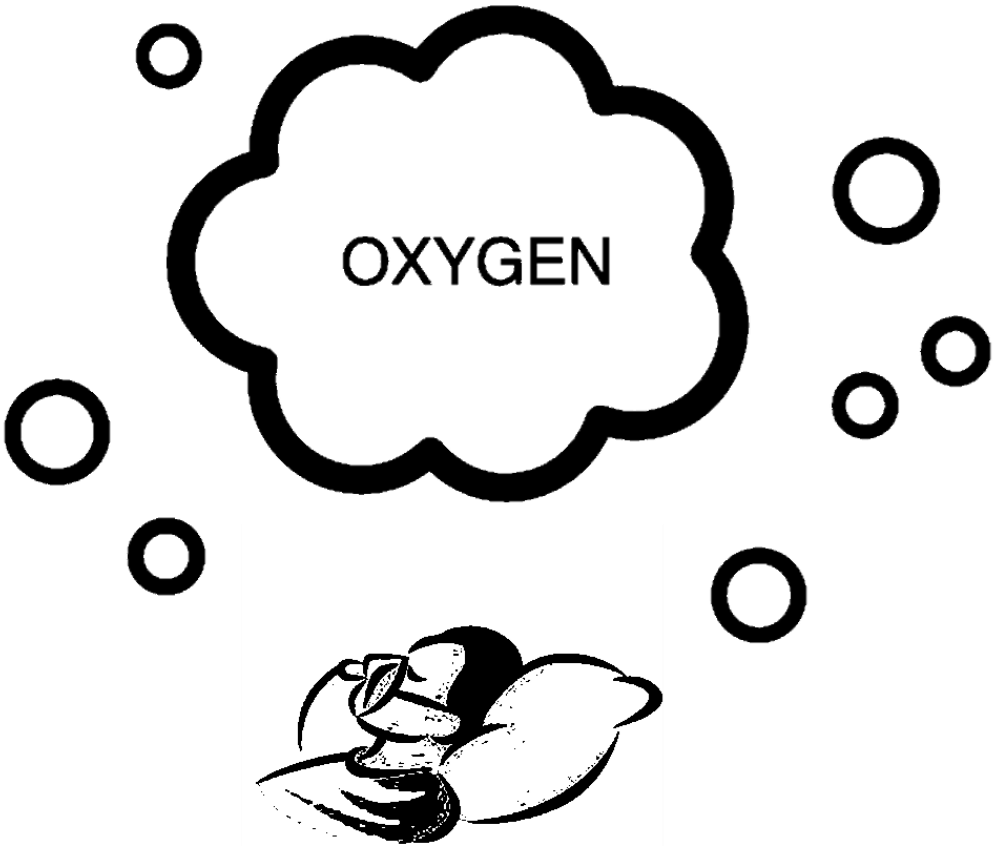

Oxygen therapy for COVID-19 patients

From guidelines to implementation

July 2021

COMMUNITY PARTNERS INTERNATIONAL

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Foreword

Since the global pandemic COVID-19 outbreak, medical oxygen has become the most important life-saving commodities in the fight against COVID-19. Medical oxygen plays an essential role when a COVID-19 infected patients develop pneumonia and hypoxaemia – a low blood oxygen level. Medical oxygen can be used to treat hypoxaemia due to COVID-19 at all level of health care system. When medical oxygen is used judiciously in the treatment of hypoxaemia, it undoubtedly saves life. However, oxygen is often used inappropriately and the dangers of over-oxygenation are unappreciated.

Since early July of 2021, Myanmar has reported daily record-breaking numbers of confirmed COVID-19 cases and deaths in what is a rapidly escalating third wave. This oxygen therapy booklet aims to help the healthcare service providers understand the best way to use oxygen while they are providing care for patients infected with COVID-19 at primary level (home, community care and health care clinic).

Pathophysiology of Oxygen

Human body needs energy for all kinds of activities. Energy comes from glucose and oxygen. All functions of the human body require oxygen. In human body, blood brings oxygen and nutrients to all the parts of the body so they can keep working. Oxygen is carried in the blood in two forms: (1) dissolved in plasma and RBC water (about 2% of the total) and (2) reversibly bound to hemoglobin (about 98% of the total). The main carrier of oxygen in the blood is haemoglobin.

Low level of oxygen in the blood called **hypoxaemia**. **Hypoxia** can be defined as inadequate oxygen in tissues for normal cell and organ function, and **hypoxia results from hypoxaemia**.

Oxygen deprivation can have severe adverse effects on the cells that perform important biological processes. Lack of oxygen leads very quickly to dysfunction of the organ systems especially brain and result in death. Therefore, hypoxaemia is a life-threatening emergency condition that requires early detection and treatment.

Causes of Hypoxaemia (In Adult)

- Lower respiratory tract infection (severe pneumonia or bronchiolitis)
- Upper airway obstruction
- Severe asthma
- Common neonatal conditions like birth asphyxia and in respiratory distress syndrome
- Severe sepsis
- Heart failure
- Carbon monoxide poisoning
- Obstetric and perioperative emergencies.

Causes of Hypoxaemia (In Child)

- Acute Respiratory Tract Infection: Hypoxaemia is a common complication in ARTI and is a strong risk factor for death. An estimated 14 million children each year have severe or very severe pneumonia and developed 1.86 million cases of hypoxaemic pneumonia annually.
- Pneumonia
- Bronchiolitis

Other causes (not common like pneumonia/bronchiolitis)

- Acute asthma
- Meningitis
- Sepsis
- Severe anaemia
- Severe heart failure

Causes of Hypoxaemia (In Neonate)

In the first hour after delivery, normal newborn infants have lower normal oxygen saturation. It may take an hour or more for oxygen saturation to reach levels above 90%. The normal level for a newborn in the first hours of life is typically 88% or more. But in pre-term babies not higher than 95%.

Conditions that can lead to hypoxaemia in neonates are:

- Respiratory distress syndrome (RDS): lack of surfactant
- Birth asphyxia: Prolonged 2nd stage
- Transient tachypnoea of the neonate (TTN)
- Pneumonia is also very common
- Very LBW (< 1.5 kg or gestational age < 32 weeks): Apnoea
- Perinatal asphyxia: Respiratory depression at the time of birth

Oxygen saturation in Blood

As mentioned above, the main carrier of oxygen in the blood is haemoglobin, and each haemoglobin mol-ecule can carry four oxygen molecules. The oxygen content of haemoglobin is expressed as oxygen saturation in blood (SpO2), which is related to arterial oxygen tension (PaO2), is therefore used to define hypoxaemia.
The "gold standard" for measuring arterial oxygen tension (PaO2) and for calculating oxygen saturation is blood gas analysis. This method is, however, invasive, painful and distressing to the patient, and blood gas machines and reagents are very expensive. Therefore, it is not appropriate in most district hospitals in developing countries.
The normal range of SpO2 at sea level is 97–99%, with a lower limit 94%. In practice, the threshold at which oxygen is given is often SpO2 < 90%. Small reductions in SpO2 below 90% may represent a dangerous fall in arterial oxygen tension (PaO2).
Oxygen therapy at higher thresholds than 90% SpO2 are required in some conditions. Give oxygen if the SpO2 is < 94%. i.e Severe anaemia, sepsis, severe heart failure, brain injury.

When to start oxygen therapy in COVID-19 patients

Patients with COVID-19 pneumonia present with hypoxaemia of varying degrees. The cornerstone for the management of the hypoxaemia is the application of oxygen therapy via a variety of delivery methods.

Adult

Measure the oxygen therapy with pulse oximeter and check the other hemodynamic symptoms (Blood pressure and Respiratory rate) at the same time.
Oxygen therapy in COVID-19 infected patient should start in the following situation:
Give oxygen if hypoxemic- measure oxygen saturation by pulse oximeter then titrate.

- SpO2 <90% (hemodynamically stable patient)
- SpO2 <94% (pts with hemodynamically unstable)
- SpO2 <92-95% (pregnant women)

Child

- Infants aged < 2 months with signs of severe respiratory distress (tachypnoea, severe chest indrawing, head nodding or grunting) should always be given oxygen, because hypoxaemia increases their risks for apnoea and death.
- Oxygen should always be given *continuously* until normal saturation is maintained without O2.
- Children with emergency signs (obstructed or absent breathing, severe respiratory distress, central cyanosis, signs of shock, coma or convulsions) should receive oxygen therapy
- Any child with an SpO2 < 90% should receive oxygen. Very severe anaemia, severe heart failure, septic shock or acute neurological illness will certainly benefit more than other.
- SpO2 range is lower at higher altitudes, it may be appropriate to give oxygen only at an SpO2 of ≤ 87% to children living at altitudes > 2500 m, if oxygen supplies are limited.

Danger signs indicating urgent and immediate treatment / referral include:

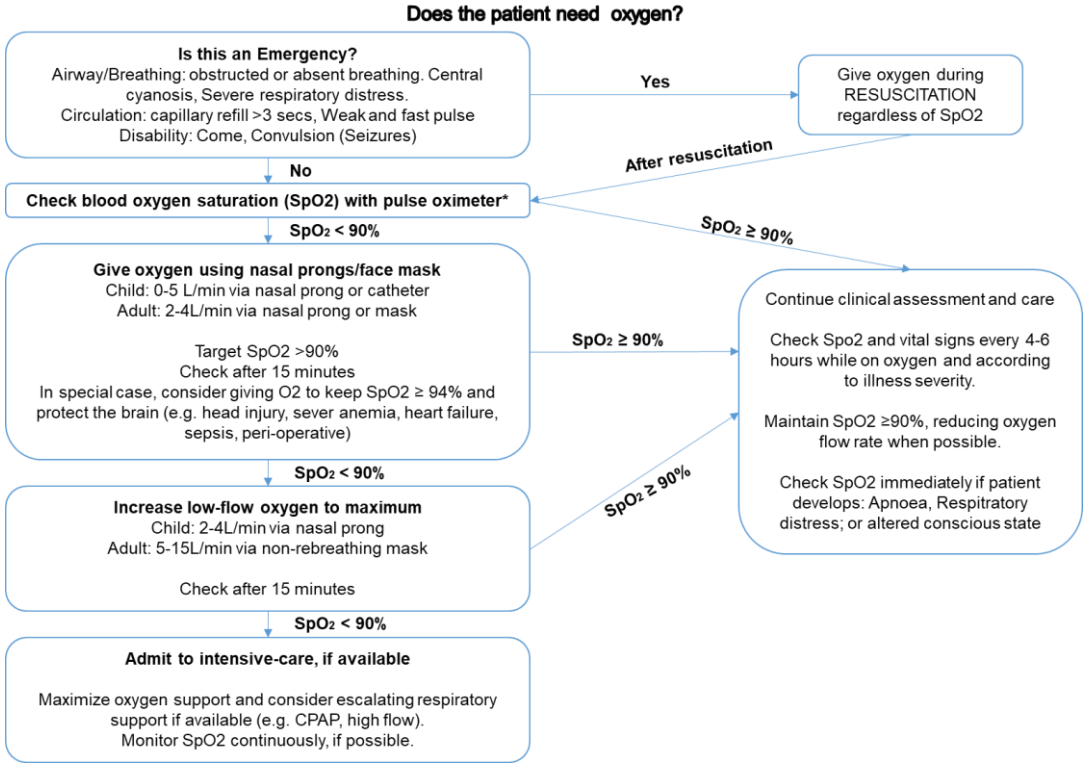
- oxygen saturation of < 90% in room air
- cyanosis
- nasal flaring
- inability to drink or feed (when this is due to respiratory distress)
- grunting with every breath and
- depressed mental state (i.e. drowsy, impaired consciousness, lethargic)

Non-specific signs of hypoxia

- severe lower chest walls indrawing,
- respiratory rate of ≥ 70/min or
- head nodding (i.e. a nodding movement of the head, synchronous with the respiration and indicating severe respiratory distress).

*Even the best observations of clinical signs commonly result in misdiagnosis of hypoxaemia in children. Pulse oximetry is the most accurate non-invasive method for detecting hypoxaemia. It is used to measure the % of oxygenated haemoglobin in arterial blood (SpO2).

Flow charts for oxygen therapy and clinical indications



***If you do not have a pulse oximeter, use clinical signs:**
Central cyanosis, severe lower chest indrawing, Respiratory rate ≥70 breath per minute, inability to drink (due to respiratory distress), grunting with every breath, depressed mental state
***Make sure your pulse oximeter is reliable and quality device to show the correct % of oxygen**

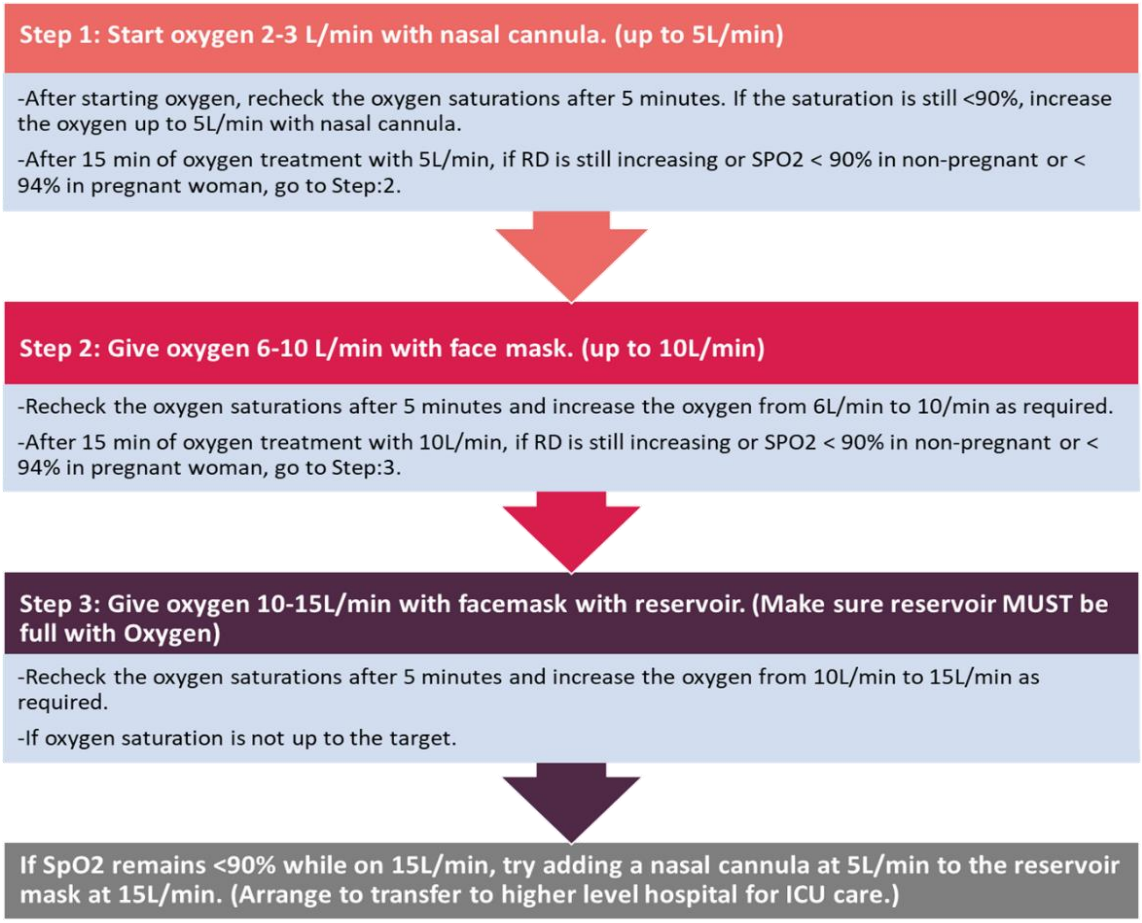
How to start Oxygen therapy in COVID-19 patients

Adult

Target[1]:

- SpO2 ≥90% in non-pregnant adults and SpO2 ≥94% in pregnant patients.

Procedure:



*RD = Respiratory Distress

Note: The use of the **prone position** in non-intubated patients and conscious patients who are hypoxaemic are proved to be much beneficial.

- Check oxygen saturation every 2 hours and step up or step down according to the above procedure.
- Step up if the patient is not improving from previous measurement.
- Titrate oxygen therapy up and down to reach targets by means of a nasal cannula, simple face mask or face mask with reservoir bag, as appropriate.
- Step down if the patient reaches the target SpO2 >90% in 2 consecutive measurements
- Monitor SpO2 for 5 minutes after stepping down.

***** Try prone position to improve oxygenation in all severe COVID-19 patients. See **Annex 1** for positioning of patients in details.

*** Nasal cannula should not be reused.

*** Face masks and reservoir bags must be heat disinfected between each patient use if they are used for more than one patient.

[1] World Health Organization. Clinical management of severe acute respiratory infection when novel coronavirus (nCoV) infection is suspected 2020 [Available from: https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratoryinfection-when-novel-coronavirus-(ncov)-infection-is-suspected.

Child and neonate

Target[2]:

- Children with emergency signs (obstructed or absent breathing, severe respiratory distress, central cyanosis, shock, coma or convulsions) should receive oxygen therapy during resuscitation to target SpO2 ≥94%; otherwise, the target SpO2 is ≥92%.

Procedure:

Nasal prongs are the preferred method of delivering oxygen to infants and children < 5 years of age with hypoxaemia who require oxygen therapy.

Practical considerations:

- The distal prong should fit well into the nostril (premature infants: 1 mm; infants weighing up to 10 kg: 2 mm).
- The prongs should be secured with a piece of tape on the cheeks near the nose.
- Care should be taken to keep the nostrils clear of mucus to avoid blockage.

Starting flow and titration parameters

- 0.5–1 L/min for neonates;
- 1–2 L/min for infants;
- 2–4 L/min for older children or through an appropriately sized face mask (> 4 L/min) to reach an SpO2 of ≥ 94%.
- If severe hypoxaemia persists despite maximal flow rates: start oxygen using face mask with reservoir bag.

Once oxygen therapy has been initiated, the child must be checked within 15– 30 min to observe whether the treatment is working.

METHOD	MAXIMUM O2 FLOW (L/MIN) [a]	PEEP (Positive End Expiratory Pressure)	HUMIDIFICATION	RISK FOR HYPERCAPNOEA	RISK FOR AIRWAY OBSTRUCTION	EQUIPMENT REQUIRED	NURSING DEMAND
Nasal prongs	Neonates: 0.5–1	Minimal	Not Required	No	Minimal	Nasal prong	+
	Infants: 2						
	Preschool: 4						
	School: 6						
Nasal catheter	Neonates: 0.5	+	Not Required	No	+	8-F catheter	++
	Infants: 1						
Nasopharyngeal catheter	Neonates: 0.5	++	Required	No	++	8-F catheter, humidifier	+++
	Infants: 1						
Headbox, Facemask, Incubator, Tent (Not recommended)	Head box: 2–3 L/kg /min	NIL	Not Required	Yes	No	Headbox, facemask, tent	+++

[2] World Health Organization. Clinical management of severe acute respiratory infection when novel coronavirus (nCoV) infection is suspected 2020 [Available from: https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratoryinfection-when-novel-coronavirus-(ncov)-infection-is-suspected.

Oxygen Therapy in Neonate

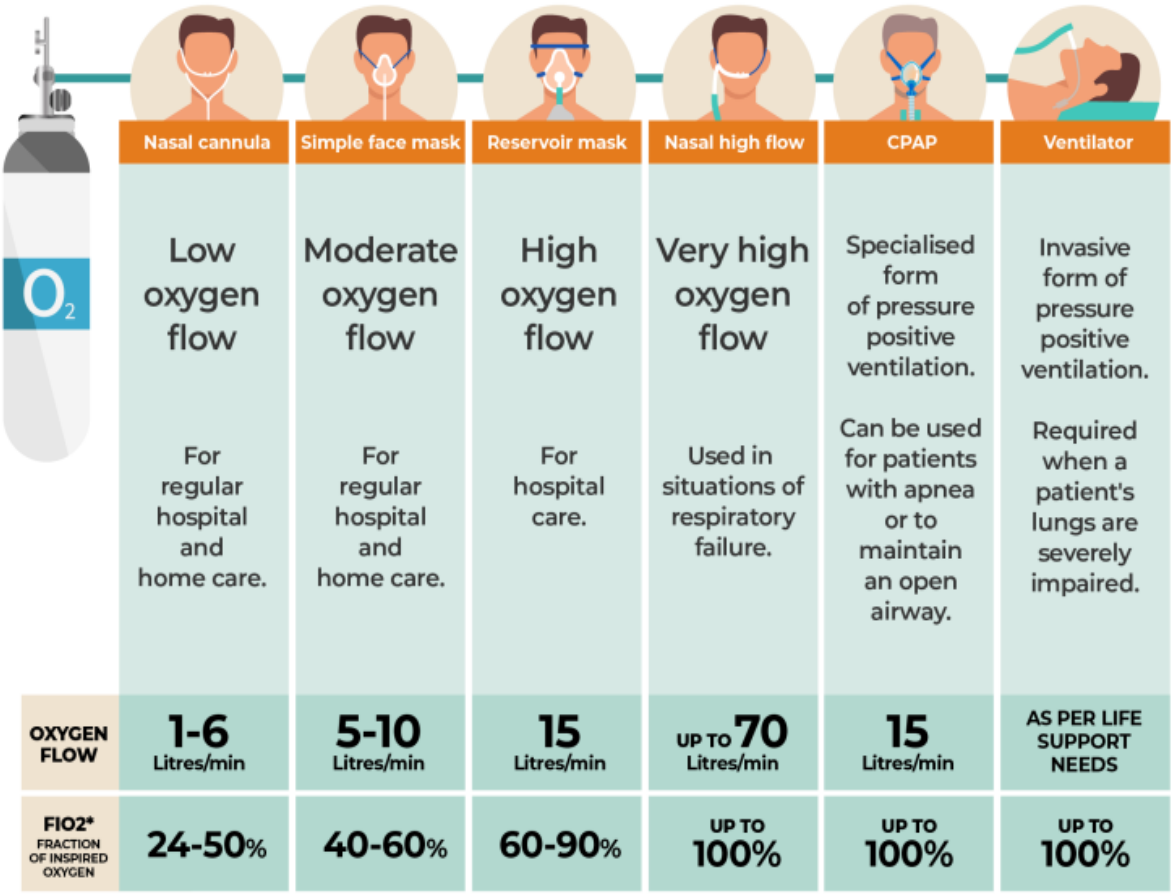
- Newborn infants in the first few hours of life, particularly those who are preterm, have lower normal oxygen saturation than older newborns. **The normal level for neonates in the first hours of life is ≥ 88%.**
- When pulse oximetry is not available, oxygen should be given to all neonates who have cyanosis or a respiratory rate > 70/min or who are too sick to feed.
- For neonates who are not breathing at birth, a self-inflating bag and face-mask can effectively provide positive pressure ventilation with room air, but supplemental oxygen may be required in some cases.
- CPAP is useful in the management of neonates with severe respiratory distress or apnoea and effective, safe methods for delivering bubble CPAP are available.
- Perinatal asphyxia: Respiratory depression at the time of birth: neonatal resuscitation. (bag-and-mask resuscitation with air containing 21% oxygen is effective.
- For preterm infants (< 32 weeks' gestation), bag-and-mask resuscitation with 30% oxygen should be used.
- In preterm infants born at < 32 weeks' gestation, SpO2 should be maintained between 88% and 95%. (not above 95%, to avoid eye damage)

Oxygen therapy in COVID-19 infected COPD patient[3]

- Oxygen therapy is used to maintain the SpO2 above 90%.
- Blood gases should be analyzed in case of acute respiratory failure in a COPD patient in order to assess hypercapnic acidosis. Hypercapnic acidosis (pH <7.35) should raise the question of adding non-invasive ventilation to oxygen therapy after discussion with the resuscitation team, without delaying any indication of invasive ventilation or high-flow nasal oxygen therapy in the intensive care unit.

[3] Proposals for the management of COPD patients in the context of the COVID-19 epidemic, G Deslée, M Zysman, L Boyer, N Roche, PR Burgel for the COPD group
Version dated 29/03/2020

Types of Oxygen therapy



Source: How is medical oxygen, vital for COVID-19 patients, produced? by By Mohammed Hussein and Alia Chughtai, 11 May 2021

Non-Rebreathing Mask

A non-rebreathing mask is a medical device that helps deliver oxygen in emergency situations. The mask covers both nose and mouth of patient. It consists of a face mask connected to a reservoir bag. The reservoir bag is connected to an oxygen tank. A reservoir bag is filled with oxygen and as the oxygen depletes due to the breathing, it gets filled up from the oxygen tank.

A non-rebreathing mask can prevent the patient from inhalation of own exhaled air and it allows the patient to breath only pure oxygen. A non-rebreathing mask typically delivers 70 to 100 percent oxygen. Make sure to pre-fill the reservoir bag prior to placing the mask on the patient.

Non-rebreathing mask use

- Oxygen flow must be at least 10L/min and the reservoir bag should fill up in between breaths.
- Check the mask fits well to the patient's face
    - o Tighten the elastic strap
    - o Shape the metal nose piece to their nasal bridge
    - o Explain to patient the importance of keeping it on
- Check that the mask is working and the bag is fully inflated. (Reservoir bag MUST be full of oxygen)
- After oxygen flow is coming, just close the opening on top of the reservoir for 1-2 sec, then bag will fill with oxygen and release after fully filled.
- In a small number of patients with severe respiratory distress, a non-rebreather mask will not deliver an adequate

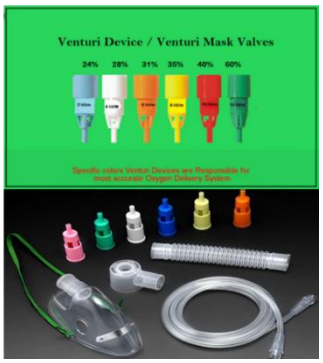
flow of oxygen. Suspect this is the case if the reservoir bag is emptying completely despite 15L being delivered. In this situation try adding a nasal cannula with 5L (picture below) and ensure that the mask is not too tight on the patient's face.

Nasal cannula + Non-rebreather mask (picture): If SpO2 remains <90%, try adding a nasal cannula (5L/min) to the non-rebreather mask (15L/min).

NOTE: All non-rebreather masks should have a hole in one side as an anti-suffocation protection (visible below the left nostril in the photo). In reality, air also enters around the edges of the mask. If you are able to provide 15L/min, it will hopefully be uncommon that a patient's respiratory requirements are not met. There is a suffocation risk when people start taping the valve and the edges of the mask (not advised!) or clamping the mask on really tightly.

Venturi Mask / Venturi devices

Liters Per Minute (LPM)	Approximate FiO2
1	24%
2	28%
3	32%
4	36%
5	40%
6	44%
7	48%
8	52%
9	56%
10	60%



- Venturi mask looks like face mask which has different function.
- The venturi mask is a medical device to deliver a known oxygen concentration to patients on controlled oxygen therapy.
- A venturi mask mixes oxygen with room air, creating high-flow enriched oxygen of a **desired concentration**. It provides an accurate and constant FiO_2.
- The venturi mask is ideal for a patient with COPD who has a low **to** moderate oxygen requirement but is at risk for hypercapnia with uncontrolled oxygen therapy.
- A Venturi mask can deliver accurate oxygen concentrations from 24% to 50% with flow rates from 4 to 10 L/min.
- This is the most accurate form of oxygen delivery.
- The addition of humidification is not necessary with this device.

Humidification

- Higher flow rates without effective humidification may cause drying of nasal mucosa, with associated bleeding and airway obstruction.
- When oxygen is given at a low flow rate (< 4 L/min) (standard flow) through nasal prongs, humidification is not necessary.
- Humidification is needed when oxygen is given via a nasopharyngeal catheter and for all patients with an endotracheal tube or a tracheostomy. (dry oxygen)
- In general, humidification is not required in tropical climates if oxygen is delivered from a concentrator rather than a cylinder, as concentrators provide oxygen at room temperature, whereas cylinders deliver cold oxygen.
- Bubble humidifiers reduce the dryness of the oxygen supplied from a cylinder by bubbling the gas through water at room temperature. The water level in the humidifier should be checked twice daily and topped up as necessary.

- Humidifier equipment must be washed and disinfected regularly to prevent bacterial colonization.

Complication of Oxygen

Complication of Oxygen in Neonates

- Eye damage (retinopathy): can result from exposure of very low-birth-weight infants to excessive oxygen. Infants at highest risk are those born at < 32 weeks' gestation or weighing < 1250 g; the smaller the infant, the greater the risk. SpO2 should be maintained above 88% but not higher than 95%, to prevent eye damage.
- All infants born at < 32 weeks' gestation or weighing < 1250 g and larger preterm infants who received oxygen should be screened for retinopathy of prematurity at 4–6 weeks of age.
- High Oxygen can develop depress breathing

Symptoms of oxygen toxicity

The majority of the time, symptoms of too much oxygen are minimal and can include:

- Headache
- Sleepiness or confusion after beginning supplemental oxygen
- Coughing
- Shortness of breath (as the airways and lungs become irritated)
- Trouble breathing
- Mild throat irritation.
- Chest pain.
- Muscle twitching in face / hands.
- Dizziness
- Blurred vision
- Nausea

Measurement of Oxygen Saturation with Pulse oximeter

- The pulse oximeter measures oxygen saturation of haemoglobin in the blood.
- **Pulse oximetry** is the **most accurate non-invasive method for detecting and monitoring hypoxaemia**. It is used to measure the percentage of oxygenated haemoglobin in arterial blood (SpO2).
- Sensor probe, which is attached to the patient's finger, toe or earlobe. The oximeter displays the SpO2 with an audible signal for each pulse beat, a pulse rate and, in most models, a graphical display of the blood flow past the probe.
- Pulse oximetry correctly identified hypoxaemia in 20–30% more children than with signs alone.
- Use of pulse oximetry can also reduce unnecessary oxygen administration.
- Pulse oximetry should therefore be performed on all patients admitted to an inpatient ward with respiratory illness, emergency or priority signs or any sign of hypoxaemia.

Features of pulse oximeter

- Alarm: A low-battery alarm is essential to alert health workers when the machine should be plugged into a power supply.
- Sensors: A wide range of probes is available in different sizes. It is important to choose a sensor probe that is appropriate to the size of the patient.
- Probe: sensor house

There are various types of pulse oximeter: Hard plastic finger clip for adults, Soft rubber sensor probe, Y-sensor probe etc.

Effect of pulse oximetry reading

- Blood pressure generally needs to be >80 SBP
- Disturbance of vascular flow from any cause
- Elevation with respect to the heart
- Compression by the probe
- Bright light interferes the probe
- Heart Rate extremes <30 or >200
    - Cold
    - Fear (Endogenous catecholamine)
    - Medications

Annex 1. Positioning of the patient

(1) Prone position

Awake prone position is highly recommended position for lung oxygenation if there is no contraindication. If the oxygen saturation is still <90%, ask the patient to lie on his/her tummy in 'prone' position for as long as he/she is comfortable (including sleeping in that position if possible). Make sure that patient is comfortable and uses pillows and blankets to pad the pressure areas. Keep the prone position as much as the patient can. Monitor oxygen saturations 15 minutes after each position change to ensure oxygen saturation has not decreased. Recheck the oxygen saturation regularly.

*** Avoid prone position in conditions like pregnancy, deep vein thrombosis, cardiac conditions, spinal or fracture issues.

(2) Semi-prone position (Right and Left lateral positon)

Another position that may help to improve lung oxygenation is the lateral, semi-prone position, with the patient lying on their side. Make sure that patient is comfortable and uses pillows and blankets to pad their pressure areas. Switch to lying on your side left and right for 30 minutes to 2 hours. Monitor oxygen saturations 15 minutes after each position change to ensure oxygen saturation has not decreased. Recheck the oxygen saturation regularly.

(3) Lean forward position while sitting

Lean forward position while sitting can also be used as alternative way to improve lung oxygenation. Make sure that patient is comfortable and uses pillows for comfort leaning and blankets to pad their pressure areas. Switch to another position for 30 minutes to 2 hours. Monitor oxygen saturations 15 minutes after each position change to ensure oxygen saturation has not decreased. Recheck the oxygen saturation regularly.

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