Management of Ventilated Patient

Contents

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Management of a ventilated patient

2.1 Safety of a ventilated patient

While receiving ventilator assistance, the patient will experience an adequate supply of oxygen and elimination of carbon dioxide at the cellular level.

Any mechanical, physical or psychological barrier to effective respiration should be identified and corrected promptly.

Minute ventilation should be adjusted based on patient comfort, results of arterial blood gases and ventilator mechanics.

Problems commonly encountered during mechanical ventilation

1. Low Saturation of Oxygen (SpO$_2$)
2. High End Tidal Carbon Dioxide (ETCO$_2$)
3. High Airway Pressure (Paw)

2.1.1 Low Saturation - Hypoxaemia

A. Causes

There are many causes for the reduction of the oxygen levels in blood.

a) Inadequate supply -
- Oxygen failure
- Ventilator malfunction
- Disconnection
- Leaks

b) Increased demands -(Critically ill patients)
- Temperature
- Respiratory failure
- Hyper catabolic status

c) Inadequate gas exchange due to **Hypoventilation (low** minute volume)

i. Pulmonary Complications
- Existing lung condition
- New lung pathology

ii. Poor compliance
- Pneumonia
- ARDS
- Pulmonary Oedema
- Aspiration

iii. Pleural wall problems
- Pneumothorax
- Haemothorax

iv. Breathing out of synchrony (Patient fighting the ventilator)
- Anxiety
- Lung pathology

d) Endobronchial Intubation / Accidental Extubation

i. Airway Obstruction

Mechanical -
- Blocked Endotracheal tube (ETT)
- Secretions
- Mucus plug
- Kinked ETT
- Dislodged ETT

Lung pathology -
- Bronchospasm
- Pulmonary oedema

B. Management

- **Follow ABC**
- **100% oxygen via a breathing circuit**
- Look for the cause / correct the cause
- Relieve Tension Pneumothorax
- Relieve Heamothorax
- Insert Inter Costal Tube (IC tube)
- Bronchodilators, Diuretics, Sedatives
- Suck out secretions
- Chest Physiotherapy
- Adjust or change ETT
- Adjust or change ventilator
- Change ventilator settings
- Add PEEP or increase PEEP

Inverse ratio ventilation

PNEUMOTHORAX - Immediate relief of Tension Pneumothorax is essential before commencing IPPV to prevent cardiac arrest.

Diagnosis

- Reduced breath sounds on the affected side
- Reduced or no chest expansion over the affected side
- Hyper-resonance on the affected side
- Trachea shifted to opposite side
- Sudden severe hypotension

Management

- Insert 12G canula into the second intercostal space ,midclavicular line on the affected side

- To achieve an adequate level of oxygenation, the patients oxygen saturation should be maintained >94%. Exceptions can be expected in patients with cyanotic heart disease or advanced chronic obstructive lung disease.

- To avoid oxygen toxicity and absorption atelectasis, FiO_2 should be decreased to <0.5 as soon as possible.

2.1.2 High End Tidal Carbon Dioxide (ETCO$_2$) / High Arterial CO$_2$

A. Causes

Main cause is **hypoventilation** (poor elimination of CO_2)
Increased production (Hyper catabolic state)

a) Ventilator malfunctions
- Disconnections
- Leaks
- Failure
- Exhausted soda lime / By passed soda lime

b) Obstruction to the Airways

Mechanical - Blocked ETT / Trachaeostomy tube
- Secretions
- Mucus plugs
- Kinked ETT
- Dislodged ETT
- Inadequate ETT size
- Increased Apparator dead space

Lung pathology
- Bronchospasm due to any reason (Asthma, Anaphylaxis, Aspiration)
- ARDS

c) Respiratory Depressants
- Opioids
- Sedatives
- Anaesthetic Agents
  (Patients on spontaneous mode of ventilation)

B. **Management**

- **Follow ABC**
- **100% Oxygen / Increase oxygen concentration**
- Look for the cause / Correct the cause
- Increase minute volume depending on the lung condition
- Suck out secretions
- Adjust ETT / Change ETT
- Change ventilatory settings
- Reduce Apparator dead space
- Check for leaks / Disconnections
- May need to change the ventilator
- Change Soda Lime
- Use Bronchodilators

In certain patients (ARDS) increased amount of CO2 is permitted if the pH remains > 7.2 (Permissive Hypercapnia)

2.1.3 High Airway Pressure (Paw)

A. **Causes**

a) Mechanical obstruction to the Airways

- Blocked ETT with secretions / mucus plug
- Kinked ETT
- Inadquate size of ETT
- Blockd Heat and Moisture Exchanger (HME)
- Patient biting the tube
- Endobronchial Intubation

b) Pulmonary factors

- Bronchospasm (Existing Asthma)
- Anaphylaxis
- Aspiration

- Stimulation under light Anaesthsia
- Pneumothorax
- Heamothorax
- Lung collapse
- Pleural effusion
- Pulmonary oedema

Wrong ventilator settings

- Asynchrony with the ventilator (patient fighting the ventilator)
- Spontaneous breathing efforts in paralyzed and ventilated patients

B. Management

- **Follow ABC**
- **100% Oxygen via a breathing circuit (easy manual ventilation will confirm the ventilator malfunction.)**
- Pneumothorax –treat as above
- Haemothorax –insertion of IC tube
- Anaphylaxis – treat according to protocol
- Aspiration - treat according to protocol
- Insertion of the oropharyngeal airway or a bite block.
- Sedation or paralysis may be necessary.
- Suction of the ETT with 5 ml of saline
- Reposition the ETT, replace ETT, HME
- Use Bronchodilators (Salbutamol, Ipratropium-Bromide, Aminophyllin)
- Use Diuretics ,Morphine , IPPV for Pulmonary odema
- Plural Effusion - insertion of IC tube
- Chest physiotherapy

Pulmonary complications are diagnosed by reduced chest movements, dullness or hyper-resonance on palpation and .reduced or no breath sounds on auscultation on the affected side

Pink frothy secretions and fine crepitations with low blood pressure will be seen in pulmonary oedema.

Do a Chest X-ray (CXR) when feasible to confirm.

Any of the above complications may be associated with a reduction of cardiac output

An inotropic support may help to maintain cardiac out put.

2.2 Setting up a ventilator

Initial set up of the ventilator is dependent on various parameters, such as age of the patient, reason for ventilation and the existing lung pathology. Ventilatory strategies have been devised for different disease processes to protect pulmonary parenchyma while maintaining adequate gas exchange.

2.2.1 Initial set up of the ventilator:

General Guidelines:

- Ventilatory mode
- Tidal volume
- Oxygen (FiO_2 – Fraction of Inspired oxygen)
- Rate (Frequency)
- PEEP (Positive End Expiratory Pressure)
- Peak Inspiratory pressure
- Peak flow / Inspiratory flow rate
- Inspiratory / expiratory flow rate
- Sensitivity
- Alarm settings

2.2.2 Modes of ventilation

Mode of ventilation should be tailored to the need of the patient

The main two modes are:

- Volume- cycled mode
- Pressure -cycled mode

Volume- cycled mode

A preset tidal volume is delivered followed by passive exhalation

- Ensure constant minute ventilation
- High airway pressure may cause barotrauma

Pressure –cycled mode

A preset peak inspiratory pressure (PIP) is applied lung inflation occurs until the PIP is attained.

- Ensure homogeneous gas distribution throughout the lungs.
- Pulmonary pathology may result in varying tidal volume

Once the right main mode described above is selected one of the following modes can be applied to the ventilatory settings.

Most ventilators can be set to apply the delivered tidal volume in a control mode or support mode.

Control mode:

Total control of rate and tidal volume, prevents effective spontaneous ventilation. It delivers the pre set tidal volume regardless of patient’s efforts

Support mode:

Provide ventilatory assistance through the use of an assist pressure. It requires an adequate respiratory drive.

Continuous mandatory ventilation (CMV):

A preset tidal volume delivered at intervals regardless of patients efforts. This mode is used most often in the paralyzed or apnoeic patients.

Assist control ventilation (ACV):

A preset tidal volume is delivered in coordination with the respiratory efforts with of the patient. Spontaneous breaths independent of the ventilator are not allowed.

Intermittent mandatory ventilation (IMV):

A preset tidal volume is delivered at intervals and spontaneous breathing is allowed between the ventilator-administered breaths.

Synchronized Intermittent Mandatory Ventilation (SIMV):

Delivers preset rate and tidal Volume in coordination with the respiratory effort of the patient. Spontaneous breathing is allowed between breaths.

Positive End Expiratory Pressure (PEEP) :It is an adjunct to other modes and maintains a preset amount of pressure in the Alveoli at the end of expiration allowing more Gas exchange.

Pressure Support Ventilation (PSV). This has been advocated for the spontaneously breathing patient. Assists spontaneous breaths with a preset amount of pressure .it limits barotraumas, and reduce the work of breathing.

Continuous Positive Airway Pressure (CPAP)- It is similar to PEEP ., but applied to spontaneous breaths .Mainly used for weaning .

2.2.3 Tidal volume

8- 10 ml / kg body weight, In ARDS 6ml /kg body weight to prevent volutrauma

2.2.4 Oxygen (FiO_2 – Fraction of Inspired oxygen)

When setting a patient on the ventilator it is good practice to initially set FiO_2 at 1.0 and then reduce to < 0.6 as soon as possible while maintaining Arterial Oxygen Saturation (SaO_2) > 94% to avoid O_2 toxicity.

2.2.5 Rate (Frequency)

10- 12 for an adult may change according to the $ETCO_2$ / $PaCO_2$.Children will need higher rates.

2.2.6 PEEP (Positive End Expiratory Pressure)

5- 15 depending on the lung condition. Beware of Barotrauma

2.2.7 Peak Inspiratory pressure (used to achieve adequate tidal volumes)

Normal -20 cm H_2O or 15 cm H_2O above PEEP

May need higher volume in patients with lung pathology.

Inspiratory / expiratory ratio – normal is 1:2 (in ARDS it could be 1;1 or 2:1)

2.2.8 Peak flow / Inspiratory flow rate - Speed at which volume is delivered,- 60l/min

2.2.9 Sensitivity – degree to which the ventilator is sensitive to Spontaneous breaths, - 1-2

2.2.10 Alarm settings

At the start of a new patient it is recommended to

set alarms.
Main settings are

- Oxygen failure - should be set at 24 %

The following alarms are set according to patient's factors such as age, weight and lung pathology.

- High pressure
- Low pressure
- Low volume
- Ratio alarm

It is recommended never to turn alarms off.

2.3 Mechanical Ventilation

Mechanical ventilation (Provision of advanced respiratory support) is one of the main functions of an intensive care unit. (ICU) and in operating theatre for selected patients and understanding of the indication and methods available is therefore essential for anyone working in this environment.

Mechanical ventilation can be divided to

- Invasive ventilation with Endo-tracheal Tube (ETT)or Tracheostomy tube
- Non invasive ventilation

2.3.1 Non invasive Ventilation

The application of mechanical respiratory support through a mask in place of a endotracheal intubation. This is most useful in the treatment of early respiratory failure and used mainly in the Emergency Treatment Unit (ETU), or a Respiratory ward.

2.3.2 Indications

The main indication for mechanical ventilation is respiratory failure; however there are other many indications for respiratory support.

Respiratory failure

This is the primary indication of the respiratory support. It occurs when pulmonary gas exchange is sufficiently impaired to cause hypoxemia with or without hypercarbia.

a) Type 1 respiratory failure
  - SaO_2 - reduced
  - $PaCO_2$ –Normal or low

b) Type 11 Respiratory failure

The causes of respiratory failure are diverse and the problem may occur due to

- Disease at the alveolar-endothelial interface
- Disease at the respiratory pump mechanism resulting in inadequate minute ventilation

2.3.3 Causes of respiratory failure

a) Inadequate gas exchange

- Pneumonia, pulmonary odema, pulmonary haemorrhage
- Acute respiratory distress syndrome (ARDS)
- Chronic Obstructive Airway Disease (COPD)

b) Inadequate breathing

- Chest wall problems eg, fractured ribs, flail chest
- Pleural wall problems eg, pneumothorax. Haemothorax

- Respiratory muscle failure eg myasthenia gravis, poliomyelitis, tetanus
- Central nervous system depression eg drugs, brain stem compression
- Internal Splinting after major abdominal surgery

c) Obstruction to breathing

- Upper airway obstruction eg, epiglottitis, croup, oedema, tumour
- Lower airway obstruction eg: bronchospasm, foreign body

d) Other Indications

- Control of intracranial pressure
- Airway protection in patients with decreased level of consciousness
- Cardio-respiratory arrest
- Prolonged recovery after anaesthesia eg , suxamethonium apnoea

2.3.4 Criteria for Mechanical Ventilation

i. Hypoxia -PaO_2 < 8 kPa on (SaO_2 < 94 % on oxygen on or more than 60 %)
ii. Hypercarbia – $PaCO_2$ > 8 kPa
iii. Respiratory rate > 35 / min or < 5 /min
iv. Tidal Volume < 5 ml /Kg or Vital Capacity < 15 ml /Kg
v. pH < 7.2 on ABG (respiratory acidosis)
vi. Exhaustion with laboured pattern of breathing

Decision to start the mechanical ventilation is made according to the criteria with the clinical picture of the patient.

2.3.5 Ventilator Management

General Guidelines

Ventilatory management must be provided by a qualified anaesthetist, and she or he is responsible for directing airway management , ventilatory support and removal from the ventilator.

A. Management of Airway

a) The ETT or Tracheostomy tube should be secured safely and comfortably.
b) Attention should be given to the prevention of unplanned extubation
c) Secretions must be suctioned using a sterile technique

B. Ventilatory support

a) Sedation is recommended for a ventilated patient.
b) Neuromuscular blocking agents are recommended in patients with increased intra cranial pressure (ICP) and increased work of breathing.
c) Before initiating neuromuscular blockade the patient should be sedated.
d) Every effort must be made to discontinue neuromuscular blocking agents as soon as possible
e) Consider administering prophylactic eye care, prophylaxis for deep vein thrombosis (DVT) and physiotherapy.
f) Consider Arterial line if frequent blood gas analysis is required to achieve patient's comfort.

2.4 Weaning

To prevent complications of mechanical ventilation it is essential to discontinue ventilatory support as soon as possible.

2.4.1 Complications of mechanical ventilation

- Barotrauma
- Ventilator associated pneumonia
- Reduction of cardiac output.
- Respiratory muscle weakness – on prolong ventilation.
- Weaning from short form ventilation for prolonged recovery is not difficult and it is more straight forward.
- The speed of weaning from the long term ventilation (ARDS) is often dependent on the duration and the mode of ventilation.
- Assisted modes of ventilation are important to prevent atrophy of the respiratory muscles.

2.4.2 Indications for weaning

The decision to start is often subjective and based on clinical experience. However there are a few criteria, which should be met before starting weaning.

2.4.3 General criteria

- Underlying illness is treated and improving
- Absence of fever.
- No residual neuromuscular blockade.
- No sedation or minimal sedation.
- Patient awake, alert and cooperative.
- Patient should be in semi recumbent position
- Good nutrition.

2.4.4 Respiratory functions

- Respiratory rate < 35/breaths/minute
- SaO_2>94% on FiO_2 <0.5
- PEEP<10 cm H_2O
- Spontaneous TV>5 ml kg
- Vital capacity >10ml / kg {ability to cough}
- Minute volume < 10 1 / min.

2.4.5 Cardiovascular system

Cardiovascular system should be stable without support or minimal support.

2.4.6 Fluid and electrolyte balance

There should be optimal fluid balance and pH, electrolyte deficits replaced.

2.4.7 Methods of Weaning

There are several methods

1. Direct method

Connect the patient directly to the T- piece

Useful in patients ventilated for a short time (delayed recovery)

2. Unsupported spontaneous breathing trials

Patient is connected to T-piece intermittently for increasing periods of time thereby allowing the patient to take over breathing.

3. Intermittent mandatory weaning

The ventilator delivers a preset minimum minute volume, which is gradually decreased. The breaths are synchronized to the patient's own breaths. This is rarely used now.

4. Pressure support weaning

The patient initiates all breaths and, these breaths are assisted by the ventilator.

Gradually the level of pressure support is reduced, thus making patient responsible for an increasing minute volume.

Once the level of pressure support is low (10 mm Hg above PEEP), a trial of CPAP followed by T- Piece should be commenced.

During the weaning process, the patient should be observed for early indications of fatigue

These signs include

- Distress
- Increasing respiratory rate
- Falling tidal volume
- Haemodynamic compromise - (tachycardia , hypertension)

If fatigue occurs the level of respiratory support should be increased.

If the weaning process is difficult, tracheostomy will be helpful as it reducs the dead space, requires no sedation and allows good pulmonary care.

It is sensible to start the weaning in the morning to allow close monitoring of the patient through out the day. In prolonged weaning, ventilatory support should be increased overnight to allow adequate rest for the patient.

3. Oxygen (O_2)Theapy

3.1 Introduction

Oxygen is absolutely essential for cellular metabolism. Cells can undergo anaerobic metabolism for extremely short periods of time. This time period varies depending on the tissues in which the cell belongs.

Oxygen is taken into the body via the lungs .it is then carried to the cells by the blood .oxygen is transported by the blood in two ways.

1. Combined with Heamoglobin
   O_2 flux = [Hb% × Sa O_2 × 1.34]

2. Dissolved in blood
   0.003ml/ mmHg (a very insignificant amount)

Therefore oxygen delivery to the tissues can be improved by

1. increasing oxygen saturation
2. optimizing haemoglobin concentration
3. improving cardiac output

The oxygen cascade illustrates how the oxygen tensions decrease from the atmospheric oxygen to the alveoli and down to the cells, and now oxygen flows along this gradient.

If the lesion is higher up in the oxygen cascade, low concentrations of oxygen are sufficient to correct hypoxia.

Devices to be used when a variable concentration of oxygen may be given

(a) MC, Edinburgh, Harris & Hudson masks
(b) Nasal catheter ,nasal prongs

Difficult to predict exact concentration of oxygen delivered to patient. It varies from 30-60% from patient to patient and from breath to breath, depending on the breathing pattern.

Which patient should routinely be given 30-40 % oxygen supplementation in the ward?

- Obese patients
- History of snoring or sleep apnea
- Myocardial ischeamia (for at least 72 hours)
- Severe aneamia
- Patients with ventilation perfusion mismatch. e.g. Elderly, cardiac disease , kyposcoliosis
- Upper abdominal and thoracic surgery
- Pre existing lung disease

3.2 Equipment needed to give oxygen therapy

1. oxygen flow meter
2. humidification
3. tubing
4. delivery system – nasal cannulae, face masks, breathing system etc.

3.3 Devices to be used to provide 100% oxygen

a) Magill breathing system connected to the anaesthetic machine, delivering oxygen via a close fitting face mask or an endotracheal tube.
b) Ventilation via an endotracheal tube
c) Ventilation on CPAP machine, via a close fitting face mask.

3.4 Devices used for a fixed concentration of oxygen to be given

a) Venturi device connected to a face mask .

- Oxygen flow rate should be accurate and as indicated on the Venturi device.

- Used specially for COPD patients who are on a hypoxic drive and when weaning patients off oxygen.

b) Via a **endotracheal tube** or **tracheostomy tube** trough a ventilator.

3.5 Devices used for variable concentrations of oxygen

a) MC, Edinburgh, Harrris and Hudson masks.
b) Nasal catheter, nasal prongs

Difficult to predict exact concentration of oxygen delivered to patient. It varies from 30-60% from patient to patient and from breath to breath depending on the breathing pattern.