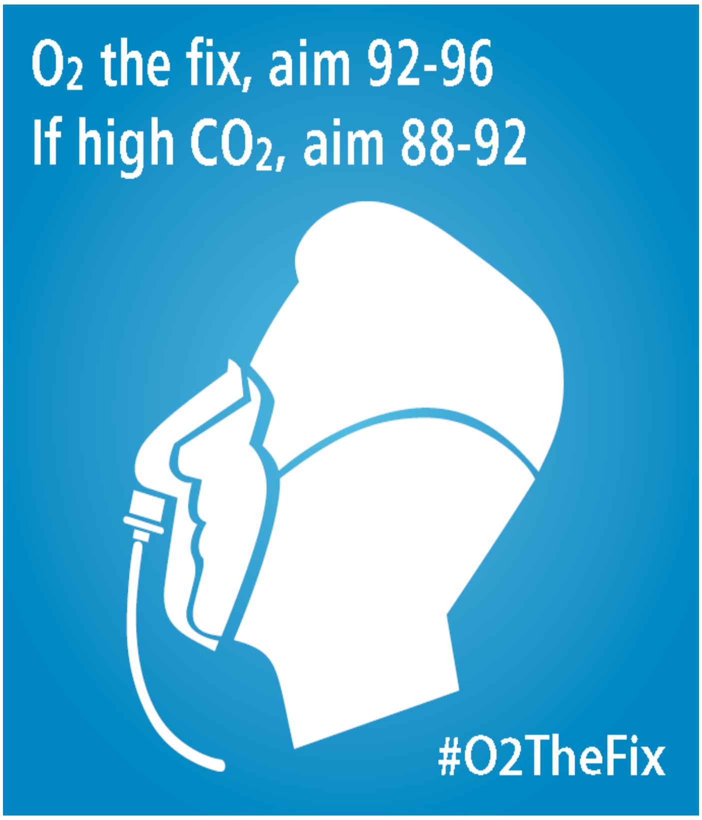
Waitemata
District Health Board
Best Care for Everyone

Oxygen Workbook



Produced by the Oxygen Steering Group, 2018

Contents

1. Pre-workbook Quiz

1. Oxygen is a drug? ☐ Y ☐ N ☐ maybe
2. Oxygen is a treatment for?
   - ☐ breathlessness
   - ☐ hypoxia
   - ☐ high carbon dioxide
3. Humidified High Flow Nasal O_2 Therapy should be documented as 'Oxygen percentage'? ☐ Y ☐ N ☐ maybe
4. Can oxygen be given in an emergency without prescription? ☐ Y ☐ N ☐ maybe
5. The maximum amount of oxygen to be given through nasal prongs is?
   - ☐ 2L
   - ☐ 3L
   - ☐ 5L
6. What type of oxygen delivery system would normally be used in a self-ventilating patient with $SaO_2 < 60\%$?
   - ☐ nasal cannula
   - ☐ Venturi mask
   - ☐ Reservoir mask
   - ☐Hudson mask
7. A patient presents to ED with a 60 pack year smoking history, obesity and swollen ankles, his target saturations should be?
   - ☐ 98-100%
   - ☐ 90-95%
   - ☐ 88-92%
   - ☐ 92-96%
8. What is the target oxygen saturations for a 20 year old asthmatic patient who presents with an acute exacerbation of asthma?
   - ☐ 94-98%
   - ☐ 88-92%
   - ☐ 90-99%
   - ☐ 92-96%
9. 50 year old man with no previous medical history having ankle surgery is on a PCA, what are his target saturations?
   - ☐ 88-92%
   - ☐ 95-100%
   - ☐ 92-96%
10. A Venturi mask can be used as alternative to HHFNP ? ☐ Y ☐ N
11. Which of the following devices can give controlled oxygen (ie with a fixed FiO_2)?
    - ☐ Venturi mask
    - ☐ Hudson mask
    - ☐ Humidified High Flow Nasal Prongs (Airvo)
    - ☐ nasal prongs

2. Understanding breathing

Anatomy of the Lung

The respiratory system is made up of organs related to the exchange and interchange of gases, they consist of the following:

Nose

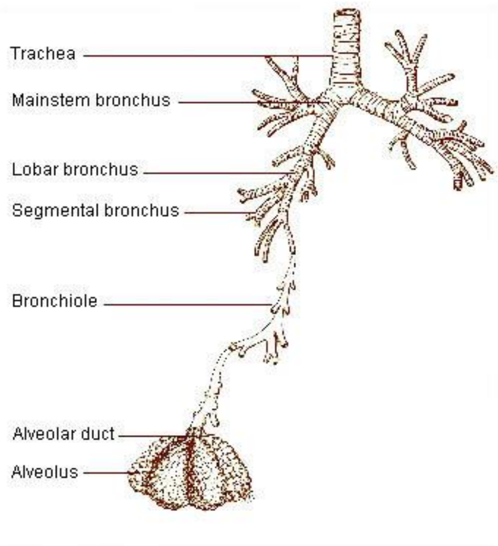
The most important functions of the nose are to filter the atmospheric air before passing it further into the respiratory system, and to provide the sense of smell.

Pharynx

Is a common passageway for air and food; the pharynx opens into two pathways, one that leads to the oesophagus, the other trachea or air passage. The pharynx continually removes dust and warms inhaled air.

Larynx

Protects the airway from food and liquid; also protects the vocal chords.



Trachea

Continuously cleans air and is lined with goblet cells and ciliated epithelial cells which produce mucus and carry dirt and particles back up to the pharynx. The mucus moistens the air when it passes through the respiratory tract.

Lungs

Contain alveoli and bronchi. They are responsible for transporting oxygen from the atmosphere into blood and releasing carbon dioxide from blood back to the atmosphere.

Bronchi

One of the primary functions of bronchi is to allow air to pass through it. As the trachea splits into two parts, the inhaled air then enters the bronchi. From here, it passes through further divisions of the bronchi; these divisions are known as bronchioles. The bronchioles then divide to form alveolar ducts which eventually end into alveolar air sacs or alveoli. Thus, the bronchi basically act as a passage for air to pass through.

Alveoli

The functional unit of the lungs are tiny air sacs that arise from bronchioles called alveoli. These terminal air sacs are the area where the exchange of gases takes place within the lungs. This air exchange consists of absorption of oxygen and removal of carbon dioxide.

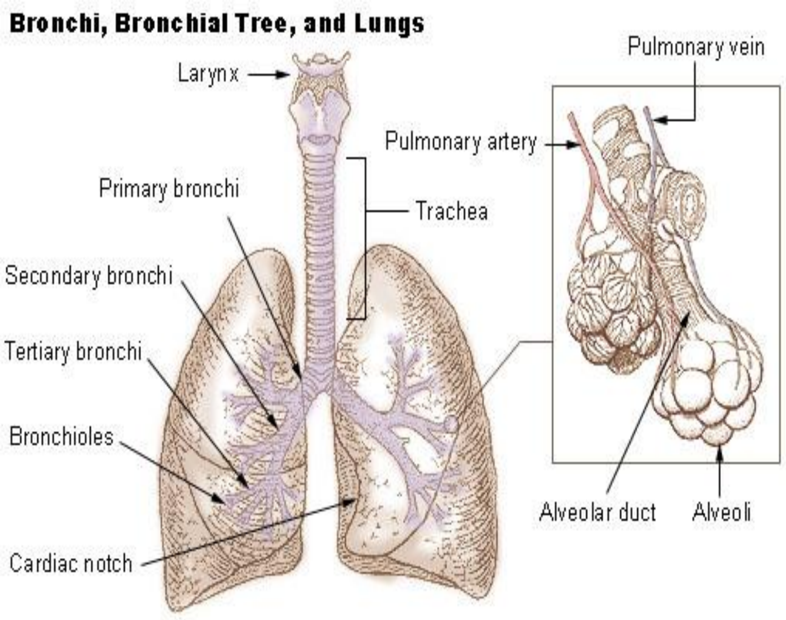
Source: **http://training.seer.cancer.gov/lung/anatomy/respiratory.html**

Respiratory Tract

The respiratory tract is divided into two main parts: the upper respiratory tract consisting of the nose, nasal cavity and the pharynx; and the lower respiratory tract consisting of the larynx, trachea, bronchi and the lungs.

The trachea, which begins at the edge of the larynx, divides into two bronchi and continues into the lungs. The trachea allows air to pass from the larynx to the bronchi and then to the lungs.

The bronchi divide into smaller bronchioles, which branch in the lungs forming passageways for air. The terminal parts of the bronchi are the alveoli. The alveoli are the functional units of the lungs and they form the site of gaseous exchange.



Source: **http://www.proprofs.com/flashcards/upload/a2365854.bmp**

Function of the Lungs

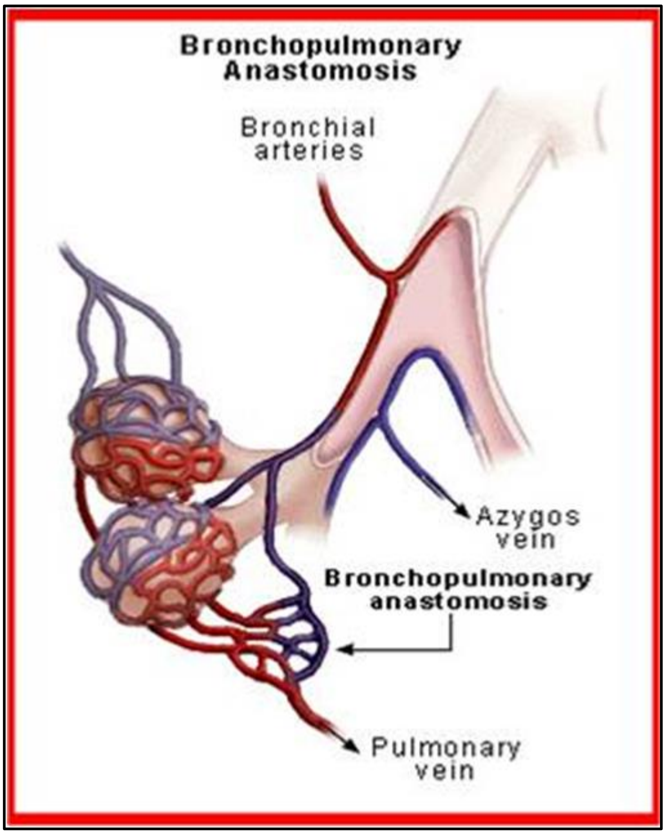
Lungs take in oxygen, which cells need to live and carry out normal functions. The lungs also get rid of carbon dioxide (travels in the blood as bicarbonate), a waste product of the body's cells.

Lungs are enveloped in a membrane called the pleura. Visceral pleura lines the lungs and parietal pleura lines the thoracic cavity. Between the two is a potential space which contains a lubricating fluid, this allows pleural layers to slide against each other easily during respiration.

The pleura keeps the lung next to the chest wall, to allow for optimum inflation of the alveoli during respiration. It directly transmits pressures from the chest wall to the lung. Therefore, movements of the chest wall during breathing are coupled closely with movement of the lungs.

When you inhale

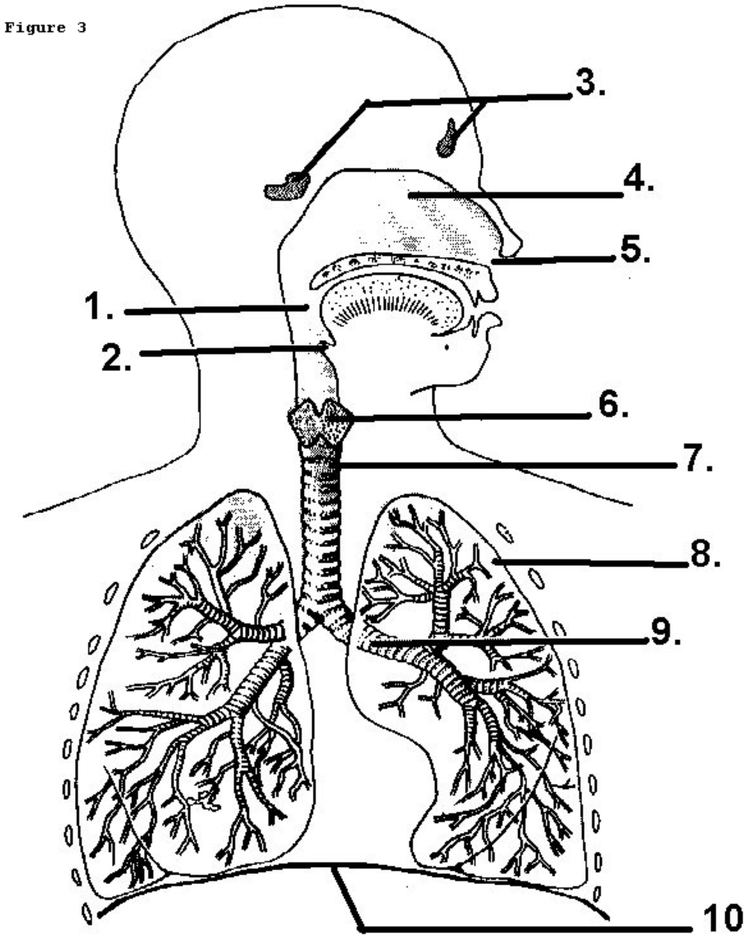
- Air enters the body through the nose and/or mouth
- Travels down the throat through the larynx and trachea
- Air enters into the lungs through tubes called main stem bronchus
- One main stem bronchus leads to L) lung one to the R) lung.
- In the lungs, the main-stem bronchus divide into smaller bronchi
- Then into bronchioles, bronchioles end in alveoli.
- It is here where the exchange of oxygen and carbon dioxide between air and the blood in the lungs occurs.
- Blood enters the lungs via the pulmonary arteries.
- It then proceeds through arterioles and into the alveolar capillaries.
- Oxygen and carbon dioxide are exchanged between blood and the air.
- This blood then flows out of the alveolar capillaries, through venuoles, and back to the heart via the pulmonary veins.



Exercise 1

Review the Respiratory System diagram
(You can find images on Google for Respiratory tract)

Identify each of the numbered areas; enter your answers in the table below.



ANSWERS			
1		6	
2		7	
3		8	
4		9	
5		10	

3. Mechanics of Breathing

What is a Respiration?

- Respiration is the transport of oxygen from ambient air to the tissue cells and the transport of carbon dioxide in the opposite direction.

It consists of:

- Inspiration (inhaling)
- Expiration (exhaling)

Inspiration

Inspiration is an active process requiring 75% diaphragmatic muscular effort.

During inspiration

- The diaphragm moves downwards increasing the volume of the thoracic cavity.
- Intercostal muscles pull the ribs up expanding the rib cage and further increasing this volume.
- Through this there is a fall in intra-pleural pressure and a fall in alveolar pressure (below atmospheric pressure). **This is negative pressure**.
- Air always flows from a region of high pressure to a region of lower pressure. In inspiration the pressure gradient is from the mouth to the alveoli (ie gas follows the pressure gradient).
- Air is sucked in through the respiratory tract and into the alveoli.

This is called negative pressure breathing.

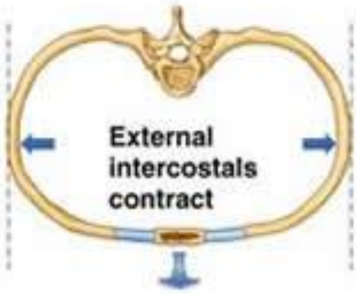
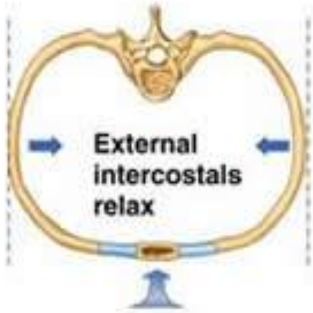
Expiration

In expiration the diaphragm and intercostal muscles relax. This is usually a passive process.

This relaxation of the muscles and diaphragm causes:

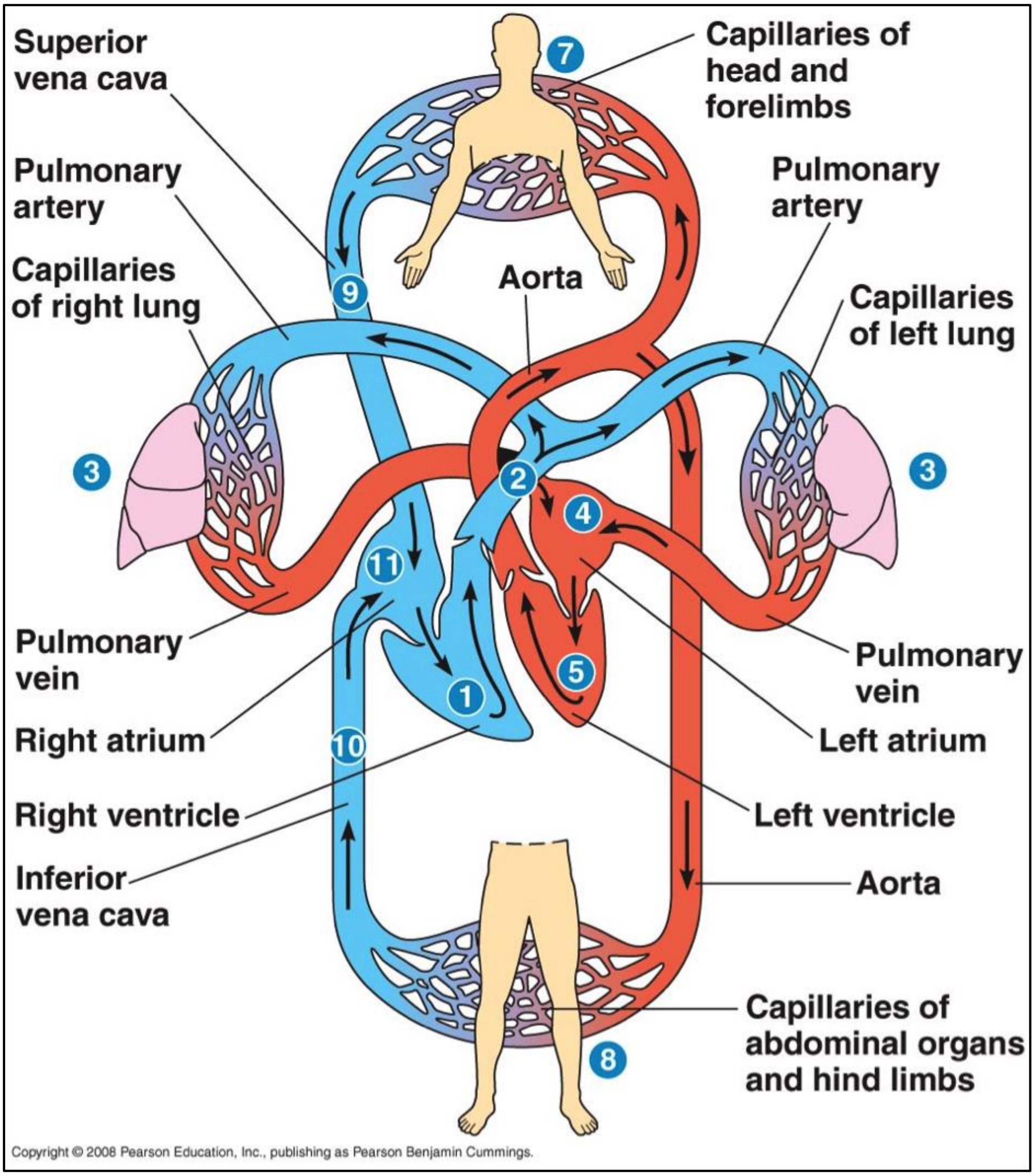
- The intra-pleural pressure to become less negative.
- The alveolar pressure rises (above atmospheric pressure).
- The gas flows from high pressure gradient to a low pressure gradient.
- The gas is forced out into the air.

Inspiration and Expiration

	Sequence of events	Changes in anterior-posterior and superior-inferior dimensions	Changes in lateral dimensions
Inspiration	① Inspiratory muscles contract (diaphragm descends; rib cage rises) ↓ ② Thoracic cavity volume increases ↓ ③ Lungs stretched; intrapulmonary volume increases ↓ ④ Intrapulmonary pressure drops (to –1 mm Hg) ↓ ⑤ Air (gases) flows into lungs down its pressure gradient until intrapulmonary pressure is 0 (equal to atmospheric pressure)		
Expiration	① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages) ↓ ② Thoracic cavity volume decreases ↓ ③ Elastic lungs recoil passively; intrapulmonary volume decreases ↓ ④ Intrapulmonary pressure rises (to +1 mm Hg) ↓ ⑤ Air (gases) flows out of lungs down its pressure gradient until intrapulmonary pressure is 0		

Source: http://classes.midlandstech.edu/carterp/Courses/bio211/chap22/chap22.htm

Gaseous exchange



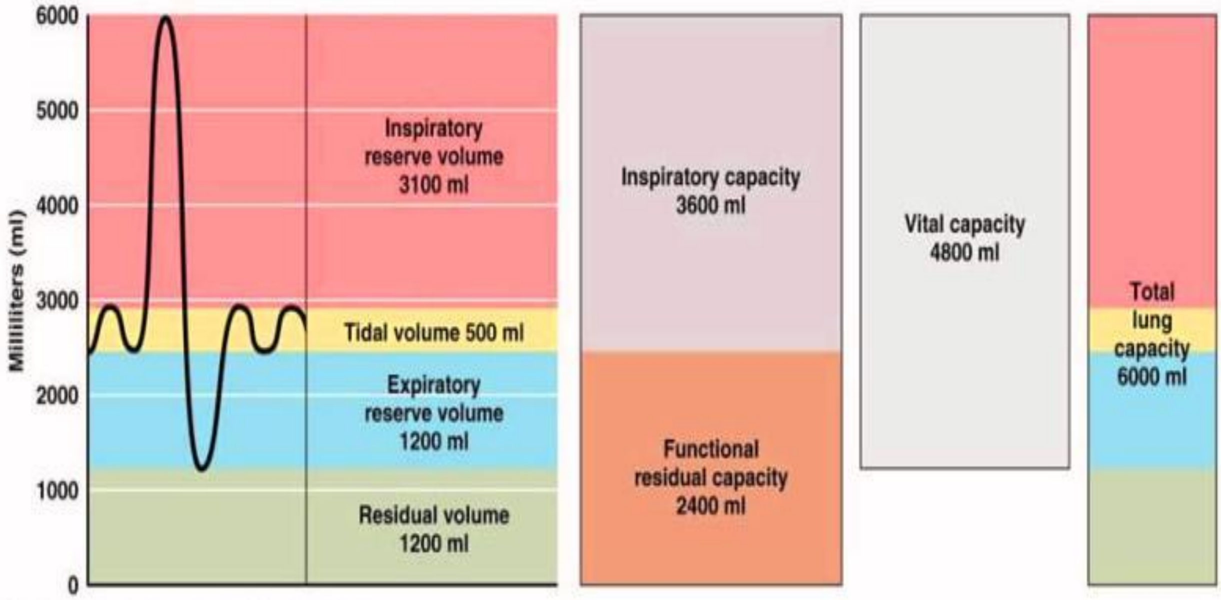
SOURCE:
https://www.google.co.nz/search?q=heart+and+lungs+circulation/+gas+exchange&rls=com.microsoft:en-NZ:IE-Address&dcr=0&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiytrS_g5LYAhUJXLwKHdWfBKYQ_AUICigB&biw=1280&bih=879#imgrc=W9JCUrvaLJyPxM:&spf=1513547428797

Composition of Gases in Air

Gas	Proportion by Volume
nitrogen, N	78.03
oxygen, O	20.99
carbon dioxide, CO	0.03
hydrogen, H	0.01
argon, Ar	0.94

Source: http://www.taftan.com/thermodynamics/AIR.HTM

Lung Volumes and Capacities



(a) Spirographic record for a male

	Measurement	Adult male average value	Adult female average value	Description
Respiratory volumes	Tidal volume (TV)	500 ml	500 ml	Amount of air inhaled or exhaled with each breath under resting conditions
Respiratory volumes	Inspiratory reserve volume (IRV)	3100 ml	1900 ml	Amount of air that can be forcefully inhaled after a normal tidal volume inhalation
Respiratory volumes	Expiratory reserve volume (ERV)	1200 ml	700 ml	Amount of air that can be forcefully exhaled after a normal tidal volume exhalation
Respiratory volumes	Residual volume (RV)	1200 ml	1100 ml	Amount of air remaining in the lungs after a forced exhalation
Respiratory capacities	Total lung capacity (TLC)	6000 ml	4200 ml	Maximum amount of air contained in lungs after a maximum inspiratory effort: TLC = TV + IRV + ERV + RV
Respiratory capacities	Vital capacity (VC)	4800 ml	3100 ml	Maximum amount of air that can be expired after a maximum inspiratory effort: VC = TV + IRV + ERV (should be 80% TLC)
Respiratory capacities	Inspiratory capacity (IC)	3600 ml	2400 ml	Maximum amount of air that can be inspired after a normal expiration: IC = TV + IRV
Respiratory capacities	Functional residual capacity (FRC)	2400 ml	1800 ml	Volume of air remaining in the lungs after a normal tidal volume expiration: FRC = ERV + RV

(b) Summary of respiratory volumes and capacities for males and females

Source: http://classes.midlandstech.edu/carterp/Courses/bio211/chap22/chap22.htm
Go to site http://en.wikipedia.org/wiki/Lung volumes

Vital Capacity

'Vital capacity' is maximal inspiration followed by maximal expiration and this is the volume measured in simple spirometry.

Vital Capacity is affected by factors such as:

- Gender (eg 20-25% less in adult females)
- Age (maximum in young adults)
- Body size.

Vital Capacity is also affected by illness and disease such as:

- Paralysis eg:
  - Muscular dystrophy/motor neuron disease
  - Polio
  - Spinal cord injury.

- Lung inflation problems/restrictive disorders eg:
  - Pulmonary fibrosis/silicosis
  - Scoliosis/kyphosis.

- Obstructive disorders eg:
  - Asthma
  - COPD
  - Collapse of bronchi/emphysema
  - Tumour.

Work of Breathing

'Work of breathing' (WOB) is how much work that the body has to do to breath.

- WOB accounts for 5% of total body oxygen consumption in a normal resting state but can increase dramatically during acute illness.
- Most of this is used to overcome the lung and chest wall stiffness during inspiration (called 'compliance')
- Work to overcome airway resistance is usually very small, except during exercise or in unusual situations like asthmatics.
- Patients with respiratory diseases have increased respiratory workloads, which may be due to:
  - High respiratory rates
  - Stiff lungs
  - High airway resistances.

When a patient becomes so exhausted that they can no longer keep up workload respiratory failure results.

Exercise 2 - Respiratory Anatomy & Physiology Quiz

Match by **drawing** a line between the pulmonary measurement and the correct definition.

Tidal Volume	Total volume of air in the lung
Inspiratory Capacity	Volume of air inspired or expired in a normal breath
Total Lung Capacity	Expiratory reserve volume + residual volume
Vital Capacity	The maximal amount of air that can be inspired after a tidal expiration
Residual Volume	Maximal volume of air expired forcefully after a maximal inspiration inspiration followed by maximal expiration
Functional Residual Capacity	Air remaining in the lungs after forced expiration
Expiratory Reserve Volume	Volume of air that can be forcefully inspired after a normal tidal exhalation

Exercise 3 - Respiratory Anatomy & Physiology Quiz

Write your answers using the word bank below:

1. ______ pleura lines the thoracic cavity.

2. ______ volume is the volume that remains after the most forceful exhalation (1200 ml).

3. A disease of the lungs in which the walls of alveoli lose elasticity and remain filled causing increased chest size (barrel-chested) is called ______.

4. Breathing in; or inhaling is called ______.

5. Breathing out; exhaling is called ______.

6. Difficult expiration caused by contraction in the muscles surrounding the bronchioles, often caused by allergic reactions, is called ______.

7. Inflammation of the bronchi is called ______.

8. Inflammation of the pleura is called ______.

9. Mucus in the respiratory system is pushed upward by ______.

10. Normal breathing volume (normally about 500 ml. per breath) is called ______.

11. Oxygen deficiency is called ______.

12. Secondary bronchi branch into smaller tubes called ______.

13. Sputum is another term for ______.

14. The ______ pleura covers the lungs.

15. The ______ is the narrow portion at the top of the lungs.

16. The ______ is the volume that can be inhaled after normal inspiration

Word Bank - Apex, asthma, bronchioles, bronchitis, cilia, emphysema, expiration, hypoxia, inspiration, inspiratory reserve volume, mucous, pleurisy, residual, tidal volume, visceral. parietal.

Exercise 4 - Respiratory Anatomy & Physiology Quiz

Write your answers using the word bank below

1. The exchange of oxygen from blood to cells is called ______ respiration.

2. The exchange of oxygen from air to blood is called ______ respiration.

3. The machine used to measure breathing volume is called a. ______.

4. The maximum breathing volume is called ______ capacity.

5. The membrane that lines the tubes in the respiratory system is called the respiratory. ______.

6. The millions of tiny sacs that exchange oxygen and carbon dioxide are called ______.

7. The substance that coats the inside of the alveoli is called ______.

8. The two tubes that branch off the trachea are called the ______.

9. The volume that can be exhaled after expiring tidal volume (1000 – 1200 ml) is called ______ volume

Word Bank - Alveoli, expiratory reserve, external, internal, mucosa, primary bronchi, spirometer, surfactant, vital.

4. Indications for Oxygen Therapy

The rationale for using oxygen therapy in the acute setting is prevention of cellular hypoxia caused by hypoxemia (low $pa0_2$) and thus, prevention of potentially irreversible damage to vital organs.

Oxygen therapy does not relieve breathlessness in the absence of hypoxaemia. For example, there is no clinical benefit with short burst oxygen therapy in COPD patients with breathlessness.

Hypoxemia

Hypoxemia is defined by the British Thoracic Society (2017) as “low partial pressure of oxygen ($pa0_2$) in the blood”.

The normal $pa0_2$ is between 10.6 -13.3 kPa.

Arterial Blood Gas monitoring is the gold standard for measurement as it provides critical information about ventilation, pulmonary gas exchange and acid/base status.

Oxygen Saturations

For an initial, safe, simple and continuous measurement of Hypoxaemia, we can use Oxyhaemaglobin Saturation ($Sp0_2$). This can be measured non-invasively and is an approximation of arterial oxygenation. This does not give us detailed information about ventilation of a patient. It is further limited by having less accuracy in certain situations such as poor peripheral perfusion, nail polish, movement artefact, cold temperatures, digital clubbing, skin colour.

The Thoracic Society of Australia and New Zealand recommend an oxygen saturation range of 92-96% for most patient, and 88-92% for patients at risk of hypercapnic respiratory failure (Type 2 Respiratory Failure).

Fraction of inspired oxygen (FiO_2)

Fraction of Inspired Oxygen (FiO_2) represents the percentage of oxygen a person inhales with each breath. Room air contains a FiO_2 of 21%; therefore the FiO_2 of a patient without supplemental oxygen is 21%. As we increase the amount of oxygen a patient gets, we increase the FiO_2. Devices used for the delivery of oxygen can either provide a variable FiO_2, or a fixed FiO_2.

Respiratory Failure

The respiratory system basically consists of a gas exchanging organ (lungs) and a ventilatory pump (respiratory muscles and thorax). Either or both of these can fail and cause respiratory failure.

Respiratory failure is defined as a failure to maintain adequate gas exchange and is characterised by abnormalities of arterial blood gas tensions.

Type 1 failure is defined by a $Pa0_2$ of <8kPa with a normal or low $PaC0_2$<6.0kPa eg pneumonia/ pulmonary oedema.

Type 2 failure is defined by a $Pa0_2$ of <8kPa and a $PaC0_2$ of >6kPa, eg COPD. Respiratory failure can be acute, acute-on-chronic or chronic.

Type I - Hypoxaemic Respiratory Failure

It can be defined as hypoxaemia without hypercapnia; the carbon dioxide (CO_2) level may be normal or low.

To put it another way, this time with values; type I respiratory failure is a PaO_2 < 8 kPa (60 mmHg) with a normal to low $PaCO_2$ (<6.0 kPa (45 mmHg).

Therefore this type of respiratory failure is seen as an oxygenation failure but overall ventilation has been maintained.

This is the most common form of respiratory failure.

Causes

- Low inspired FiO_2
  - Low atmospheric gas (seen in ventilated patients)
  - High altitude
- Cardiac shunt
  - Left to right cardiac shunt (as seen in atrial or ventricular septum defect)
- Diffusion limitation
  - Such as seen in interstitial lung diseases
- V/Q mismatch
  - Perfused but not ventilated (intra pulmonary shunt) eg consolidation (pneumonia) atelectasis
  - Perfused but partially ventilated eg COPD, severe asthma, pneumonia, pulmonary oedema
  - Ventilated and partially perfused eg hypoxaemia, shock, pulmonary vasoconstriction
  - Ventilated but unperfused eg pulmonary embolism.

Type II - Hypercapnic Respiratory Failure

It can be defined as hypercapnia with or without hypoxaemia (more likely with hypoxaemia unless supplemental O_2 has been given).

To put it another way, this time with values; Type II respiratory failure is PaO_2 < 8kPa (60 mmHg) and $PaCO_2$ > 6.0 kPa (50 mmHg).

Type II respiratory failure may be acute or chronic in nature.

Where type II is chronic HCO_3 (bicarbonate) will also be high as the kidneys have had time to retain HCO_3. If the pH is normal this is known as compensated Type II respiratory failure and where the pH remains low (acidosis) this is partially compensated Type II respiratory failure and known as acute-on- chronic respiratory failure.

Normal ARTERIAL BLOOD GAS Values

Parameter	Normal Arterial Values
pH	7.36 – 7.44
PaCO2	4.6 – 6.0 kPa (35 – 45 mmHg)
HCO3 (Bi-carbonate)	20 – 28 mmol/L
PaO2	10.6 -13.3 kPa (79.5 – 99.8 mmHg)
Base excess	-3 to +3
Oxygen Saturation	>95%

Causes

- Respiratory centre problems:
  - CVA
  - Tumour
  - Central hypoventilation
  - Over sedation with drugs.

- Muscle weakness:
  - Guillian-Barré syndrome
  - Motor neuron disease
  - Myasthenia gravis
  - Muscular dystrophy
  - Polio
  - Spinal injuries
  - Muscular fatigue as seen in obesity hypoventilation.

- Chest wall / pleural diseases:
  - Pneumothorax
  - Kyphoscoliosis
  - Massive pleural effusion
  - Diaphragmatic paralysis.

- Airway disorder:
  - Asthma
  - Pneumonia
  - COPD
  - Bronchiectasis/cystic fibrosis.

Exercise 5

Hypercapnic respiratory failure can be defined as $PaO_2 < 8$ kPa and $PaCO_2 > 6.0$ kPa.

- ☐ True
- ☐ False

Treatments for respiratory failure include:

- ☐ Bronchodilators
- ☐ Antibiotics
- ☐ oxygen
- ☐ All of the above

Type II respiratory failure is the most common form of failure.

- ☐ True
- ☐ False

Name four causes for Type I respiratory failure.

- ……
- ……
- ……
- ……

Which are treatments for respiratory failure?

- ☐ Treat underlying cause
- ☐ Control any airway obstruction
- ☐ Control secretions
- ☐ Give controlled oxygen as required
- ☐ Consider NIV for carbon dioxide control
- ☐ All of the above

Name four causes for Type II respiratory failure.

- ………
- ………
- ………
- ………

Name four signs and symptoms for respiratory failure.

1. ………
   ………
2. ………
   ………
3. ………
   ………
4. ………
   ………

5. Risks

Fire Hazard – Oxygen is an accelerant of fire.

- Administration of prophylactic oxygen to a patient who is not hypoxaemic may cause a delay in recognising clinical deterioration.
- Not recommended in the absence of hypoxaemia for treatment of ACS and CVA.
- High concentration oxygen in myocardial infarction is associated with greater infarct size.
- Oxygen toxicity.
- For patients with type II respiratory failure the administration of high concentration of oxygen (above 2L/minute) may result in hypercapnia, respiratory acidosis, reduced GCS and poorer outcomes.

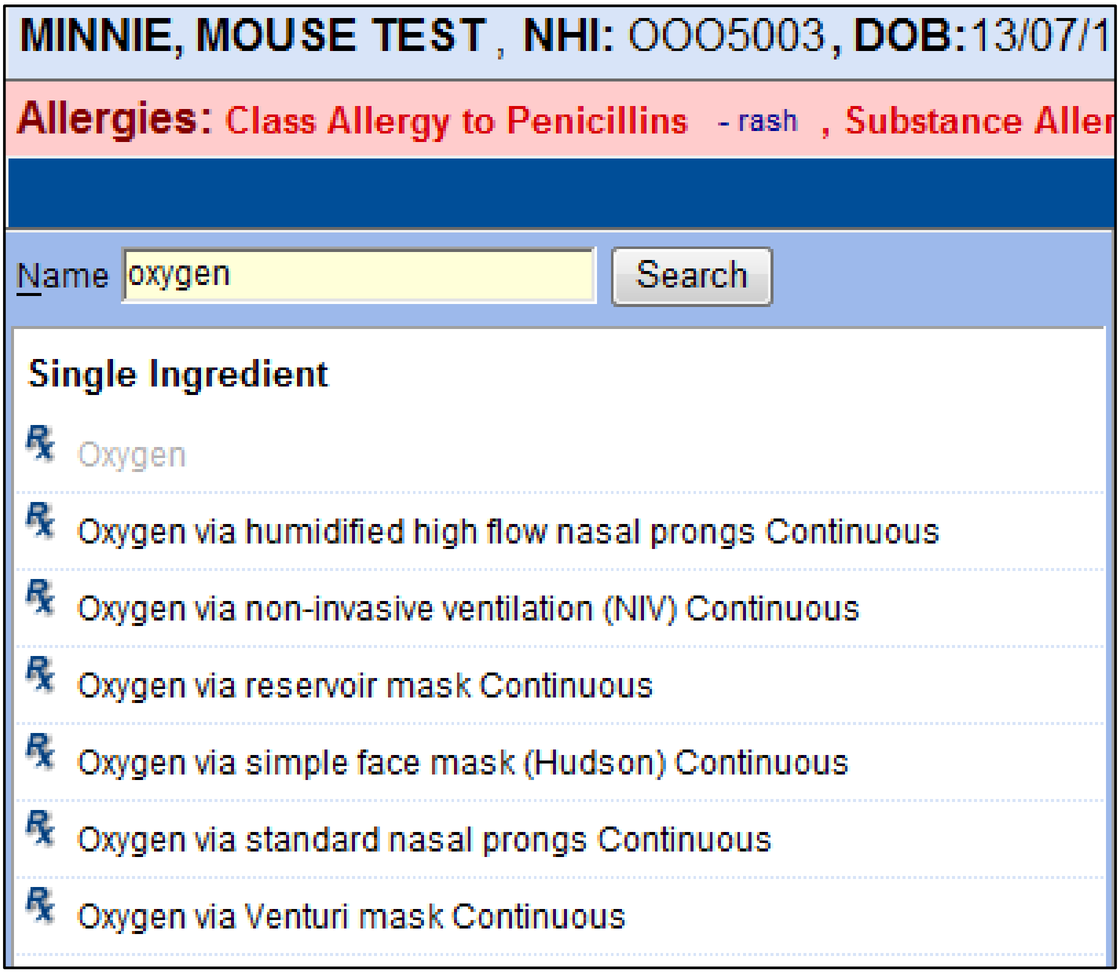
6. Prescribing oxygen therapy

As oxygen is considered a drug at concentrations higher than ambient air**, it must be prescribed by a doctor** or independent prescriber, except in emergency situations.

- Oxygen is used to alleviate hypoxaemia (low arterial oxygen content).
- It is not a treatment for breathlessness and should therefore not be prescribed or administered if the oxygen saturation is > 92% on air.
- Oxygen must be prescribed on MedChart according to a specific oxygen delivery device and target saturation range.

In an emergency situation with severe hypoxia oxygen administration without a prescription is appropriate while waiting for medical assessment of the patient. In these situations, use high concentration oxygen (15L/min via non-rebreathe mask).

Via MedChart



Medication	Details
Oxygen via standard nasal prongs Continuous Inhalation	DOSE: **0.25 to 4 L/min** Inhalation **PRN** minimum dosage interval **1** minute Target SpO2 = 88-92%
Oxygen via standard nasal prongs Continuous Inhalation	DOSE: **1 to 4 L/min** Inhalation **PRN** minimum dosage interval **1** minute Target SpO2 = 92-96%

7. Administration of Oxygen Therapy

Oxygen Administration flowchart

Patient with suspected Hypoxaemia:

Obtain oximetry

Consider ABG in:

- Critically ill patients with cardiorespiratory or metabolic dysfunction
- In patients with an SpO_2 of <92% in whom Hypoxia may be present
- Deteriorating SpO_2 requiring increased FiO_2 outside treatment parameters
- Patients at risk of Hypercapnia
- Breathless patient in whom an accurate SpO_2 cannot obtained

Is the patient at risk of hypercapnic respiratory failure?

Yes

SpO_2 <88%

- Start O_2 therapy
  Venturi 24% set at 2L/min **OR**
  Venturi 28% set at 4L/min
  OR
  Humidified High Flow Nasal Prongs
- Titrate O_2 to achieve SpO_2 88-92% target
- Give Bronchodilator (if prescribed) by air driven nebuliser or MDI with spacer
- Obtain ABG

pH <7.35 and pCO_2 >6.0kpa

- Consult COPD pathway –

COPD_pathway.pdf

and refer to ICU/HDU

- Controlled O_2 as needed to maintain SpO_2 88-92% target saturations range.

SpO_2 $\geq$ 88%

- No O_2 therapy
- Continue monitoring
- Consider ABG

pH $\geq$7.35

Controlled O_2 as needed to maintain SpO_2 88-92% target

No

SpO_2 <85%

- Start O_2 4L/min nasal cannula, 5-10L/min via mask, 15L/min via a reservoir mask
- Titrate O_2 to achieve SpO_2 92-96% target range
- Obtain ABG

$PaCO_2$ >6kpa or paO_2 $\leq$8kpa

- Senior medical review
- Controlled O_2 as needed to maintain target saturations range 92-96%.

SpO_2 85-91%

- Start 2-4L/min via standard nasal prongs and/or
- Titrate O_2 to achieve SpO_2 92-96% target range
- Consider ABG

$PaCO_2$ <6kpa and PaO_2 $\geq$8kpa

- Monitor SpO_2
- Titrate O_2 to maintain SpO_2 92-96%
- Consider medical review

Devices

Oxygen therapy can be administered in many different ways, and should be determined by clinical indications and assessment of the patient's needs. There are many devices available in the various inpatient settings which can be utilised based on clinical indications and the intended use of the device. These must be charted as the flow rate and device, with an appropriate target saturation range.

Oxygen delivery devices can be divided into those which provide a fixed percentage of oxygen (FiO_2) and those which provide a variable amount of oxygen (FiO_2) depending on the patient's minute volume.

Any patient who is at risk of carbon dioxide retention, or who is a known cO_2 retainer, must use a controlled oxygen delivery device to ensure we do not over oxygenate the patient causing type II respiratory failure.

Fixed (controlled) oxygen delivery devices

Venturi mask

- Aim to deliver constant oxygen concentration within and between breaths.
- This is a good mask for patients with raised $C0_2$ (patients with a target of 88-92%)
- With TACHYPNOEA (RR >30/min) the oxygen supply should be increased by 50%. Increasing flow does not increase oxygen concentration.
  - Delivers 24-60% oxygen
  - Different colours deliver different rates
  - Flow rate: Varies with colour. The correct flow rate to use with each colour is shown on mask, along with the percentage of oxygen delivered.

    Types:

    Blue = 3L/min = 24% O_2
    Yellow = 6L/min = 28% O_2
    White = 8L/min = 31% O2
    Green = 12L/min = 35% O_2
    Pink = 15L/min = 40% O_2
    Orange = 15L/min = 60% O_2

Venturi masks are used in COPD, where it is important not to over-oxygenate the patient.

Humidified High Flow Nasal Prongs

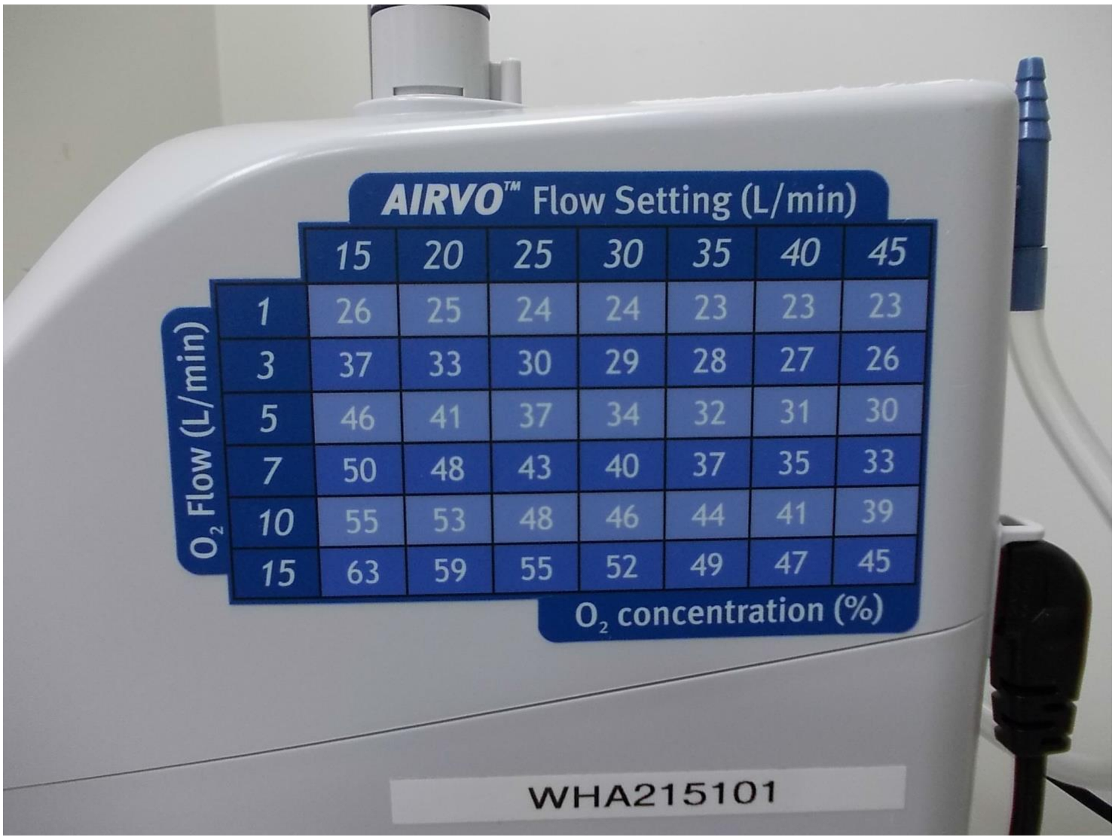
Humidified High Flow Nasal Prongs differ significantly from standard oxygen delivery devices.

It delivers a fast humidified gas flow (blended air and oxygen) via wide bore nasal cannulae, providing low-level (mean) positive airway pressure and a fixed concentration (%) of oxygen. Air flow is usually set at 35L/min. Mean positive airway pressure increases with higher air flows. Oxygen concentrations of **21% - 52%** can be delivered.

- **Fixed delivery of oxygen concentration** – HHFNP meets inspiratory demand, reducing room air entrainment
- **Reduced work of breathing** due to delivery of high flow inspired gas
- Optimal **humidification** to aid expectoration
- Ability to eat, drink and communicate
- Allows the patient to self-administer inhaler therapy with a spacer.

Waitemata DHB Policy [P] Oxygen –Humidified High Flow Nasal Prongs - Adult

Oxygen
Warnings
37
°C
35
L/min
21
%O2



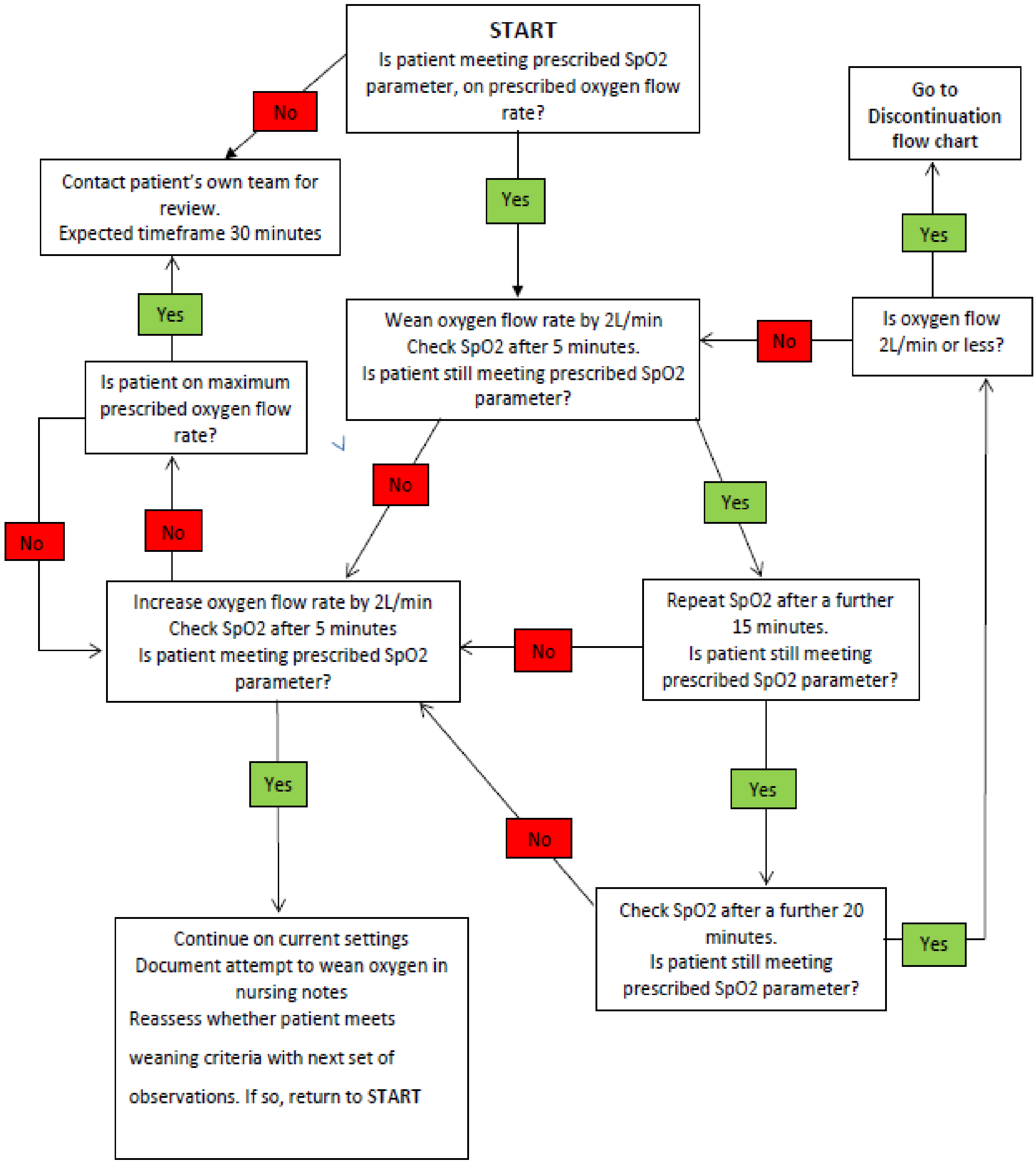
AIRVO™ Flow Setting (L/min)
15 20 25 30 35 40 45
O2 Flow (L/min)
1 26 25 24 24 23 23 23
3 37 33 30 29 28 27 26
5 46 41 37 34 32 31 30
7 50 48 43 40 37 35 33
10 55 53 48 46 44 41 39
15 63 59 55 52 49 47 45
O2 concentration (%)
WHA215101

Weaning Humidified High Flow Nasal Prongs

Note:
Oxygen should be administered at the lowest flow that achieves the prescribed SpO_2 parameter. Nurse-led weaning of oxygen is encouraged.

Oxygen flow may be weaned when patient meets following criteria:
1. Respiratory rate < 24 per minute
2. No signs of increased work of breathing (eg accessory muscle use)
3. Meeting prescribed target SpO_2 percentage.

If criteria are met, commence weaning as per flow chart



Variable (uncontrolled) oxygen delivery devices

Nasal cannulae

Nasal prongs are **variable** delivery devices, as the exact amount of oxygen (FiO_2) the patient is receiving changes due to the patient's minute volume.

Nasal prongs can be used for a flow rate up to 4L/min, and deliver FiO_2 at approximately:

1 litre/min	24%
2 litres/min	28%
3 litres/min	32%

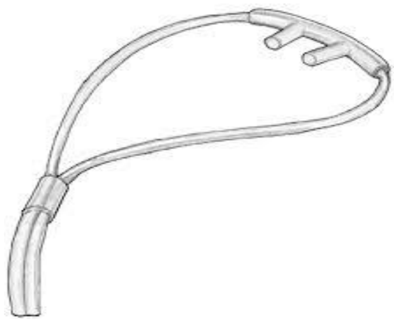
Note: These are approximations only and cannot be relied upon.

Nasal prongs allow the patient to eat and drink while in use. They can also feel less intrusive than a mask. Nasal prongs work best when the curve of the prongs is aimed towards the back of the nasal cavity. They are best suited to otherwise stable patients.

Nasal prongs are not recommended for patients with nose bleeds, and can dry out nasal mucosa.

- Deliver 24-30% oxygen
- Flow rate 1-4L/min (4L will dry the nose, 2L is more comfortable)

Used in non-acute situations or if only mildly hypoxic (e. saturations stable at 92% in a patient without lung disease).



Simple face mask (Hudson)

A simple face mask (Hudson) mask is a **Variable** delivery device, as the amount of oxygen a patient receives changes as the patient's breathing rate changes. Oxygen delivery via a Hudson mask is not recommended as a long term therapy. If the patient requires a longer period of oxygen, humidity may be needed.

Oxygen via a Hudson mask can be delivered in an emergency when higher amounts of oxygen are required. A minimum of 5 litres/min is used, as the high flow prevents the patient from rebreathing CO_2. A hudson mask can be used to deliver up to 10 litres/min of oxygen before a different device is required. Hudson masks come in different sizes, and the correct size is important for appropriate delivery of oxygen. The mask adds a reservoir of 70-100 mls where oxygen can be inhaled from, along with room air.

Oxygen delivered via a hudson mask can deliver approximately:

5 litres/min	40%
6 litres/min	45-50%
8 litres/min	55-60%
10 litres/min	60%

Reservoir Bag Mask

This is a **Variable** delivery device, as the patients breathing rate changes the amount of oxygen they draw in with each breath.

Where a patient requires higher amounts of oxygen than a Hudson mask can deliver (>60% FiO_2), a reservoir bag can be used. Prior to using this, the reservoir bag needs to inflate to give a reservoir of oxygen. This is then inhaled along with the supplemental oxygen and room air, to give a higher FiO_2. To inflate the bag, place your finger over the hole and let the bag inflate. Do not over inflate the bag, as it will burst.

Patients who are in shock or showing severe respiratory distress will require a higher FiO2. If you are considering applying a reservoir bag mask, consider urgently contacting the team, or calling an Adult Resus call (777). A reservoir bag mask can be used with oxygen flow at 15 litres/min.

- Delivers 85-90% oxygen
- 15L flow rate
- Bag on mask with valves stopping almost all rebreathing of expired air
- **Used for acutely unwell patients**
- Note that saturations should be maintained at 92-96%, not 100%.
- Do not keep patients on 15L for longer than necessary as over-oxygenating for prolonged periods can be harmful.

Ambubag

In an emergency situation, where the patient requires more than 80% $Fi0_2$, or where the patient requires support with ventilating, an Ambubag can be used.

This device can be used to deliver 100% oxygen to the patient if required. Valves in the device control the flow of oxygen from the reservoir to the patient, and prevent the exhaled carbon dioxide from entering the reservoir and diluting the oxygen concentration. The flow rate applied to the bag should be more than 10litres/min to prevent the bag from fully deflating on inhalation.

10-15 litres/min	80-100%

An ambubag can be used for oxygen delivery alone. It cannot be used as a long term device, and your patient will need urgent review. In order to ensure the patient is receiving what is in the reservoir, you will need to hold the mask firmly over the patient's nose and mouth. **Remember your target saturations range**.

8. Titrating and weaning Oxygen

In most cases of acute illness, oxygen therapy will be reduced gradually as the patient recovers.

The need for continuing oxygen therapy must be assessed on a daily basis by the medical team and documented in the medical notes.

In stable patients, if the oxygen saturations exceed the desired target range, active weaning is appropriate and encouraged.

With low levels of supplemental oxygen (1L/min nasal prongs or 24% by venturi mask), stop oxygen and re-check saturations after the patient has been breathing room air for 5 minutes, then again after 15 minutes. If saturation remains in the target range on air, the health professional can discontinue oxygen therapy. Should oxygen saturations subsequently fall below the target range, oxygen may be re-started.

Weaning flow chart

Patient condition is stable.

Patient is meeting their target Saturation range on current oxygen therapy?
Ensure patient is weaned of HHFNP if being used for oxygen delivery (see HHFNP weaning policy)
Consider weaning

START

- Record $Sp0_2$ with vital signs
- Assess patient's breathing including respiration rate, depth of breathing, bilateral chest movement and work of breathing

- Decrease oxygen by half the amount for example 4L to 2L
- If on venturi, reduce to next valve down for example 35% - 28%.
- Check $Sp0_2$ levels after 5 minutes

Is the oxygen level still within the target $Sp0_2$ range?

No

Return the oxygen flow to previous level and continue on current settings.

Inform medical team.
Document failed attempt to wean oxygen in nursing notes.

Reassess weather meets weaning criteria with next set of observations. If so, return to **START**

Yes

Repeat $Sp0_2$ after a further 15 minutes.
Is patient still meeting prescribed $Sp0_2$ parameter?

No

Yes

Return to start and repeat steps until patient is able to maintain target $Sp0_2$ on room air

9. Home oxygen

Short Term Oxygen Therapy (STOT) and Long Term Oxygen Therapy (LTOT)

The aim of long term oxygen therapy is to prolong life by improving organ function and reducing the risk of right sided heart failure.

This needs to be prescribed by a specialist after clinical assessment with blood gases showing hypoxia of <7.3 $Pa0_2$ or <8.0 $Pa0_2$, if there is any evidence of end organ failure such as right sided heart strain, or pulmonary hypertension.

Patients who have this prescribed are required to use it for a minimum of 16 hours a day to prevent R) heart strain. They can obtain most of their time on oxygen overnight whilst they are sleeping and we recommend this due to nocturnal shallow breathing.

Sometime patients who meet this criteria in hospital will be sent home with Short Term Oxygen Therapy (STOT) for a period of around six weeks while they recover. They then require specialist assessment after that period to see if they still meet the criteria and can go on to have LTOT. It is important that the discharging team refer the patient to Respiratory Outpatients Clinic for review six weeks post discharge.

When patients receive oxygen at home they use an *oxygen concentrator.* This machine extracts air and 0_2 from the atmosphere and delivers oxygen to the patient.

When patients receive STOT at home, they will receive a concentrator which runs on power and is about the size of a dehumidifier. They are issued with 7.5m tubing which will allow them to mobilise around their home with their oxygen on. This allows them to keep the concentrator outside their bedroom as it can be noisy.

If, after review, the patient is put on LTOT, they will receive a longer tube of 15m and also a *'D' size* back up oxygen cylinder in the event of a power cut. They can also use this this cylinder if required for appointments. Patients are entitled to have their cylinder replaced every three weeks if required.

10. Scenarios

Scenario - Mrs Brown

Mrs Brown is a 67 year old lady who has been admitted to your ward for supportive treatment of her COPD. Her blood gases in ED indicate that she is at risk of CO_2 retention. At the beginning of the shift her vitals were within normal range with an unaltered NEWS of 0, and she was comfortable on room air, with no shortness of breath. At 1100hrs you check in on her and notice that she is pursed lip breathing, and showing signs of accessory muscle use. You record her vitals and note the following:

Heart Rate: 106 bpm, regular
Blood Pressure: 152/95
Respiratory rate: 28 breaths per minute
SpO_2: 82% on room air
Temperature: 36.7^{o}C

You discuss this with the team house officer who suggests she may benefit from oxygen therapy.

Which device do you think would be most appropriate, and what flow rate/settings?

What would be the target saturations range for Mrs Brown? Explain your rationale.

How would you document the oxygen therapy in her notes?

What would be your next steps if her oxygen requirements increase/decrease?

Increase	Decrease

Scenario - Steve

Steve is a 35 year old admitted to your ward, with a history of asthma. While on the ward he mentions that he feels tightness in his chest and shortness of breath. He takes multiple breaths to tell you this information and there is an audible inspiratory wheeze. His respiratory rate is 28 breaths per minute, prior to receiving nebulised salbutamol and ipratropium. You re-check on him 15 minutes after he has finished his nebuliser and note the following:

Respiratory rate: 34 breaths / minute, audible wheeze
Heart rate: 123 beats/minute
SpO2: 89% on room air
Blood pressure: 124/78
Temperature: 36.4^{o}C

Steve is for full Resus, and as per the NEWS algorithm you place a 777 call, and notify the ICU outreach team.

What actions can you take while waiting for the team to respond?

Which device do you think would be most appropriate, and what flow rate/settings?

What would be the target saturations range for Steve? Explain your rationale.

How would you document the oxygen therapy in his notes?

What would be your next steps if his oxygen requirements increase/decrease?

Increase	Decrease

Scenario - Olivia

Olivia is a 42 year old healthcare worker who was admitted with bilateral pneumonia. She has been receiving Q8hrly IVAB's and has been on oxygen therapy, 2 litres/min via nasal prongs.

You go to administer her morning IVAB's and note that her respiratory rate is 24 resps / minute. You note that there is dry areas around her nostrils, and her e-prescribing record shows that her oxygen has been on for the past 24 hours since her admission, consistent at the rate prescribed.

You note that her respiratory rate has been within normal limits after her admission to the ward, and the record from ED shows that she had a respiratory rate of 25 on admission, which resolved with oxygen. Her SpO_2 has been consistent in the low 90's for the past 12 hours, but her increased respiratory rate has only just been noted.

Her current observations are:
Respiratory rate - 24 breaths/minute
Heart rate - 86 beats / minute
Blood Pressure – 132/76 mmHg
SpO_2 – 92% on 2 litres/minute oxygen via Nasal Prongs
Temperature – 37.2^{o}C

You power-page the House Officer and advise them of the change in respiratory rate, and accompanying vitals.

Which device do you think would be most appropriate, and what flow rate/settings?

What would be the target saturations range for Olivia? Explain your rationale.

How would you document the oxygen therapy in her notes?

What would be your next steps if her oxygen requirements increase/decrease?

Increase	Decrease

Scenario - Meredith

Meredith has been admitted to your ward with a plan for comfort cares, as she has end stage COPD, and has reached the ceiling of care provided. Her family have been involved in this decision, and have agreed to symptomatic care and support, including IVAB's and oxygen therapy. She is not for NEWS or vital signs.

You are advised by her daughter (next of kin), that she is sounding "rattly", and seems to be in some discomfort. You support the family to turn her, and give her some suctioning for the secretions you can hear causing the rattling that the daughter reported. She is receiving oxygen via a face mask at 6 litres/minute, which she has been receiving continuously for the past 36 hours. You notice that she is using accessory muscles, and, despite the secretions, you note that she is dry on the lips and around the mouth. You count her respiratory rate, which is 32 respirations per minute and find that her SpO_2 is 80%

You page the house officer to advise them of what you have observed.

Which device do you think would be most appropriate, and what flow rate/settings?

What would be the target saturations range for Meredith? Explain your rationale.

How would you document the oxygen therapy in her notes?

What would be your next steps if her oxygen requirements increase/decrease?

Increase	Decrease

Scenario - Adam

Adam is a 45 year old man admitted to your ward for pain management. You are looking after him for an afternoon shift, and have just taken handover from the morning nurse. For his pain he is charted:

- IV Morphine, as per protocol 0.5mg-2.0mg every 5 minutes, PRN
- Sevredol, 20mg, PO, Q1hrly, PRN
- Paracetemol, 1gm, Q6hrly, regularly
- Codeine, 60mg, PO, Q6hrly, PRN

During the handover the morning nurse tells you that he has required regular morphine throughout the shift for his pain, as well as having Sevredol. The nurse states that he was consistently complaining of 8/10 pain throughout the shift, which is why he was having these doses. When rounding was done half an hour ago he was in 5/10 pain, and alert. His e-vitals record shows that his respiratory rate has been between 15 and 18 throughout the shift. His vitals have all been within normal limits.

You go with the morning nurse to the bedside to introduce yourself to the patient, and find that he is unresponsive, has a respiratory rate of 6 breaths per minute, and is cyanosed on the lips.

You press the emergency bell and the morning nurse goes to call 777.

What actions can you take while waiting for the team to respond?

Which device do you think would be most appropriate, and what flow rate/settings?

What would be the target saturations range for Steve? Explain your rationale.

How would you document the oxygen therapy in his notes?

What would be your next steps if his oxygen requirements increase/decrease?

Increase	Decrease

Scenario - Jennifer

Jennifer is a 67 year old female who has a L) NOF repair following mechanical fall and fracture. Her medical history consists of osteoporosis, hypertension and diverticulitis. She is on the ward 4 hours post op, she has a PCA in situ and is drowsy with a GCS of 15/15. She hasn't used her PCA for the last half hour and claims her pain is 2/10 on the pain scale. She has oxygen prescribed via the NOF protocol and has O_2, 2L via simple nasal cannulae in situ.

Her current observations are:
Respiratory rate - 24 breaths/minute
Heart rate - 90 beats / minute
Blood Pressure – 127/65 mmHg
SpO_2 – 96% on 2 litres/minute oxygen via Nasal Prongs
Temperature – 36.0^{o}C

What is the most appropriate course of action in this situation?

What would be the target saturations range for Jennifer? Explain your rationale.

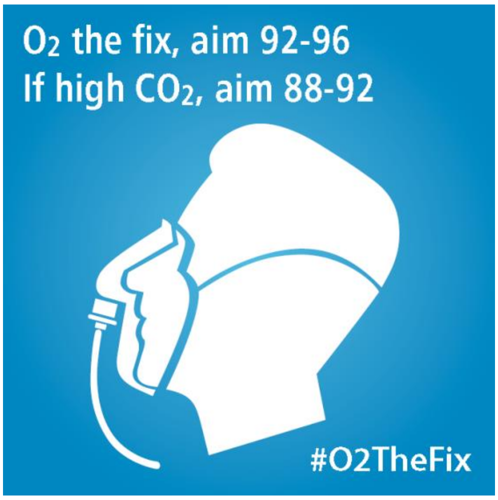
How would you document the oxygen therapy in her notes?

What would be your next steps if her oxygen requirements increase/decrease?

Increase	Decrease

11. Key messages

- Oxygen is a drug which must be prescribed.
- A fixed delivery of oxygen device is recommended for patients at risk of $C0_2$ retention.
- In an emergency situation oxygen administration without a prescription is appropriate while waiting for medical assessment of the patient.
- Oxygen must be prescribed for a specific oxygen delivery device and target saturations range.
- If it is necessary to increase the oxygen flow rate to maintain the desired target saturation range in a previously stable patient, then a review of the patient's clinical condition by the medical team and ICU outreach is required as per the NEWS algorithm.
- Oxygen administration should be documented on e-vitals with the $fi0_2$ the patient is receiving from a controlled delivery device and the Litres of oxygen at the flow metre for variable rate (uncontrolled) delivery devices.
- Any patient requiring oxygen administration during transit requires the attendance of a registered nurse.
- Oxygen should be administered at the lowest flow that achieves the prescribed SpO_2 parameter.
- Nurse-led weaning of oxygen is encouraged.



12. Glossary / Terms

ABGs	Arterial Blood Gases
ADLs	Assisted Daily Living skills
AH	Absolute Humidity
AIRVO	Humidifier with PEEP
ARDS	Adult Respiratory Distress Syndrome
b/m	Breaths per Minute
BiPAP	Bi-level Positive Airway Pressure
CHF	Congestive Heart Failure
cmH_2O	Centimetres of Water
CNS	Central Nervous System
CO_2	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
CPAP	Continuous Positive Airway Pressure
CT	Computed Tomography
CVA	Cerebral Vascular Accident
CVS	Cardio Vascular System
EPAP	Expiratory Positive Airway Pressure
FEV1	Forced Expiratory Volume in 1 Second
FiO_2	Fraction of Inspired Oxygen in a gas mixture
HCO_3	Bicarbonate
HMEs	Heat and Moisture Exchangers
Hz	Hertz
IPAP	Inspiratory Positive Airway Pressure
kPa	Kilopascal
LOC	Level of Consciousness
M3	Muscarinic acetylcholine receptor also known as the cholinergic receptors
mg/L	Milligrams per Litre
mmHg	Millimetre of Mercury
mmol/L	Millimoles per Litre
NIPPV	Non Invasive Positive Pressure Ventilation
NIV	Non Invasive Ventilation
O_2	Oxygen
$PaCO_2$	$PaCO_2$ is the partial pressure or CO2 in the alveolus
PaO_2	Symbol for partial pressure of oxygen in arterial blood.
pCO_2	pCO_2 is the partial pressure of CO_2 in blood. (*There will be a small difference to $PaCo_2$ because of the pressure gradient across the membrane that causes CO_2 to diffuse from the blood into the lungs*)
pH	Hydrogen Ion Measure (Acid or Alkaline)
pO2	Total Pressure Oxygen Gas Component
R	Rate
RH	Relative Humidity
S	Spontaneous
S/T	Spontaneous / Timed
SaO_2	SaO_2 can be measured either by ABG analysis or by pulse oximetry. (*SaO_2 refers to the amount oxygen bound to haemoglobin in arterial blood.)*
SpO_2	SpO_2 simply means that the SaO_2 was measured using pulse oximetry.
TV	Tidal Volume
V/Q	Ventilation / Perfusion Ratio
VC	Vital Capacity
WOB	Work of Breathing
β	Beta2 Adrenergic Agonist

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