National Guideline on Management of Oxygen Therapy in Neonates

Ministry of Health
Male', Republic of Maldives

RELEASE RECORD

Version No	Version Date	Description of change
1	30 January 2024	Initial release

DOCUMENT NUMBER: MOH-QA/G/24/159-0

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Published by Quality Assurance and regulations Division
Ministry of Health, Male, Republic of Maldives

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1.INTRODUCTION

Clinicians must keep in mind that oxygen is a **drug** and must be used in accordance with well recognized pharmacologic principles (i.e., since it has certain toxic effects and is not completely harmless, it should be given only in lowest dosage or concentration required by the patient).

Oxygen is the most used therapy in the neonatal intensive care units. The goal of oxygen therapy is to achieve an adequate tissue oxygenation, but without creating an oxygen toxicity or complications.

Oxygen supplementation using non-invasive measures is an important component of intensive care of the newborn.

Careful monitoring is required to minimize pulmonary toxicity or the consequences of hypoxia

Non-invasive oxygen administration and monitoring for the neonate, including the preterm infant, oxygen administration during neonatal resuscitation in the delivery room and neonatal mechanical ventilation: will be reviewed here.

2.DEFINITIONS

Definitions of different degrees of prematurity based upon gestational age or birth weight (BW) are provided in (table 1).

Table 1: Classification of prematurity categorized by birth weight or gestational age.

	Birth weight
Low birth weight (LBW)	<2500 g
Very low birth weight (VLBW)	<1500 g
Extremely low birth weight (ELBW)	<1000 g
	Gestational age
Term	≥37 weeks
Late preterm	34 weeks to <37 weeks
Moderate preterm	32 weeks to <34 weeks
Very preterm	<32 weeks

In using these definitions, the definition of VLBW infants includes ELBW infants, and the category of very preterm infants also includes those who are extremely preterm. This is an **important** consideration when one is **reviewing** published data of VLBW and very preterm infants.

3.PHYSIOLOGICAL CONSIDERATIONS

Tissue oxygenation depends on:

- Inspired oxygen
- Gas exchange mechanisms within the lungs
- Oxygen carrying capacity of the blood (approximately 97% of oxygen transported to the tissues is carried by haemoglobin, and 3% is dissolved in plasma)
- Cardiac output
- Local tissue oedema or ischemia

4.RESPIRATORY SUPPORT DEVICES

Respiratory support systems used in neonates include:

- Low-flow nasal cannula (LFNC)
- High-flow nasal cannula (HFNC)
- Hood
- Face mask
- Nasal continuous positive airway pressure (nCPAP)
- Nasal intermittent positive pressure ventilation (NIPPV)
- Endotracheal intubation and invasive mechanical ventilation (MV)

These respiratory support devices provide warmed and humidified gas that is delivered using a system in which the oxygen concentration can be regulated. Individualized assessment and frequent reassessment of the adequacy of oxygenation is required. The inspired oxygen concentration (**FiO2**) should be monitored with an oxygen analyser, if possible.

Although the level of oxygenation can be assessed in several ways, pulse oximetry, which measures haemoglobin saturation (**SpO_2**), is the accepted standard for routine monitoring of oxygenation.

5.OXYGEN TARGET LEVELS

5.1. Goals — The goals of supplemental oxygen therapy in preterm infants are to:

- Meet the metabolic needs of the infant.
- **Avoid** hyperoxia and high concentrations of oxygen, which contribute to bronchopulmonary dysplasia (**BPD**) and retinopathy of prematurity (**ROP**).
- Avoid hypoxemia, which is associated with increased risk of mortality and neurodevelopmental impairment.

Targets for preductal SpO_2 during neonatal resuscitation in the delivery room are summarized in (table 2).

Table 2: Targets for preductal SpO_2 during neonatal resuscitation

Time since delivery	**Target SpO_2 (%)**
1 minute	60-65
2 minutes	65-70
3 minutes	70-75
4 minutes	75-80
5 minutes	80-85
10 minutes	85-95

Adapted from American Heart Association

The oximeter probe should be placed in a preductal location (i.e., on the right upper extremity, usually the wrist or medial surface of the palm). Immediately following birth, the neonate's oxygen saturation normally remains in **the range of 70 to 80% for several minutes**.

Normal pulse oximetry values in;

- ✓ **healthy term infants** average **97** percent on **room air** and
- ✓ **95** percent in **healthy preterm infants**.

Attempts to maintain SpO_2 values greater than 95 percent using supplemental oxygen may result in excess oxygen exposure and hyperoxia.

5.2. Targets for neonates requiring ongoing respiratory support

For **preterm** neonates requiring ongoing oxygen therapy in the Neonatal Intensive Care Unit (NICU), our suggested approach to setting target ranges for SpO_2 according to Gestational Age (GA) is as follows:

- **Neonates <28 weeks gestation**: SpO_2 target range of **90** to **95** percent during the first few weeks after birth rather than higher or lower levels. This target range minimizes both the low and high extreme oxygenation levels that have been associated with adverse outcomes, and it is supported by clinical trial data. **If the infant still requires supplemental oxygen when the corrected postmenstrual age (PMA) is >32 weeks, the SpO_2 target can be raised to >95 percent.**
- **Neonates 28 to <34 weeks gestation**: SpO_2 target range of **90** to **95** percent for preterm infants 28 to <34 weeks GA. Although data are lacking in more mature infants, indirect data from trials in EPT infants support this practice and this target range appears to be safe for preterm infants ≥28 weeks gestation.
- **Neonates 34 to <37 weeks gestation**: SpO_2 target range of **90** to **97** percent. A more liberal range is reasonable in these infants since they are at low risk of bronchopulmonary dysplasia and retinopathy of prematurity.

6.CHOICE OF MODALITY

The choice of respiratory and oxygen delivery device is dependent on the clinical setting and the needs of the individual neonate. Usually, the choice **based on** the gestational age (**GA**) of the neonate, the **underlying respiratory** condition, and the phase of **illness** (i.e., initial support versus following extubation).

6.1. General approach is as follows:

- **Very preterm infants (VPT; GA <32 weeks)** – who are at risk for respiratory distress syndrome (RDS), **nCPAP** is our preferred initial primary respiratory support.
- **Moderate preterm infants (GA 32 to <34 weeks).**
- the initial respiratory support depends upon the degree of respiratory distress. For infants who display **respiratory distress** (tachypnoea, grunting, nasal flaring), **nCPAP** is the preferred respiratory support system as these infants may be at risk for RDS.
- For infants with **hypoxemia** without respiratory distress, **LFNC** is usually sufficient.

- **Late preterm and term infants (GA ≥34 weeks)** – the modality depends upon the underlying diagnosis. Positive pressure typically is not necessary unless there is considerable intrinsic lung disease.
- **Transient tachypnoea of the newborn** and **Neonatal pneumonia** – In this setting, oxygen supplementation is provided by **hood** or **LFNC** to maintain oxygen saturation >90 percent.
- **Cyanotic heart disease** – Choice of respiratory support is dependent upon the specific defect, operative status (repaired versus unrepaired), and the infant's respiratory status and oxygen saturation.
- **Persistent pulmonary hypertension of the newborn (PPHN)** – The respiratory support for PPHN depends on the infant's respiratory status and oxygen saturation.
- **Following extubation** – typically use **nCPAP** when managing infants who have been intubated and mechanically ventilated for a period and who are at risk for requiring reintubation following extubation. **nCPAP** is preferred over HFNC and NIPPV because there is greater experience and familiarity with this modality, particularly in VPT infants. The available data suggest that all three modalities are effective in preventing reintubation.

- For **preterm** infants with **advancing age** who continue to require supplemental oxygen following extubation and who poorly tolerate the CPAP nasal prongs, **HFNC** or **LFNC** are **reasonable alternative methods for oxygen delivery**.

Figure 1: Oxygen therapy via nasal prong

6.2. Devices used according to conditions;

6.2.1. Low-flow nasal cannula

Consequently, there is considerable variability is the effective FiO2 delivered to the lungs with LFNC due to variability in respiratory rate, oxygen flow rate, extent of mouth breathing, and size of the nasopharynx.

- In neonates, LFNC is typically provided with unblended oxygen at flow rates <1 L/min, which provides no or minimal positive pressure (<1 cm H_2O).
- Alternatively, LFNC can be used with a blender to administer a lower oxygen concentration (FiO2 0.25 to 0.4) at a higher flow rate (1 to 2 L/min). The effective oxygen concentration the lungs receive will be lower than the FiO2 setting on the air/oxygen blender.
- In preterm infants, the latter approach is commonly used when transitioning from nCPAP to LFNC. The benefit of this approach is that it provides a small amount of positive airway pressure (approximately 1 to 3 cm H2O) without exposing the neonate to high oxygen concentrations.
- There are established formulas to estimate the effective delivered FiO2 based upon patient size, oxygen concentration, and flow rate. However, these formulas are rarely used in clinical practice because they are cumbersome, and they provide only a rough estimate. It is simpler to just assume that the effective FiO2 delivered by LFNC is lower than prescribed and, in some cases, almost equivalent to room air.

6.2.2. Hood

is a high-flow, high-concentration oxygen system (7 to 15 L/min) that uses a hard plastic or soft tent-like structure or dome that fits over the infant's head (if in an incubator) or over the body (if in a crib) (figure 2). Hoods are not routinely used for oxygen delivery in neonates since they limit access to the infant's face and head. They are generally used only in settings when a cannula is not tolerated.

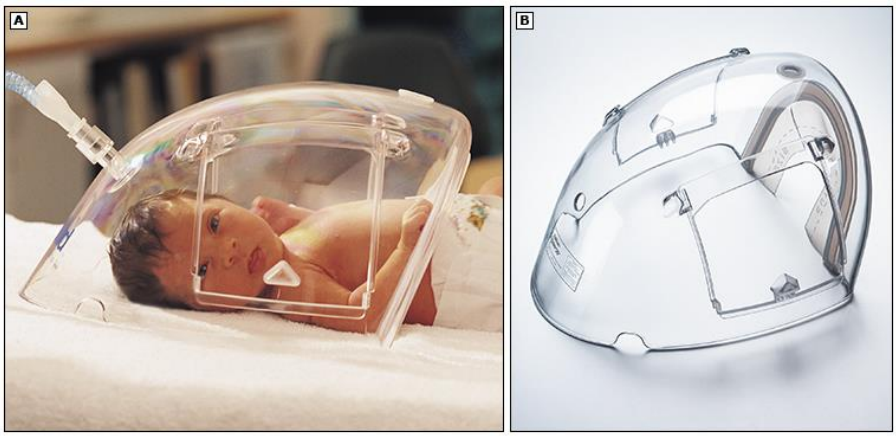

Figure 2: Oxygen therapy via a hood

Oxygen enters the hood through a gas inlet. Oxygen concentrations of 80 to 90 percent can be achieved with oxygen flow rates ≥10 to 15 L/min. In preterm neonates <1500 g, the oxygen is heated to the same temperature as the incubator. In larger infants, room temperature is maintained within the hood to prevent tachypnoea.

6.2.3. Face mask

A face mask used for oxygen delivery is rarely used beyond the delivery room resuscitation. However, a mask is occasionally used to deliver free-flow oxygen as a temporary measure during periods of oxygen desaturation or prior to endotracheal intubation. The distance of the mask from the face affects the delivered FiO_2. If a mask is employed for the resolution of apnoea, every effort would be made to mirror the FiO_2 that is used prior to the episode.

Servo-control incubator — Stable oxygen concentration can be achieved in a servo-controlled incubator. In preterm infants receiving supplemental oxygen, a small single-centre trial reported episodes of hypoxemia were lower when using a servo-controlled environment compared with the use of a nasal cannula to deliver.

6.2.4. High-flow nasal cannula

HFNC delivers heated, humidified air at flow rates that are higher than standard LFNC. The flow rate and FiO_2 are set by the clinician. Typical initial flow rates for neonates are 4 to 6 L/min up to maximum of 8 L/min. At these flow rates, the amount of positive airway pressure provided by HFNC ranges from 2 to 5 cm H2O.

HFNC may be used as an alternative to nCPAP in the following settings:

- Apnoea of prematurity.
- Primary mode of respiratory support in preterm infants with RDS.
- Following extubation

The theoretical benefit of HFNC is that the high flow rate washes out nasopharyngeal dead space and replaces the end-expiratory gas within the upper airway with fresh oxygenated and humidified gas. In addition, the nasal cannula used for HFNC are **smaller** than the nasal prongs used for nCPAP and they are **easier** to apply and associated with **less nasal trauma**. However, there is greater variability in the amount of positive airway pressure provided with HFNC compared with nCPAP. For this reason, and because there is greater experience with nCPAP, many centres, preferentially use nCPAP for initial management of VPT infants.

HFNC is a reasonable alternative for neonates who do not tolerate nCPAP and those who develop problematic nasal trauma on nCPAP.

HFNC can also be used to provide apnoeic oxygenation during endotracheal intubation in non-emergency situations (i.e., when time and resources allow for setting up the HFNC system). The aim of HFNC use in this setting is to maintain cardiorespiratory stability during the procedure and allow more time for successful intubation.

- HFNC prongs are smaller in length and diameter than those used for nCPAP and do not require a seal to operate.

- HFNC prongs should occupy no more than 50 percent of the internal diameter of the nares to permit sufficient leak and protection from high pressure.
- The cannula should **not** occlude the nares since this can generate high nasopharyngeal pressure and can potentially cause traumatic air dissection.

6.2.5. Continuous positive airway pressure

6.2.5.A. Clinical application;

- nCPAP is our preferred modality for initial respiratory support in preterm neonates with RDS or apnoea. It is also commonly used for respiratory support following extubation.
- nCPAP is thought to be effective by splinting the pharyngeal airway with positive pressure, thereby maintaining lung recruitment, and reducing the risk of upper airway collapse and obstruction (figure 3)

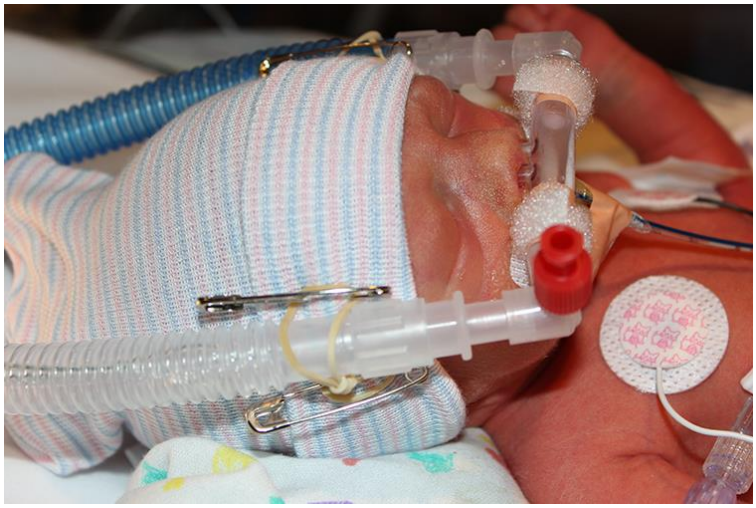

Figure 3: CPAP

CPAP systems — CPAP is administered through nasal prongs or mask through a variety of systems (picture 3).

CPAP can be delivered using different systems, which are broadly categorized as:

- **fluidic** (**variable flow**) CPAP,
- **constant flow** CPAP, and
- **bubble** CPAP.

The fluidic (variable flow) system allows rapid transition from inspiration to expiration, and this may reduce work of breathing, especially in smaller infants.

● **Constant flow systems**: use a standard nasal prong or mask interface attached to a standard ventilator circuit. The level of CPAP is controlled by the ventilator settings and the bias flow (the amount of flow left in the circuit during exhalation).

Most ventilators deliver constant pressure to achieve CPAP. However, in low birth weight (BW) infants, minimum or smaller respiratory efforts in very low birth weight (VLBW) infants are sometimes **not recognized by the ventilator, making it less responsive to their needs, and thus making this system less favourable.**

● **Bubble CPAP** is a constant-flow variable pressure system that incorporates a standard nasal prong or mask interface attached to a dual-limb heated and humidified circuit.

- It is the least expensive system, is commonly used in level 2 and 3 neonatal care units and is easy to initiate in the delivery room.
- low flows bubble CPAP prevent buildup of back pressure in the system, making it a safe application for neonates.
- The desired level of CPAP in cm H_20 is determined by not only the depth of the tubing within the water column but also the amount of flow powering the system.
- Continuous bubbling **requires a base flow rate of 4 to 8 L per minute** depending on the type of system used.
- Bubble CPAP systems' characteristics vary, so careful attention to both the depth and the flow are important factors to consider.
- Gas flow is responsible for bubbling in the circuit and produces mini oscillations generated within the chest that can equate to nearly 5 to 20 Hz at average CPAP levels.

6.2.5.B. Initial settings

administer nCPAP with an initial pressure level of **5 cm H_20** and then increase to 6 to 8 cm H_20 as needed.

- In select cases, infants may benefit from **higher pressures up to 10 to 11 cm**, which is affected by the amount of leak around the nasal prongs and patient-specific factors, including lung compliance and impaired hypopharyngeal function.

6.2.6. Nasal intermittent positive pressure ventilation

- NIPPV provides non-invasive respiratory support with phasic positive pressure ventilation (i.e., higher pressure during inspiration, lower pressure during exhalation).
- It is delivered via nasal prongs or mask using a mechanical ventilator. The peak inspiratory pressure, expiratory pressure, and breath rate are set by the clinician. Breaths are time-cycled and pressure- or flow-limited; the size of the breath is determined by the difference between the inspiratory and expiratory pressures.

Clinical trials evaluating NIPPV in neonates have used a wide range of:

- set peak inspiratory pressures (10 to 25 cm H_2O),
- breath rates (10 to 60 breaths per minute),
- and inspiratory times (0.3 to 0.5 seconds).

As with invasive MV, NIPPV can be delivered either **as synchronized** or **non-synchronized breaths**. However, synchronization is difficult to achieve in with non-invasive ventilation in neonates, and there are few devices that are approved by the US Food and Drug Administration (FDA)-approved for delivery of synchronized NIPPV in neonates. **As a result, NIPPV is generally used in a no synchronized mode.**

NIPPV has been used clinically in the following settings:

- Apnoea of prematurity.
- Primary mode of respiratory support in preterm infants with RDS.
- Following extubation.

Compared with nCPAP,

- **NIPPV is more costly and complex to use because it** requires a ventilator for administration. For this reason, many centres **preferentially use nCPAP for initial management of VPT infants.** However, **NIPPV is a reasonable option for neonates who fail nCPAP.**
- Another disadvantage of NIPPV is that because it delivers breaths **through a smaller** interface (nasal prongs) than with invasive MV, it generally requires a higher flow rate. Inadequate flow will not overcome the back pressure in the ventilator system and can

result in insufficient pressure being delivered to the infant such that there may be little to no tidal volume.

- Abdominal distention has been observed in patients managed by NIPPV, but the rate of necrotizing enterocolitis (NEC) appears to be similar to that in patients receiving nCPAP. **It remains uncertain whether NIPPV is associated with increased risk of nasal septum injury compared with nCPAP.**

6.2.7. Non-invasive neutrally adjusted ventilatory assist (NIV-NAVA)

- NIV-NAVA is similar to synchronized NIPPV. However, breath delivery is triggered by a signal from the electrical activity of the diaphragm rather than flow sensing on the ventilator.
- As such, NIV-NAVA is **not affected by leaks** around the interface and the delivered breaths more closely match the infant's spontaneous effort. Like NIPPV, NIV-NAVA has been used in neonates **who fail nCPAP** in attempt to reduce the need for intubation and mechanical ventilation.
- The available data on NIV-NAVA in preterm neonates are limited to a few small clinical trials and observational studies. Based upon these limited data, NIV-NAVA appears to have similar efficacy compared to other modes of NIV (e.g., nCPAP, NIPPV) efficacy.
- Additional larger trials are needed to determine in which clinical settings NIV-NAVA is safe and cost-effective.

6.2.8. Non-invasive high-frequency oscillatory ventilation (nHFOV)

nHFOV applies an oscillatory pressure waveform to the airways using a nasal interface. It has been used in some centres for management of preterm neonates who fail nCPAP.

nHFOV is more costly than other more standard respiratory support modalities. As a result, we suggest not using nHFOV outside the research setting until further clinical trials clearly demonstrate that it is safe and more effective (and more cost-effective) compared with conventional modes of oxygen delivery and respiratory support.

6.2.9. Bilevel nCPAP

Bilevel nCPAP systems provide two alternating levels of pressure with,

- longer duration (0.5 to 1.0 second for the higher nCPAP pressure),
- lower cycle rates (10 to 30 breaths per minute), and
- lower pressures than NIPPV

The difference between the two alternating CPAP levels is small (<4 cm H_2O).

Data are insufficient to determine whether bilevel nCPAP provides any advantage over standard CPAP for respiratory support in neonates. **As a result, standard nCPAP is preferred as the initial modality.**

6.2.10. Mechanical ventilation

6.2.10.A. General principles

While lifesaving, mechanical ventilation (MV) can also cause lung injury and contribute to hemodynamic instability, with secondary injury to the brain and other organ systems. The impact of ventilator-induced lung injury (VILI) and the imperative for utilizing lung-protective strategies are important considerations for neonates with respiratory failure who require MV.

The general approach to achieving adequate gas exchange using conventional mechanical ventilation (CMV) is based on the following:

•Ventilation (carbon dioxide [CO_2] clearance) is largely determined by minute ventilation, which is based on the frequency and size of breaths (i.e., respiratory rate [RR] and tidal volume [Tv]).

- In volume-targeted ventilation (VTV), Tv is set and controlled by the ventilator.
- In pressure-limited ventilation (PLV), Tv is determined by other settings (inspiratory pressure and inspiratory time [Ti]) and will vary depending upon lung compliance.

•Oxygenation (uptake of oxygen [O_2]) is primarily determined by the fraction of inspired O_2 (FiO_2) and the mean airway pressure (MAP). In CMV, MAP is largely determined by the set PEEP.

6.2.10.B. Strategies to minimize VILI – In neonates,

Therapeutic strategies to support gas exchange while minimizing VILI include:

- Volume targeting that supports gas exchange while minimizing volutrauma
- Use of positive end-expiratory pressure (PEEP) to maintain lung recruitment and avoid atelectasis.
- Avoidance of high inspired oxygen levels
- Setting targets for gas exchange that do not aim for normal levels, when appropriate to the specific disorder
- Use of high-frequency ventilation (HFV) for infants with inadequate gas exchange despite high CMV settings

6.2.10.C. Neonatal conditions associated with a high risk of respiratory failure include the following:

- Neonatal respiratory distress syndrome primarily seen in very preterm (VPT) infants (gestational age <32 weeks
- Bronchopulmonary dysplasia
- Apnoea of prematurity
- Persistent pulmonary hypertension of the newborn
- Meconium aspiration syndrome
- Congenital diaphragmatic hernia
- Critical congenital heart disease
- Primary pulmonary conditions including pneumonia and respiratory syncytial virus (RSV) bronchiolitis

6.2.10.D. Modes of MV

- Ventilator types can be categorized as **CMV** or **HFV**. **CMV** is used more commonly than HFV in neonates.
- Within each type, there are distinct subcategories or "modes" of ventilation.
- The selection of ventilator modes and settings is tailored to meet the needs of the individual neonate, recognizing that gas exchange needs may differ between patients and within the same patient over time.

- Individualized assessment and frequent reassessment of the adequacy of ventilator settings is critical.

1.**CMV** – CMV comprises numerous distinct modes with various properties, including those that control the following:

- -Initiation of breaths (triggering) – Breaths can be triggered by the ventilator (mandatory breaths), the patient (spontaneous breaths), or a combination of the two.
- For most neonates requiring MV, we suggest a synchronized mode that provides mandatory breaths and supports spontaneous breaths (i.e., synchronized intermittent mandatory ventilation plus pressure support [SIMV + PS] or assist-control ventilation [ACV]) rather than only mandatory breaths (i.e., SIMV alone)

2.**HFV** – HFV delivers small TVs at a rapid rate on a sustained MAP. HFV modes are usually very effective in achieving pulmonary gas exchange.

- The two major forms of HFV are high-frequency oscillatory ventilation (**HFOV**) and high-frequency jet ventilation (**HFJV**). HFOV is used more commonly than HFJV. HFOV is primarily used as rescue therapy for neonates who fail to achieve adequate gas exchange despite optimal CMV.

7. MEASUREMENTS OF OXYGENATIONS

- ✓ Oxygenation should be monitored in any neonate who receives supplemental oxygen therapy **to prevent** episodes of hypoxemia and hyperoxia, and **to avoid** the use of excessive supplemental oxygen and periods of profound hypoxia, which are associated with mortality and morbidity.
- ✓ In preterm infants, high concentrations of supplemental oxygen are associated with increased risk of bronchopulmonary dysplasia (**BPD**) and retinopathy of prematurity (**ROP**).
- ✓ Although the level of oxygenation can be assessed in several ways, **pulse oximetry**, which measures haemoglobin saturation (SpO_2), **is the accepted standard for routine monitoring of oxygenation.**

7.1. Pulse oximetry

Pulse oximetry measures **SpO_2** and reflects the **98** percent of **arterial oxygen content** that is carried normally by haemoglobin.

This monitoring technique provides data that are **continuous** and **non-invasive**, and, therefore, avoids some limitations of intermittent arterial blood sampling. ***As a result, in most neonatal intensive care units (NICUs), pulse oximetry is the accepted standard for routine monitoring, and SpO_2 has been called the "fifth vital sign"***.

- It should be noted that pulse oximeters provide time-measure values over several heart beats and do not give out instantaneous readings. Longer averaging times provide a more stable assessment with fewer alarms but are less sensitive to brief episodes of changes in oxygen saturation.
- It is **important** to determine the target pulse oximetry saturation range that adequately meets metabolic demands of the neonate yet **limits the need for high** concentrations of supplemental oxygen that might cause lung injury or retinopathy of prematurity (ROP).
- Normal pulse oximetry values in healthy term infants average 97 percent on room air and 95 percent in healthy preterm infants as mentioned before. Attempts to maintain SpO_2 values greater than 95 percent using supplemental oxygen may result in excess oxygen exposure and hyperoxia.

Most NICUs establish guidelines for target pulse oximetry saturation levels. However, it is challenging to maintain these targets, as SpO_2 values fluctuate in unstable neonates and are often outside the intended targeted range.

7.2. Sources of error

Pulse oximetry is easy to use and does not require calibration. However, interpretation of pulse oximetry readings must account for a variety of technical and clinical factors that may artificially influence the results. The best defence against these potential sources of error is a high level of training regarding the function of the pulse oximeter.

7.3. Choice of oximeter

Variation in the design of the monitor may result in differences of 2 to 3 percent among various instruments. In particular, different algorithms are used to derive SpO_2, correct for minor haemoglobin variants, or to exclude motion artifact.

In addition, algorithms vary on the averaging time for waveform analysis, which may affect the rate and detection of desaturation events. As a result, **short events that are in proximity may be displayed as a single longer event, which may impact clinical decision making. Therefore, some pulse oximeters may not be suitable for neonatal use**.

7.4. Technical sources of error at the point of care include:

- Motion artifact
  - Low amplitude arterial pulsations in small preterm infants are particularly difficult for oximeters to detect and differentiate from venous pulsations and other movement artifacts.
  - As a result, examination of the displayed waveform is recommended to validate the oximeter signal. An alternate check is comparison of the pulse rate from the oximeter with the heart rate from the electrocardiograph monitor; **the two values should be identical.**

- Improper probe placement.
- Exposure to ambient light can be minimized by shielding of the probe.

7.5. Clinical factors that contribute to error include:

•Hypoperfusion.

Pulse oximetry readings can be **falsely low** because of signal failure in the setting of hemodynamic instability or poor limb perfusion caused by vasoconstriction. Placement of a blood pressure cuff and oximeter probe on the same extremity should be avoided.

•Abnormal haemoglobins and severe anaemia;

✓ Abnormal haemoglobins or haemoglobin variants **can interfere** with pulse oximetry if their absorption properties are similar to those of oxyhaemoglobin or deoxyhaemoglobin.

- ✓ Fetal haemoglobin does **not** interfere with oximetry measurements unless levels exceed 50 percent.
- ✓ Although pulse oximetry values are falsely lowered only when **anaemia** is very severe, clinicians must be aware that low haemoglobin concentrations decrease oxygen content and delivery.

Occurrence of short, deep desaturation events that trigger audible alarms are common during oximetry monitoring of preterm infants. These frequent events may produce "**alarm overload**" among bedside care providers and further contribute to the difficulties of maintaining target saturations in a narrowly defined range.

- To reduce the impact of these "nuisance alarms," manufacturers have employed increasingly sophisticated waveform analysis and algorithms that may include longer averaging time.
- Different averaging times used in conjunction with variable adjustments of alarm delay (which are manufacturer dependent) may influence the duration of desaturation events and the response of care providers. There is no standard for clinical practice; however, uniform policy within a NICU is desirable.

7.6. Arterial blood gas measurement

- ➢ Arterial oxygen tension (PaO_2) measures the partial pressure of the small amount of oxygen that is dissolved in plasma and has been considered **the "gold standard" for the measurement of oxygenation**.
- ➢ However, intermittent sampling of arterial blood **may not accurately reflect** the fluctuations in oxygenation that typically occur in infants with cardiopulmonary disease or in response to percutaneous puncture.
- ➢ Although PaO_2 measurements can be used to estimate oxyhaemoglobin saturation, changes in pH, temperature, or other factors may render this estimate unreliable. **Capillary** samples do **not** provide reliable measurements of PaO_2.

7.7. Transcutaneous oxygen monitoring

Transcutaneous oxygen monitors measure oxygen tension ($TcPO_2$) with a heated blood gas electrode applied to the skin surface. However, the need for frequent recalibration and transient erythema from application of the heated electrode have greatly diminished its use.

8. DOCUMENTATION

Oxygen concentration in percentage or Liter flow/minute, the method of oxygen delivery and the water temperature should be documented hourly **on the Daily Neonatal Clinical Record**. All adjustments made based on the neonate's status and/or physician orders must be noted.

Oxygen Therapy Equipment Changes

- Nasal prongs should be changed once a week, or in between if blocked with nasal secretions.
- Oxygen masks/portable oxygen analysers and SaO2 probes are changed when baby is discharged.

9. COMPLICATIONS OF OXYGEN THERAPY (OXYGEN TOXICITY)

The term "oxygen toxicity" refers to the pathologic tissue changes (whether pulmonary or extrapulmonary) that occur because of prolonged and/or high concentrations of supplemental oxygen.

Oxygen toxicity is mediated by reactive oxygen species (radicals), which can promote inflammation and induce cell death. There is no well-defined threshold FiO2, or duration of supplemental oxygen therapy below which oxygen toxicity cannot occur.

Potential adverse clinical consequences of supplemental oxygen therapy include;

Absorptive atelectasis

High concentrations of supplemental oxygen may cause washout of alveolar nitrogen to capillaries and absorptive atelectasis. This could happen when oxygen absorption from the alveoli occurs at a faster rate than its replenishment by inhaled oxygen.

Bronchopulmonary dysplasia-BPD

Bronchopulmonary dysplasia is a chronic lung disease that occurs most often in preterm infants, commonly <32 weeks' gestation. It is characterized by epithelial hyperplasia and squamous metaplasia in the large airways, thickened alveolar walls, and peribronchial and interstitial fibrosis.

Retinopathy of prematurity (ROP)

Retinopathy of prematurity is a Vaso proliferative disorder of the retina which occurs principally in preterm infants <32 weeks' gestation. Visual loss may result, so screening is mandatory for early intervention.

10. SUMMARY AND RECOMMENDATIONS

1. **Respiratory support devices** – Respiratory support devices provide warmed and humidified gas that is delivered using a system in which the oxygen concentration can be regulated. Respiratory support systems used in neonates include;

- Low-flow nasal cannula (LFNC)
- High-flow nasal cannula (HFNC)
- Hood
- Face mask
- Nasal continuous positive airway pressure (nCPAP)
- Nasal intermittent positive pressure ventilation (NIPPV)
- Endotracheal intubation and invasive mechanical ventilation (MV)

2. **Choice of modality** – The choice of respiratory device is dependent on the clinical setting and the needs of the individual neonate.

3. **Measuring and monitoring oxygenation**

•Neonates receiving supplemental oxygen should have routine monitoring of oxygenation to prevent episodes of hypoxemia and hyperoxia and to avoid the use of excessive supplemental oxygen. In preterm infants, high concentrations of supplemental oxygen are associated with increased risk of bronchopulmonary dysplasia (BPD) and retinopathy of prematurity (ROP).

•Oxygenation is generally monitored by pulse oximetry supplemented by intermittent arterial blood gas measurement.

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