Review Article

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Review Article on Oxygen Therapy in Paediatrics

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Abstract

Oxygen is a colorless, odorless, tasteless gas that is essential for the survival and all body functions to carry out smoothly. Oxygen therapy is the administration of oxygen at a concentration of pressure and concentration greater than that found in the atmospheric air. The air contain approximately 21% oxygen. Oxygen is the most important medical gas. Hypoxaemia can cause increased mortality and morbidity especially in the developing countries, still feasible and cost-effective ways to treat hypoxaemia receive little or no attention in current global health strategies. Oxygen as a mode of treatment has been used in for almost 100 years, but in developing countries most of the patients do not have access to oxygen due to financial constraints. Knowledge of the physiology of oxygenation is of key importance in oxygen therapy. Oxygen therapy is more reliable if given by high flow systems. Hence use of high flow oxygen delivery system to be implemented.

Keywords: Oxygen; Hypoxia; Oxygen Toxicity.

Introduction

Oxygen is a colorless, odorless, tasteless gas that is essential for all the bodily functions as well as survival. Oxygen was first discovered by Joseph Priestley in 1774, and has been used as treatment for hypoxaemia. Oxygen has been used with highly significant clinical benefits in all ages group of patients [1]. Lack of oxygen treatment in low- and middle-socioeconomic groups cause the greatest mortality due to lung disease. One molecule of glucose yeilds 32 molecules of ATP in aerobic condition and only 2 molecules of ATP in anaerobic condition and in addition yields lactic acid. In Oxygen therapy the concentration and pressure of oxygen in the inspired air is increased to correct or prevent hypoxia in patient. Partial pressure of oxygen in blood (PaO,) of less than 60Hg beyond the age of 28 days of life is known as Hypoxemia. hypoxemia in neonates is defined as PaO, of less than 50 mm Hg [2,3]. Around 9 million paediatric patients show mobidity and mortality mainly due to from the diseases which are preventable or treatable. Out of these cases more than 95% occur in setups in developing countries due to non availability of oxygen.

In the under 5 population Pneumonia is the one of the common causes of death in children aged <5 years, causing an estimated 18% of all deaths in this age category. Most common complication of pneumonia is hypoxaemia. And the risk of death is directly proportional to severity of hypoxaemia which is inevitable due to lack of oxygen administration [4]. In its guidelines, the WHO emphasises the importance of oxygen within the necessary package of providing care for seriously ill children, and for emergency, anaesthesia and surgical services in all levels of hospitals settings. Hypoxaemia correction requires oxygen therapy at the point of care requires a sourcethe sourses in the form ofan oxygen concentrator or cylinder, and equipments for delivery, such as tubings, face mask or nasal prongs and pulse oximeter for oxygen saturation monitoring [5].

Indication for oxygen in Paediatrics

1. Neonates

- Hyaline membrane disease as in premature lungs
- Birth asphyxia
- Transient tachypnea of neonate
- Sepsis
- Hypoglycemia
- Seizures

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2. Children

- Respiratory tract infections most comman being bronchiolitis and pneumonia.
- Acute asthma
- Meningitis
- Septecemia [6]

Methods for measuring hypoxia

Oxvgen deliver to tissues depends on the adequacy of ventilation, i.e. gas exchange. The tissue hypoxia presents within few minutes of the failure of respiratory, cardiac or central nervous systems. A better prognosis of hypoxaemia depends on the treatment of tissue hypoxia which requires early diagnosis and early intervention. Central cyanosis is not a reliable indicator of tissue hypoxia. The central cynosis only can be detected when the rduced haemoglobin concentration is below or equal to 1.5gm/dl. In general, hypoxaemia can be detected using clinical signs, pulse oximeter or blood gas analysis. Presence of more than one clinical sign is usually more sensitive for detecting hypoxaemia than a single sign like cyanosis, but specificity of this method is low, so that misdiagnosis of the presence or absence of hypoxaemia using clinical signs is common in clinical practice [7]. In a study conducted by J S Haldane,there is lack of cyanosis despite severe significant central nervous system symptoms from hypoxaemia in 1920 which shows Cyanosis has poor sensitivity for detecting hypoxia. Blood gas studies are expensive, invasive and provides a single measure in time only, also blood gas analysis is not available at all hospitals in developing countries. The oxygen saturation in the arterial blood is measured by pulse oximeter by comparing the absorption quotient of light having different wave lengths, when a part of body illuminated by the light. The most favourable site for better reliable saturation reading is nail bed. If used by correct method pulse oximetry is most reliable, most importantly, a non-invasive method for detecting hypoxaemia [8].

Pulse oximeter can correctly identify 20–30% more patients with hypoxaemia than those detected by using clinical signs alone oxygen therapy most efficiently can be monitored by using pulse oxymeter, which is especially important in resource-limited settings of developing countries. Every patient presenting with clinical signs of hypoxaemia need not be in hypoxaemia. Thus use of oxymeter is important to limit the use of oxygen unnecessarily. The unnecessary use of oxygen is also harmful as oxygen is a medicine and to be used not misused. In hospitals that care for large numbers of children with acute respiratory disease, pulse oximetry is becoming increasingly affordable as the price of oximeters decreases and availability increases.

Oxygen delivery devices

A-Low-flow devices

The low flow devies can be used when we have to provide oxygen at flow rates that are lower than patients' inspiratory demands.

B-High-flow devices

Delivers a constant FiO_2 by delivering the gas at flow rates that exceed the patient's peak inspiratory flow rate.

A. Low flow:

1. Simple face mask

A plastic oxygen mask that covers the nose and mouth only and can deliver oxygen concentrations ranging from 30%-60%. these masks covers the nose and mouth. A reservoir effect is produced by the internal capacitv of the mask to further increase the saturation of oxygen. Holes on either sides of the mask provide an egress for exhaled gases and allow the escape of exhaled gases. The FI02 varies with the patient's inspiratory flow and is not constant.

The common side effect of using simple face mask is aspiration of vomitus. Rebreathing may result in accumulation of CO_2 in mask if Oxygen flow is inadequate due to decreased breathing efforts by patient [10].

2. Partial-rebreathing masks are similar to simple masks except they contain a reservoir at the base of the mask which receives fresh gas plus exhaled gas approximately equal to the volume of the patient's anatomical dead space hence have a advantage. (Fig 1).

3. Non-rebreathing masks are similar to partial rebreathing masks but they do not allow the mixing of exhaled gases containing carbon di oxide with the fresh oxygen gas.

A series of one way valves are strategically placed at the reservoir opening. Also on the side ports ensures a fresh oxygen supply with minimal dilution from the entrainment of room air. This arrangement provides a higher FiO_2 than the simple and partial-rebreathing masks and provides 100% oxygen [11]. (Fig 2).

4. Nasal prongs:

It has 2 prongs which fit in each nostril. It delivers a low flow rate of oxygen that provides oxygen concentrations of 24% to 44%. Nasal cannula has two soft prongs that arise from the oxygen supply tubing connected to oxygen cylinder. The prongs are inserted into the patient's nostrils, and the tubing is secured to the patient's head. The oxygen delivered is carried to nasophrynx which acts as an anato,ical reservoir. In patients not having a spontaneous respiratory efforts the efficacy of oxygen delivery by nasal cannula is reduced. This is as the fractional concentration of inspired oxygen varies with the patient's inspiratory flow. (Fig. 3).

5. Oxygen hood:

Fits over infant's head and neck.

It requires oxygen flow at 10 to 15 litres per minute. The FiO_2 achieved inside the hood varies form 22 to 90% and depends on the flow rate of oxygen, babies' respiratory needs, the shape of the hood and the size of the port openings. Adequate heat and humidity should be maintained inside the hood. Oxygen hoods call he fed through a venturi system to keep Fi02 inside fixed. (Fig. 4).

6. AMBU bag:

AMBU stands for Ambulatory Manual Breathing Unit. It is a bag also known as a manual resuscitator or "self-inflating bag". AMBU is a hand-held device commonly used to provide positive pressure ventilation to patients who are not breathing spontaneously or not breathing adequately during resuscitation. A bag-valve mask can be used without being attached to an oxygen tank to provide "room air" i.e. 21% oxygen to the patient requiring only positive pressure. When connected to a separate bag reservoir which can be filled with pure oxygen from a compressed oxygen source – this can increase the amount of oxygen delivered to the patient to nearly 100% in patients needing higher oxygen concentration and positive pressure [12]. (Fig. 5).

B. High flow oxygen delivery system:

1. High-flow nasal cannula (HFNC):

An air/oxygen blender, an active humidifier, a single heated circuit, and a nasal cannula combined to form a HFNC. Delivering adequately heated and humidified medical gas at up to 60 L/min of flowis a characteristic of HFNC. It works by various physiological effects which include reduction of anatomical dead space, constant fraction of inspired oxygen, and good humidification of inhaled air.

2. Continuous positive airway pressure/Bilevel positive airway pressure devices

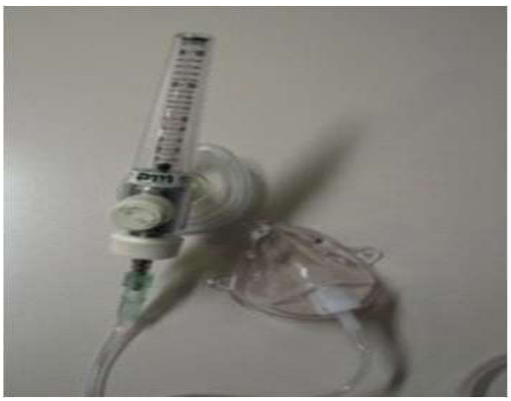

Fig. 1: Oxygen face mask

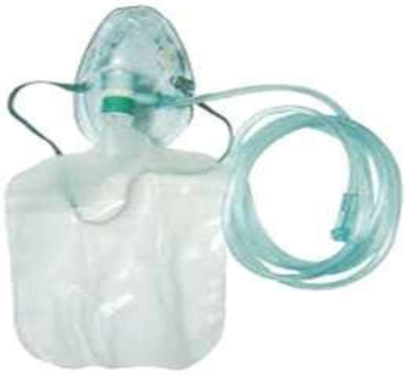

Fig. 2: Non rebreathing mask

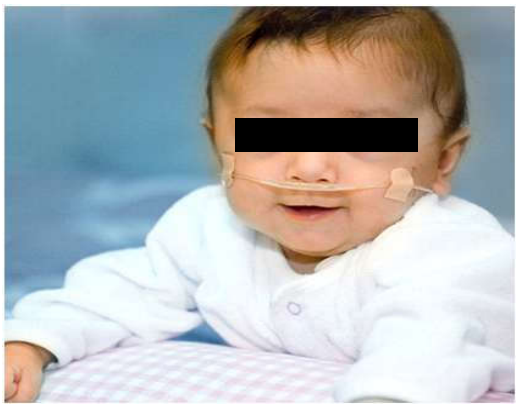

Fig. 3: Nasal prongs

Fig. 4: Oxygen Hood

Fig. 5: AMBU bag

When oxygen requirement is more than 60% with a PaO_2 of less than 60 mmHg CPAP is used which causes decreased work of breathing, increases FRC and helps maintain it, recruit alveoli, increase static compliance, and improve ventilation perfusion ratio. It is non invasive method of oxygen supplementation.

Expiratory Pressure (PEEP) (intubated patient) partially obstructs exhalation and thus keeps the lungs inflated during expiration (prevents the total collapse of lung at the end of expiration). It is easy to expand a partially collapsed lung than totally collapsed a lung. Especially in early infancy and in neonates, there is a natural tendency of lungs to collapse and hence the CPAP is very useful.

CPAP can be given

(1) Non-invasive

(2) With Intubation

(3) Mechanical ventilation:

Mechanical ventilation is artificial ventilation to assist or replace spontaneous breathing of patient.

The ventilation can be of two type-positive pressure ventilation, where air (or another gas mix) is pumped into the lungs, and negative pressure ventilation,is when air is sucked into the lungs and gas flow takes place passively.

Disadvantages of Mechanical ventilaton:

- Barotrauma-As the positive pressure ventilation provides oxygen by high pressure, it can lead to pulmonary barotrauma
- Ventilator-associated lung injury and pneumonia.
- Positive pressure ventilation appears to cause impairement in mucociliary motility of the respiaratory tract and become more susceptable to infections.
- An Invasive technique and need skillful personel for intubation.

4. Tracheostomy mask:

It is also known as tracheostomy collar.

It is a small mask which fits over the patient's tracheostomy site and used to deliver oxygen.

About 10L/ min oxygen is delivered [13,14].

Oxygen toxicity

1. CO_2 Narcosis - If these patients are given oxygen it causes their respiratory drive to decrease, causing respiratory depression and a further rise in $PaCO_2$ resulting in increased CO_2 levels in the blood and CO_2 narcosis i.e. CNS toxicity due to retention of the Carbon di oxide in body.

2. Pulmonary Atelectasis/collapse- a complete or partial collapse of a lung or lobe of a lung which develops when the tiny air sacs (alveoli) within the lung become deflated.

3. Pulmonary oxygen toxicity - High concentrations of oxygen (>60%) may damage the alveolar membrane when inhaled for more than 48 hours at high concentrations and can result in pathological lung changes which are irreversible.

4. Retrolental fibroplasia (also known as retinopathy of prematurity) An alteration of the normal retinal vascular development, it mainly affects premature neonates, which can lead to visual defects and blindness caused by neovascularisation of the retina in neonates [15,16].

Oxygen safety

Oxygen is not a flammable gas. But it can cause rapid combution.

Precautions to be taken:

- Do not smoke near the oxygen equipment as the gas can catch fire.
- Turn off oxygen cylinder valves when not in use.
- Do not store oxygen cylinders in hot places where there are chances of fire oxygen being helpful in combustion.
- Oxygen euipments should be kept out of reach of children.
- Do not use any petroleum products or byproducts e.g. petroleum jelly/Vaseline while using oxygen [17,18].

Conclusion

Oxygen is a life saving drug. The earlier the

intervention to correct the hypoxia better is the prognosis. As any common drug, oxygen used in excess, can lead to toxicity. But the fear of toxicity should be kept aside while treating patients and oxygen theray should not be withheld. Patients on oxygen therapy require close monitoring similar to patients on ventilators. Opitmum oxygenation is the best, hypoxia is bad, but hyperoxia is worst.

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