53 Other Oxygen Delivery Systems

Oxygen is the most commonly used drug in the NICU. Excessive use of oxygen is linked to BPD and RDP. At the same time, hypoxemia is equally harmful and is associated with increased risk of mortality. Hence judicious use of oxygen, titrated to the needs of the neonate using pulse oximetry, is necessary.

Hypoxemia (oxygen saturation < 90%) should be suspected in any neonate presenting with central cyanosis as well as those with significant respiratory distress (nasal flaring, tachypnea >60/min), chest retractions, grunting and altered mental status.

Pulse oximetry is an accurate method for detecting low oxygen saturation in neonates. It is non-invasive, provides continuous display of SpO_2 to titrate oxygen therapy. Blood gas analyses provide paO_2 values from which SpO_2 is derived and also measures $paCO_2$ and pH. However it is invasive and provides one time measurement, and inaccuracies can result from a poorly taken sample.

In preterm neonates, application of CPAP is beneficial to recruit alveoli and maintain FRC. However, in older neonates and infants and in certain situations, stand alone oxygen therapy may be preferable. Examples include:

1. Neonates with hypoxemia and minimal respiratory distress
2. Transient tachypnea of newborn or delayed adaptation
3. Hypoxemia with risk of air leak like hyperexpanded lungs, pneumothorax or mild meconium aspiration syndrome
4. Weaning from CPAP or HFNC
5. Bronchiolitis or pneumonia
6. Facilities where CPAP or mechanical ventilators are not available

Oxygen delivery devices[1]: Oxygen can be delivered using the following devices

1. Blow by method or free flow oxygen
2. Oxygen by hood
3. Nasal mask
4. Nasal cannula (low flow)
5. Nasal or nasopharyngeal catheters

Free flow oxygen

1. Free flow oxygen or blow-by oxygen delivery is the simplest and least cumbersome method to deliver oxygen therapy but it is also the least reliable in delivering a specific FiO_2.
2. Free flow oxygen delivery is usually done by means of large-bore oxygen tubing from a flow meter set between 3-4 L/min and other the end placed a relatively short distance (4-5 cm) from the patient's face. Flow rate of 3 L/min seems optimal as the lowest predictable FiO_2 delivered to the neonate is around 36% at this rate. The oxygen enriched area has a width of only 18 cm with oxygen tubing which may be too narrow for an active neonate.
3. This type of oxygen delivery can be used for neonates who cannot tolerate other oxygen delivery devices, require a lesser amount of oxygen and for short term use during feeding or neonatal resuscitation.

Oxygen hood

Fixed oxygen concentrations from 21% to near 100% can be maintained with a flow rate of 3-7 L/min oxygen flow into the hood. A minimum gas flow of at least 2-3 L/ kg/min ensures that exhaled carbon dioxide is flushed out and not re-breathed. Although oxygen hood can theoretically deliver high FiO_2 concentration, it is best suited for neonates who require less than 50% FiO_2. The oxyhood offers the advantage of being able to estimate delivered FiO_2. There is no increased risk of nasal obstruction due to drying of mucus or gastric dilatation. Humidification is not necessary.

Disadvantages

1. There is a risk of hypercarbia if inadequate flow rates are used.

2. Inability to maintain uniform oxygenation while carrying out routine manoeuvres like oral feeding, suctioning etc.
3. High flow rates lead to wastage of oxygen especially in units with limited resources

General considerations while using a head box

1. Use the smallest appropriate size of the head box
2. Use a flow rate of 2-3 L/ kg/min. In order to avoid excessive noise and cooling, flows greater than 10 L/min should not be used.
3. Always use an oxygen analyzer to measure the FiO_2 delivered
4. In the absence of an oxygen analyzer, an approximation method given in Table 53.1 can be used (using a medium sized head box without additional lid).[2] The delivered FiO_2 depends on the size of the hood, oxygen flow rate and presence or absence of lid or portholes. A higher and stable FiO_2 is achieved with a smaller size hood, keeping the porthole or lid in closed position and using higher flow rates.

Table 53.1: Approximate FiO2 delivered while using an oxygen hood without any lid at various flow rates

Flow rate (L/min)	2	3	4	5	6	7	8	9
FiO_2 (medium size head box- ID 21.5 cm)	51	58	67	72	77	82	86	90
FiO_2 (large size head box- ID 24 cm)	36	39	42	46	49	52	59	60

Low flow nasal cannula[3]

1. Nasal cannulae deliver gas via two small, thin, tapered tubes (usually less than 1 cm in length) that are placed inside the nostrils without occluding them.[4] This is the preferred method of oxygen delivery because of its safety and efficacy.
2. Low flow nasal cannulae (LFNC) use lower flow rates (less than or equal to 1 L/minute). Usually 100% oxygen is used, which is unheated and not humidified.
3. The predicted FiO_2 at oxygen flows of 0.5 L/min, 1 L/min and 2 L/min are about 35%, 45% and 55%, respectively.[5]

4. While low flow nasal canulae do not generally provide positive pressures, PEEP can be inadvertently generated. PEEP depends on the diameter of the prong and the flow rate of the gas; a tightly fitting prong at flow rates greater than 2 L/min can generate pressures.
5. LFNC are commonly used in preterm neonates with BPD while recovering[6] and in neonates with TTNB, asphyxia, etc.
6. Flows >2 L/min should be humidified else dryness and excoriation of nasal cavity can occur. If the need for higher flow rate arises, need for CPAP or HFNC should be discussed and a decision should be taken based on the underlying lung condition, gestational and post-menstrual age of the neonate.
7. The delivered FiO_2 can be calculated using Finer's formula[7], assuming a tidal volume of 5.5 mL/Kg. However as a rule of thumb, when the flow rate exceeds the weight of the infant in kg (e.g. >2 L/min in a 2 kg infant), the delivered FiO_2 approximates the set FiO_2 which is 100%.

$$FiO_2 = \frac{\text{Oxygen flow (mL/min X 0.79)} + (0.21 \text{ X VE})}{\text{VE}}$$

(assume minute ventilation (VE) of 300 mL/min in < 1500 g and 730 mL/min for > 1500 g neonates)

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