PPHN or Congenital Cardiac Lesions



Oxygenation Index (**OI**) = [MAP x FiO_2] / [PaO_2 x 7.5]

Given:
MAP: Mean Airway Pressure (**cmH_2O**)
FiO_2: 'Fraction' of Inspired Oxygen ***as a percentage*** (**%**)
PaO_2: Partial Pressure of Oxygen in Arterial Blood (**kPa**)

FHOC Reference: Clinical Guideline: Saturation targeting in the Infant admitted to the Neonatal Unit