Airway Management & Invasive Ventilation in the Emergency Department

Self-Directed Learning Package
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For more information, please contact:

Education & Research Unit
Joondalup Health Campus
PO Box 242
JOONDALUP  WA 6919
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Learning Outcomes

Upon completion of this SDLP the RN will be able to demonstrate understanding of:

- Responsibilities of the R1 Nurse – Action card
- Physiological differences between spontaneous (normal) breathing and mechanical ventilation and causes of ineffective breathing
- Signs and symptoms of respiratory compromise
- Airway anatomy – Paediatric & adult
- Assessment of airway including airway positioning
- Rapid sequence intubation (RSI)
- Rapid sequence intubation JHC ED checklist
- Airway assessment tools
- Commonly used medications in airway management
- Equipment used in airway management
- Difficult airway algorithms and associated equipment
- Mechanical ventilation terminology
- Draeger Oxylog 3000+
- Troubleshooting common ventilator problems
- Nursing considerations for intubated patients
- Transporting ventilated patients outside of the ED
Resus 1 Nurse Action Card

To improve patient care and efficiency we are changing the way we work in the ED

Key Responsibilities

- Works to the RIGHT of the patient
- Nursing Team Leader of resuscitation area
  
  *Provide support to Resus 2 Nurse and Scribe Nurse*

- Assists with clinical care of patient
  
  *Manage patient airway, assist intubation, provide care and management of ventilated patients*

- Liaise with team Leader Nurse, Shift Coordinator and/or EAU 1 regarding patient acuity and patient flow within the resuscitation area

- Ensure Airway, Circulation, Team Leader and Scribe stickers are used during a priority / trauma patient
Spontaneous Breathing vs Mechanical Ventilation

Spontaneous Breathing

Inspiration
During spontaneous breathing the diaphragm contracts and moves down, the intercostal muscles lift the ribs and expand the rib cage. These mechanisms cause an increase in intrathoracic volume and create a negative pressure (lower than atmospheric pressure). The negative pressure causes air to flow from an area of high pressure (atmosphere), to an area of low pressure (lungs).

Expiration
During expiration the diaphragm relaxes and moves up. The intercostal muscles relax causing a decrease in volume and an increase in pressure. Air moves along the pressure gradient from the lungs to the atmosphere. The key point to remember is that inspiration is caused by the generation of negative pressure, and expiration is a passive exercise.

Mechanical Ventilation

Inspiration
In mechanical ventilation a preset volume or pressure of gas is delivered at a set rate. The diaphragm and respiratory muscles do not contract, instead the ventilator applies a positive pressure to push a volume of gas into the lungs creating inspiration.

Expiration
Once the preset volume and/or pressure is reached, the gas flows out as the lungs naturally recoil. The key point to remember is that during inspiration the ventilator causes a positive compared to the negative pressure created in spontaneous breathing.

Boyle's Law

Boyle’s Law states that pressure and volume are inversely proportional. Therefore in spontaneous breathing when the volume of the lungs increases (inspiration) the pressure within the lungs decrease. During expiration the lung volume decreases and the pressure within the lungs increases.
Many patients that present to the Emergency Department are at risk of airway and respiratory compromise. Prompt recognition, assessment and clinical intervention is required to prevent further deterioration or even death.

**Causes of acute onset of ineffective breathing**

Respiratory distress, hypoventilation or apnoea may occur as a result of injury or illness to one or more of the following systems:

- Respiratory (Type I or II failure)
- Cardiovascular (Arrhythmia, APO or post arrest)
- Central nervous system (seizure, raised intracranial pressure or intracerebral bleeding)

Other causes include:

- Toxicology (Accidental or deliberate)
- Trauma (Chest, facial or airway)
- Environmental (Toxinology or drowning)

**Signs and symptoms of airway and respiratory compromise:**

- Increased respiratory rate
- Increased work of breathing
- Drooling
- Wheezing
- Stridor
- Head bobbing
- Grunting
- Pallor / cyanosis
- Tachycardia
- Tracheal deviation
Airway Anatomy

Upper Airway Anatomy

Lower Airway Anatomy
Paediatric Airway Anatomy

- Small nares
- Small oral cavity
- Loose teeth
- Small jaw
- Narrow cricoid cartilage
- Floppy epiglottis
- Large tongue
- Greater proportion of soft tissue
- Smaller / anterior larynx
- Floppy epiglottis
- Loosely attached mucous membranes easily susceptible to swelling
- Short neck
- Short flexible trachea with symmetrical carinal angles

(O’Meara & Watton, 2012)
Assessment of Airway

In a critically unwell or injured patient, the assessment and management of the airway always takes precedence over any other system including when there is suspected spinal trauma. When assessing the patency of the airway in an unresponsive patient, the patient’s mouth should be opened to assess for any obvious foreign material (food, object, vomit, blood or secretions) or swelling (oedema). To clear the airway it is recommended that suctioning is performed and the patient is repositioned into a lateral position unless contraindicated from spinal injury.

Once the airway is cleared the patient’s ability to breath and level of responsiveness should be reassessed. In an unresponsive adult or child with ineffective breathing despite a clear airway one of the following airway manoeuvres should be performed.

<table>
<thead>
<tr>
<th>ADULT</th>
<th>PAEDIATRIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head tilt chin lift (contraindicated in spinal patients):</td>
<td>Neutral &lt;12months</td>
</tr>
<tr>
<td>Jaw thrust</td>
<td>Sniffing &gt;12months</td>
</tr>
</tbody>
</table>
Rapid Sequence Intubation

Indications for Intubation

- Lack of airway protection (aspiration risk or unable to manage secretions)
- Impending obstruction (trauma, foreign body, laryngospasm or anaphylaxis)
- Decreased level of consciousness related but not limited to:
  - Toxicology & toxinology
  - Cerebrovascular accident
  - Seizure
  - Metabolic disorders
  - Type I (Hypoxia) & II respiratory failure (Hypercapnia)
  - Cerebral trauma
- Diaphragmatic paralysis
- Cardiac arrest
- Temperature control
- Poor ventilation and perfusion requiring mechanical ventilation
Complications of Intubation

- Pulmonary aspiration
- Hypoxia
- Haemodynamic instability
- Dental trauma
- Cervical spine trauma
- Raised intracranial pressure
- Laryngeal trauma
- Failure to establish an airway
- Failure to intubate the trachea

Predisposed Factors for Difficult Intubation

- Short or no neck
- Obesity or Muscular neck
- Decreased jaw movement
- Trismus, osteoarthritis, rheumatoid, arthritis # jaw
- Abnormal anatomy
- Micrognathia, malaligned teeth, small mouth, abnormal palate
- Laryngeal/ Oropharyngeal lesions
- Congenital conditions – eg. Marfan’s syndrome
- Cervical Collar – spinal precautions
- Facial, head and/or neck trauma
- Tension pneumothorax

(Life in the Fast Lane, 2015)
Rapid Sequence Intubation (RSI) Checklist

**Prepare Patient**
- Optimise preoxygenation
- Consider high flow nasal prongs
- Optimise position
- Optimise haemodynamics
- Consider fluid bolus
- Consider pressors
- Assess for obvious airway risks
- IV adequate and patent, 2 x IV access if possible

**Prepare Equipment**
- Full monitoring
  - ECG
  - NIBP short interval
  - Satz probe
  - Capnography
- Equipment checked
  - Suction on & under mattress
  - BMV
  - 2 x ET tubes (only open 1) and LMA
  - 2 laryngoscopes
  - Bougie or stylet
  - ETCO2 monitor
- Drugs
  - RSI drugs drawn up, labelled
  - Emergency drugs
  - Post intubation drugs

**Prepare Team**
- Identify and name
  - Team leader
  - Airway doctor
  - Airway nurse (R1)
  - Cricoid (if applying it)
  - Drug doctor
  - Procedure nurse (R2)
  - C Spine (if required)
  - Scribe
- Team leader deliver plan and difficult intubation plan
- If help required, verbalise method of contacting
  - Duty Consultant
  - Anaesthetist ext 9121

**Prepare for difficulty**
- Rescue devices and surgical airway identified and located (do not open)
- Team leader verbalise any expected complications e.g.
  - Cardiovascular collapse post RSI
  - Pneumothorax with high airway pressures
- Team leader ask for questions from the team
- Proceed

Developed by Resuscitation Focus Group July 2015 updated January 2017
Airway Assessment Tools

There are multiple airway assessment tools available for the doctor to use to assess the difficulty of the patient’s airway. For example the Mallapati Score which uses a graded system which uses the visualisation of the soft palate, uvula, and faucial pillars to determine the ease of intubation.

Pre-Oxygenation

Pre-oxygenation prior to intubation is required to de-nitrogenate the patient’s lungs and to prevent desaturation during the apneic period after induction/paralysis and intubation. Patients with their own respiratory effort requiring intubation can be preoxygenated via a non-rebreather mask at 15L/minute.

Adding additional nasal prong oxygen at 15L/minute is referred to as apnoic oxygenation. This provides ongoing maximal oxygenation during the apneic period, immediately after induction and paralysis, and before intubation of the trachea with ventilation. Apneic oxygenation has been shown to increase the frequency and duration of higher oxygenation saturations during intubation.

If the patient is hypoxic and requires ventilator support prior to intubation, positive end expiratory pressure (PEEP) may be added to the bag valve mask via a PEEP valve. (Grewal & Helman, 2014)
**Heliox Administration**

Heliox is a mixture of helium and oxygen. Helium is an inert gas with a significantly lower density (and specific gravity) than room air. It is indicated in upper and lower airway disorders such as severe asthma, COPD, bronchiolitis, croup and epiglottitis. Its action is to increase laminar flow in the airways reducing airflow resistance, work of breathing and minimize hyperinflation. It can be administered through a non-rebreather mask, bag valve mask or via an endotracheal tube.

(Life in the Fast Lane, n.d.).

**Cricoid Pressure**

Controversial technique – Individual doctor preference.

**Rationale**

- Potentially prevent regurgitation of gastric contents
- May aid with the visualisation of vocal cords

**Technique**

- Digital pressure from the thumb and index finger against the cricoid cartilage of the larynx (C6 level), pushing it backwards causing oesophageal compression against the vertebrae

(Life in the Fast Lane, 2014a)

**Inline Spinal Immobilisation**

- Indicated in rapid sequence intubation to prevent further injury in suspected trauma patients
Pre Planning & Anticipation

**Plan A:** Initial Trachael Intubation Plan
- Direct Laryngoscopy using CMAC
- Consider Change in Doctor / Anaesthetics

**Plan B:** Secondary Trachael Intubation Plan
- Video Laryngoscopy using CMAC
- Call Anaesthetics

**Plan C:** Maintenance of Oxygenation and Ventilation
- LMA Supreme or BVM with NPA/OPA
- Continue ventilation till Anaesthetic support arrives

**Plan D:** Can’t Intubate Can’t Ventilate
- Cricothyroidotomy or Rapid 02 Jet Ventilation System
- Call ENT
## Commonly used Medication in Airway Management

### Sedation Agents

<table>
<thead>
<tr>
<th>Name</th>
<th>Dose</th>
<th>Onset</th>
<th>Duration</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketamine</td>
<td>1.5mg/kg IBW</td>
<td>60-90sec</td>
<td>10-20min</td>
<td>Haemodynamically unstable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reactive airways disease</td>
</tr>
<tr>
<td>Midazolam</td>
<td>0.3mg/kg TBW</td>
<td>60-90sec</td>
<td>15-30min</td>
<td>Haemodynamically unstable / shocked patients</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>2-10mcg/kg TBW</td>
<td>&lt;60sec</td>
<td>Dose dependent</td>
<td>Haemodynamically unstable / shocked patients</td>
</tr>
<tr>
<td>Propofol</td>
<td>1-2.5mg/kg IBW</td>
<td>15-45sec</td>
<td>5-10min</td>
<td>Haemodynamically stable patients,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reactive airways disease</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Status epilepticus</td>
</tr>
<tr>
<td>Thiopentone</td>
<td>3-5mg/kg TBW</td>
<td>30-45sec</td>
<td>5-10min</td>
<td>Haemodynamically stable patients,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Status Epileptician</td>
</tr>
</tbody>
</table>

### Paralytic agents

<table>
<thead>
<tr>
<th>Name</th>
<th>Dose</th>
<th>Onset</th>
<th>Duration</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suxamethonium</td>
<td>1.5mg/kg TBW</td>
<td>45-60sec</td>
<td>6-10mins</td>
<td>Widely used unless contraindicated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contraindications: Hyperkalaemia, burns, malignant Hyperthermia &amp; neuromuscular disease</td>
</tr>
<tr>
<td>Rocuronium</td>
<td>1.2mg/kg IBW</td>
<td>60sec</td>
<td>-</td>
<td>Any – reversible with sugammadex (16mg/kg)</td>
</tr>
<tr>
<td>Vecuronium</td>
<td>0.15mg/kg IBW</td>
<td>120-180sec</td>
<td>45-60min</td>
<td>Not for routine RSI</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Any – reversible with sugammadex (16mg/kg)</td>
</tr>
</tbody>
</table>
Basic Airway Adjuncts

Oropharyngeal Airway (OPA)

Rationale for insertion
- Inserted by medical or nursing staff to lift the tongue off the posterior pharyngeal wall to prevent airway obstruction
- Can assist with oropharyngeal suctioning or bite block

Sizing / method of insertion
- Size dependent. Measure from the center of the mouth between the first incisors to the angle of the mandible (adult)
- Children – insert directly over the tongue ideally with aid of a tongue depressor (no twisting to prevent injury to the palate)
- Adults – rotate 180 degrees from concave upwards position as it is inserted over the tongue. They can also be inserted directly over the tongue with a tongue depressor

Nasopharyngeal Airway (NPA)

Rationale for insertion
- Provide airway patency in patients with an intact gag reflex, trismus or oral trauma
- Contraindicated in patients at risk of a base of skull, nasal fractures or coagulopathy

Sizing / method of insertion
- Sized by measuring from the tip of the patient’s nose to the earlobe
- Apply lubricant then insert tube with bevel facing the nasal septum. Advance along the septum horizontally, following the natural curvature of the floor of the nasopharyngeal cavity and rotated 90 degrees to lie in the nasopharynx
- Tip of the nasopharyngeal should lie behind the uvula

(Life in the Fast Lane, 2017a/b)
Laryngoscope Blades

A laryngoscope is used to allow for visualization of the vocal cords to aid insertion of an endotracheal tube during rapid sequence intubation (RSI). The following laryngoscope blades are available in ED:

**Macintosh**

- Most common blade used in ED
- Curved blade that attaches to a long or short handle at 90 degrees
- Disposable or reusable available

**Miller**

- Straight blade used in children or difficult intubation in adults
- The tip of the blade is used to lift the epiglottis to visualise the vocal cords

**Video laryngoscope**

- Direct laryngoscopy
- Indicated in difficult intubations
- Commonly used to assist in training intubations

**McCoy**

- Similar to McIntosh blade with a moveable distal tip segment flexed by a lever to displace the larynx forward

*(Life in the Fast Lane, 2015)*
Endotracheal Tubes

Mallinckrodt – Tapeguard Evac
- Standard endotracheal tube with subglottic suction port
- Decreased risk of patient developing ventilator associated pneumonia due to the ability to aspirate secretions above the endotracheal cuff

Mallinckrodt – Hi-Contour Cuffed
- Standard endotracheal tube
- Size in paediatrics: Age/4 + 3

Mallinckrodt – Hi-Contour Cuffless
- Standard endotracheal tube
- Size in paediatrics: Age/4 + 4

Parker Flex-Tip
- Flexible tapered tip endotracheal tube
- Minimised airway trauma as the tube passes down the trachea on its curved backside
- Designed to facilitate rapid fibre optic intubation
**Mallinckrodt – Microlaryngeal**

- Oral or nasal intubations
- Smaller diameter
- Often used in laryngeal surgery or difficult intubations such as burns or angioedema

**Mallinckrodt – Reinforced Lo-contour**

- Used in nasal or oral intubations
- Reinforced to prevent kinking of the tube
- Radiopaque line down the tube to assist with radiographic visualisation

**Portex Profile Soft Seal**

- Used in nasal intubations
- Larger cuff
- Reduced risk of trauma during intubation and extubation as it is made from PVC material

(Covidien, 2011; Medtronic, 2018; Parker Smith Medical, 2011)
Supraglottic Devices

Classic Laryngeal Mask Airway (LMA)

Rationale for insertion
- Supraglottic airway device often used during elective anaesthesia in patients who are low risk for regurgitation
- In ED often used as a rescue airway in failed intubation
- Can assist with blind insertion of bougie or ETT into the trachea
- Improved pre-oxygenation during rapid sequence intubation (RSI)

Sizing / method of insertion
- Weight dependent
- Partially inflated prior to insertion with lubricant over LMA surface
- Inserted by ED doctor with the aperture facing towards laryngeal inlet or posteriorly with a 180 degrees twist once behind tongue then inflated with recommended volume of air into the cuff
- Does not protect the airway from patency, regurgitation or aspiration

LMA Supreme
- Decreased thoracic compliance
- Mild to moderate obese patients
- Mechanical ventilation when higher seal pressures are required
LMA Proseal

- Increased risk of aspiration patients
- Passive regurgitation
- High seal pressure required

LMA Fastrack

- Difficult intubations
- Pre hospital airway management
- LMA assisted intubation

(Teleflex, 2014)
Introducers

Stylets

- Designed to assist with tube placement during intubation
- Can be used to shape endotracheal tube
- Single use

Frova Bougie

- 70cm in length with a 30 degree fenestrated angle tip
- To facilitate endotracheal intubation in patients where the visualization of the glottis is inadequate
- Single use

Aintree Bougie

- Replacement of an endotracheal tube or tracheostomy tube, when one is already in place
- Bronchoscope-assisted exchange of a supraglottic airway device (LMA) for an endotracheal tube
- Hollow central lumen with distal side holes and a connector that can attach and enable oxygen insufflation

Cooks Exchange Catheter

- Intended for uncomplicated, atraumatic endotracheal tube exchange
- The distal section of the catheter is flexible
- The lumen and distal side ports are designed to deliver oxygen
Suctioning

Suctioning should always be performed using sterile technique. Single use catheters and closed system inline catheters are available for endotracheal suctioning. Regular oropharyngeal suction may be required due to the patient’s impaired swallow and gag reflex.

Indications

- Excess secretions
- Mucous plugging
- Vomiting during RSI

Complications

- Oropharyngeal mucosal trauma
- Haemodynamic instability
- Atelectasis
- Raised intracranial pressure
- Hypoxaemia
- Bacteraemia

(Hyzy, 2017; Royal Children’s Hospital, 2016)
Suctioning Devices

Oropharyngeal (Adult & Paediatric)

- Single patient use
- Oropharynx and or nares only
- Rigid plastic
- Transparent for visualisation of secretions or type of fluid
- Vigorous or prolonged suctioning with this suctioning device may cause tissue grabbing causing oropharyngeal trauma
- Risk of vagal stimulation

Single Use Catheter Oropharyngeal & Endotracheal

- Each catheter is single use
- Soft flexible plastic
- Suitable for nares, nasopharynx, oropharynx and down airway adjuncts
- Risk of vagal stimulation
- Activate suctioning only when withdrawing the suction catheter

Closed System Endotracheal Suction

- Single patient use for max 72 hours
- Suctioning device for the removal of secretions from the tracheobronchial tree of ventilator dependent adult patients

(Elmansoury & Said, 2017)
Difficult Airway Algorithms

For any intubation in the emergency department, part of pre planning should include the potential for a difficult airway and the associated management. These are some examples of difficult airway algorithms used in emergency departments in Western Australia.
“CANT INTUBATE, CANT VENTILATE” (CICV) ALGORITHM

CICV

失败

Cannula cricothyroidotomy or cannula tracheotomy

失败

Palpable neck airway anatomy?

NO

失败

Scalpel finger cannula

失败

Scalpel bougie

NO

失败

YES

失败

JET VENTILATE & STABILISE

Melker 5.0 cuffed Seldinger technique

失败

JET VENTILATE & STABILISE

Railroad size six E.T. tube

失败

Consider: Awaken/other upper airway techniques

失败

Melker 5.0 cuffed Seldinger technique
Difficult Airway Management

Needle Cricothyroidotomy

- Difficult airway algorithm – Invasive rescue method to temporarily oxygenate the patient
- Intravenous cannula inserted through the cricothyroid membrane
- Life saving measure but may cause significant morbidity

Rapid 02 Jet Ventilation System

- Oxygen flow delivery system is used in conjunction with emergency needle cricothyroidotomy
- Oxygen flow at 15 L/min as a minimum for adults or 1L/min per year of age in children
- Intermittently cover and release the holes in the delivery system by pressing thumb and index finger together allows control of oxygen delivery
- 1st breath recommended to be delivered over 4 secs (250ml/sec at 15L/min) then release and wait for a response within 20seconds (decreased Spo2)
- Repeat breaths delivered over 2 seconds and release and wait for a response
**Surgical Bougie / ETT Cricothyroidotomy**

- Vertical incision through skin and subcutaneous tissue over cricothyroid membrane
- Blunt dissection with fingers or forceps to identify cricothyroid membrane
  - Incision is made through the cricothyroid membrane and the bougie is passed into the trachea through the incision
- Guide size 6 ETT over bougie into the trachea and inflate cuff
- Ensure ETT secure and remove bougie
- Connect to BVM to oxygenate and ventilate
- Contraindicated in children <12 years or open tracheal injury

**Surgical Melker Cricothyroidotomy Set**

- Similar to a bougie/ETT surgical cricothyroidotomy except a pre made kit is used to pass a tracheostomy like tube over a guidewire through the cricothyroid membrane (seldinger technique)

**Surgical Tracheostomy**

- Inserted subglottic through neck tissues directly into the trachea
- Difficult airway management including upper airway obstruction or to facilitate weaning from prolonged mechanical ventilation

(Bose et al., 2016; Life in the Fast Lane, 2016)
Complications Associated with Surgical Airways

- Failed insertion
- Bleeding
- Infection
- Damage to surrounding structures (larynx, vessels, nerves & oesophagus)
- Cricoid fracture
- Fistula formation
- Scarring
- Hypoxia
- Death

(Life in the Fast Lane, 2016)

Confirmation of Endotracheal Placement

- Visual assessment (Tube passing through the cords / misting within the tube)
- etco2 detection
- Air entry on auscultation
- Chest Xray

Position of an ETT tube on Chest X-Ray

The tip of the ETT tube should be positioned in the trachea approximately 2-5cm above the carina.

Endotracheal external position

Where possible, the length of the endotracheal tube should be measured at the patient’s teeth or gums. The patient’s lips may swell as a result of trauma or anaphylaxis. Typically, the endotracheal position in women is 20-21cm and 22-23cm in males but this may vary with age and size.

(McQuillan & Tarmey, 2017)
Securing an Endotracheal Tube

Paediatric & Adult

Complications Associated with Securing Endotracheal Tubes

- Dislodgement
- Raised intracranial pressure
- Venous obstruction

(Queensland Ambulance Service, 2016)
Endotracheal Cuff Pressure

The ETT cuff provides a seal between the ETT and the tracheal wall to ensure the accurate delivery of tidal volume during mechanical ventilation. Cuff pressure should be maintained between 20-30cmH2O but this may be affected by multiple factors such as patient position, ETT size and ventilator settings. It is recommended that cuff pressures are checked at least once per shift or when you are troubleshooting ETT or ventilator problems.

Over inflation of the cuff may cause complications such as tissue ischemia, ulceration and necrosis of the trachea wall. Inadequate cuff pressure may result in air leaks, aspiration pneumonia from oropharyngeal secretions and inadequate ventilation.

Mechanical Ventilation

Indications for Mechanical Ventilation

- Increase functional residual capacity
- Correction of hypoxia
- Facilitation of gas exchange
- Decrease work of breathing

Complications of Mechanical Ventilation

- Barotrauma
- Volutrauma (increased alveolar/capillary permeability from over distension)
- Atelectrauma (damage due to the recruitment/derecruitment of collapsed alveoli)
- Haemodynamic instability (decreased cardiac output / hypotension)
- Respiratory muscle fatigue
- Ventilator required pneumonia
- Oxygen toxicity
- Raised intracranial pressure

(Draskovic & Rakic, 2011; Furesz, 2016)
Ventilation Terminology

Mandatory Breath

A breath that is triggered, limited, and cycled by the ventilator. The ventilator performs all the work of breathing.

Assisted Breath

A breath that is triggered by the patient, then limited and cycled by the ventilator.

Supported Breath

A breath that is triggered by the patient, limited by the ventilator, and cycled by the patient. A spontaneous breath with an inspiratory pressure greater than the baseline.

Spontaneous Breath

A breath that is triggered, limited, and cycled by the patient. The patient performs all of the work of ventilation.

Respiratory Rate

The number of breaths the ventilator is set to deliver in a minute.

Tidal Volume (TV or Vt)

The volume of gas moved in and out of the lung in a single normal inspiration or expiration. It averages 500 mL or 5-8 mL/kg. To reduce the risk of acute lung injury (ALI), tidal volumes should not exceed 10 mL/kg.

Minute Volume (MV)

The volume in litres delivered to the patient in one minute -

Tidal Volume (TV) x Respiratory Rate (RR) = Minute Volume (MV)

Fraction of Inspired oxygen (FiO2)

The concentration of oxygen delivered with each breath. Room air is 21% oxygen = FiO2 0.21. Maximum oxygen is 100% = FiO2 1.0
Positive End Expiratory Pressure (PEEP)

The amount of pressure left in the lungs at the end of expiration. This keeps the alveoli open and reduces alveolar collapse. PEEP also increases functional residual capacity and improves oxygenation. PEEP is measured in cmH$_2$O and generally set at 5-10 cmH$_2$O. PEEP maintains a positive pressure within the lungs and is an alveolar recruitment technique.

Pressure Support (PS)

The pressure support level is set to assist the patient during a spontaneous breath to achieve an adequate tidal volume. PS is measured in cmH2O.

Inspiratory Time / Tinsp (s)

The amount of time taken to deliver the tidal volume (inspiratory breath). The Tinsp in set in seconds (often 1 – 1.7 seconds). Note: Changes to the Tinsp(sec) will alter the I:E ratio.

Inspiratory : Expiratory Ratio (I:E ratio)

The ratio of inspiration to expiration per each respiratory cycle. Spontaneous respiration has an I:E ratio of 1:2, but on a ventilated patient in can be manipulated to improve gas exchange. Note: On the Oxylog 3000+ the I:E ratio is manipulated by the time inspired.

Slope

The time it takes for the ventilator to reach the peak inspiratory flow. It is defaulted to 0.20 seconds of the inspiratory time. It slightly slows the flow to help open alveoli and prevent alveolar trauma. Not routinely adjusted.

Trigger

Determines how the ventilator senses the patient’s spontaneous breathing efforts and how much effort the patient has to do to trigger the ventilator. There is a constant base flow of gas through the ventilator tubing. When the patient takes a spontaneous breath, the flow of gas will be “sucked” by the patient into the lungs dropping the flow returning to the ventilator. This drop in flow returning to the ventilator is what triggers the ventilator to respond. This is a flow trigger. The Oxylog 3000+ combines a flow and pressure trigger. A spontaneous breath creates a drop in pressure (0.2 mbar) as well as a drop in return flow. The trigger is set in
L/min. The higher the trigger is set, the greater the patient’s inspiratory effort will need to be to trigger the ventilator to respond. Not routinely adjusted.

**Flow Rate**

The amount of air flow through the tubing during a breath. This is measured in litres per minute.
Joondalup Health Campus (JHC) ED has four Draeger Transport Ventilators the Oxylog 3000+.

The following modes are available on this ventilator:

- Controlled (Continuous) Mandatory Ventilation (CMV)
- Assist Control Ventilation (ACV)
- Synchronised Intermittent Mandatory Ventilation (SIMV) – Volume controlled
- Synchronised Intermittent Mandatory Ventilation (SIMV) - Pressure controlled
- Non-Invasive Positive Pressure Ventilation (spn CPAP)

(Draeger, 2015)
Controlled (Continuous) Mandatory Ventilation (CMV)

This ventilation mode delivers a pre-set TV at an interval set by the breaths per minute. For example a set TV of 500mls and a set rate of 12 breaths means the ventilator will deliver a 500ml breath every 5 seconds. This mode does not allow for changes in lung resistance or compliance, or for any respiratory effort made by the patient. For this reason, this mode is rarely used. If used patients must be sedated & paralysed.

Select and confirm VC-CMV mode:
- Set tidal volume
- Set respiratory rate
- Set PMAX
- Set Fi02
- Set PEEP
- Set I:E Ratio
- Auto flow on or off
- Ensure Trigger turned OFF
- Set patient alarms

Assist Control Ventilation (ACV)

In this ventilation mode, the patient always receives at least the set VT. Every detected inspiration effort of the patient at PEEP level triggers an additional mandatory breath. The patient thus determines the number of additional mandatory breaths. To give the patient sufficient time for expiration, it is not possible to trigger another mandatory breath immediately after a completed breath. If after the completion of the expiratory time no mandatory breath has been triggered, a mandatory breath is automatically applied (backup frequency). The control knob for respiratory rate (RR) therefore defines the minimum ventilation frequency. Because the number of mandatory breaths depends both on the patient and the set frequency (RR), the minute volume (MV) can vary.

Select and confirm VC-CMV mode:
- Set tidal volume
- Set respiratory rate
- Set PMAX
- Set Fi02
• Set PEEP
• Set I:E Ratio
• Auto flow on or off
• Ensure Trigger turned ON
• Set patient alarms

Synchronised Intermittent Mandatory Ventilation (SIMV) – Volume Controlled

For patients with inadequate spontaneous breathing, or for patients who are to be weaned gradually. The patient can breathe spontaneously between the mandatory breaths delivered by the ventilator, and thus contribute to the total minute volume. Spontaneous breathing can be assisted with Pressure Support (PS) when set.

In the SIMV mode there is a trigger window within each cycle which allows the ventilator to synchronise the mandatory breath with the patient’s own respiratory effort. For example if the RR is set at 12, each cycle is 5 seconds (60seconds/12 breaths). If the patient initiates a breath, the ventilator will synchronise the mandatory breath and provide PS to deliver a set TV to the patient. If the patient does not initiate a breath, then the ventilator will deliver the mandatory breath. During each cycle the first respiratory effort from the patient will trigger a synchronized mandatory breath, any further respiratory effort within the cycle will result in a pressure supported breath (if PS is set). This pressure supported breath will be as big/small as the patient desires. During a pressure supported breath the ventilator senses an inspiratory effort and applies a set positive pressure by increasing the flow of gas to the patient to augment the patient’s attempt at taking a breath. In volume control modes, the mandatory breaths are a set volume and the pressures within the lungs are variable depending on the resistance and compliance.

Select and confirm SIMV-VC mode:
• Set tidal volume
• Set respiratory rate
• Set PMAX
• Set Fi02
• Set PEEP
• Set I:E Ratio
• Set Pressure Support
**Auto flow on or off**

**Set patient alarms**

---

**Synchronised Intermittent Mandatory Ventilation (SIMV) - Pressure Controlled**

In PCV a pressure is set rather than a tidal volume. In PCV the mandatory breaths deliver a pre-set pressure during the pre-set inspiratory time. The tidal volume cannot be manually adjusted. Pressure-controlled ventilation combined with spontaneous breathing throughout the breathing cycle gives variable pressure support. Therefore in PCV the pressure is fixed and the tidal volume is the variable, dependant on the resistance and compliance of the lungs. SIMV+ (PC) on the Oxylog 3000+ synchronises the mandatory breaths with the patient's own respiratory effort. The patient can breathe in and out during the mandatory breath but maintains the set pressure for the inspiratory time.

Pressure control does not guarantee minute ventilation, and therefore requires more monitoring by the operator. The minute ventilation is a complex mix of the peak pressure, the time inspired (Ti), the lung and chest wall compliance, resistance in the airway and from other thoracic structures. If there is a rapid change in the compliance, then the patient may hypoventilate and become hypoxic.

To initiate pressure control is slightly more difficult than volume control. Again, the PEEP and FiO2 are determined by lung mechanics and oxygenation targets. The inspiratory pressure is determined by looking for a tidal volume of 5-8ml/kg. The respiratory rate is determined by the minute volume requirement. The inspiratory time is usually set at 1sec, but can be increased if:

1. Target tidal volume is not achieved
2. The patient remains hypoxic in spite of a plateau pressure 30cmH2O. In this way the mean airway pressure is used to increase overall lung volumes, and improve V/Q matching.

*Note: Longer inspiratory times and faster respiratory rates predispose to alveolar gas trapping.*

**Select and confirm SIMV-PC mode:**

- Set respiratory rate
- Set PMAX
- Set FiO2
- Set Pinsp to achieve calculated tidal volume
- Set PEEP
- Set Pressure Support
- Set I:E Ratio
- Set patient alarms

**AutoFlow**

AutoFlow is a function of the Oxylog 3000+ and is an adjunct to volume controlled ventilation modes. It automatically regulates inspiratory flow and inspiratory pressure. When AutoFlow is activated the inspiratory flow pattern changes from the constant flow typical of volume controlled ventilation to a decelerating flow pattern usually associated with pressure controlled ventilation. AutoFlow is only available in volume controlled modes such as VC-CMV, VC-AC, VC-SIMV, VC-SIMV/PS.

The aim is to deliver the set tidal volume at the lowest possible inspiratory pressure, therefore reducing peak airway pressures. It will also allow the patient to breathe any time in the respiratory cycle.

On the first breath the ventilator measures peak and plateau pressures to calculate the flow required to provide the minimal pressure to obtain the set tidal volume. The ventilator will subsequently measure each breath and provide the flow according to the measurement of the previous breath.

AutoFlow is not recommended for patients with irregular breathing patterns such as asthmatics, as the ventilator cannot maintain the set tidal volume. In this case the ventilator will alarm ‘volume not constant’ or ‘low minute volume’. You may need to de-activate AutoFlow in these instances. The Pmax alarm has an additional function during AutoFlow: it limits the inspiratory pressure control to a level of 5mbar below the Pmax setting. Therefore the alarm ‘VT low, pressure limit’ will occur if the pressure alarm is set within 5cmH₂O of the peak pressure.
Non-Invasive Positive Pressure Ventilation (spn CPAP)

At JHC ED this mode is used for the transport of patients receiving non-invasive positive pressure ventilation (NIPPV) on the V60 and need to be transferred to another facility.

*Select and confirm spnCPAP mode:*
- Set NIV to ‘ON’
- For CPAP – Set a PEEP
- For BiPAP – Set a PEEP (EPAP) and PS (Difference between IPAP and EPAP)
- Set FiO2
- Set Alarms

*Note:* PEEP (EPAP) will be set between 5cmH₂O and 10cmH₂O as usual. Pressure support (PS) is then set at a number above the PEEP to support inspiration (approximately 10cm - 20cmH₂O). With the Oxylog 3000+, PS is added to the PEEP to give a peak inspiratory airway pressure (IPAP). For example, a patient receiving BiPAP on the V60 with a PEEP(EPAP) of 5cm and Inspiratory pressure(IPAP) at 15cm will have the values on the Oxylog set as a PEEP of 5cmH₂O and PS of 10cmH₂O to achieve a peak inspiratory pressure (PIP or IPAP) of 15cmH₂O.

When changing the patient who requires BiPAP/CPAP from the V60 to the Oxylog, the patient’s mask must also be changed to the Draeger NIPPV Disposable Mask (see below). Do not use the mask which is used on the V60.

See Appendix F
Invasive & Non-Invasive Observation Chart

<table>
<thead>
<tr>
<th>Baseline settings</th>
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</thead>
<tbody>
<tr>
<td><strong>Date</strong></td>
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<tr>
<td>MRN: .................................................</td>
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<tr>
<td>IPPV</td>
</tr>
<tr>
<td>Mode:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Patient ventilator observations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date</strong></td>
</tr>
<tr>
<td>OBSERVATIONS</td>
</tr>
<tr>
<td>DATE</td>
</tr>
<tr>
<td>TIME</td>
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<tr>
<td><strong>SpO2</strong></td>
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<tr>
<td><strong>pH</strong></td>
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<tr>
<td><strong>BSL mmol/L</strong></td>
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</tbody>
</table>
Troubleshooting Common Ventilator Problems

Always review the patient first and have first line equipment for airway and breathing management readily available including bag valve mask. Use a systematic assessment to start troubleshooting from the patient back to the ventilator and wall. Consider the following:

- Patient – Complication of ventilation, inadequate sedation/paralysis, anaphylaxis or change in clinical condition
- Endotracheal tube – Placement, position and patency
- Ventilation circuit – Connect, patency, damage or leaks
- Ventilator – Mode, settings or battery life
- Wall – Oxygen supply or power

Decreasing SaO2

- Check position of the SaO2 probe
- Consider if patient is peripherally shut down as effective SaO2 monitoring may be difficult
- Review patient’s haemodynamic status (perfusion etc)
- Auscultate for equal air entry
- Review the ventilator settings
- Review ABG’s
- Increase FiO2 (if less than 100%)
- Do they need PEEP or Pressure Support?
- Do they need suctioning?

Low Minute Volume

- Assess for a leak in the circuit
- Not coping with the leak around the ETT?

High Minute Volume

- Spontaneous breathing
- Need for further sedation/paralysis
High Airway Pressure

- Reduced compliance
- Chest trauma
- Lung collapse
- Increased airway resistance
- Bronchospasm
  - Consider bronchodilators
- Mucosal oedema
- Obstruction
- Mucous / secretions
- Kinked tubing
- Biting on the tube
- Resisting the ventilator (coughing, spontaneous breathing etc.)
- ETT in right main bronchus

Low Airway Pressure

- ETT leak
- Leaking circuit
- Disconnection

Increasing ETCO2

- Increase Respiratory Rate
  - Consider ABG – Ventilator setting changes should be done in conjunction with checking ABG’s
  - Need to encourage medical staff to do an ABG and if possible add an ART Line

Decreasing ETCO2

- Decrease set Respiratory rate
  - Consider ABG – Ventilator setting changes should be done in conjunction with checking ABG’s
Need to encourage medical staff to do an ABG and if possible add an ART Line

**Machine/ Battery Failure**

- Connect to power source
- Handbag with Bag Valve Mask
- Seek alternative ventilator

**Decreasing BP**

**Identify**
- Drop in blood pressure
- Reduced urine output

**Reasons**
- Increase in intrathoracic pressure from PPV causes impaired pre load
- Sedation drugs will cause hypotension

**What can be done to correct this problem?**
- Fluids
- Reduce PEEP
- Consider inotropes (need to have a central line – if inotropes are required you can start with a peripheral line in the short-term)

**Increasing ICP**

**Identify**
- Pupils changing (may be masked secondary to opiate sedation)
- Widening pulse pressure
- Bradycardia

**Reasons**
- Patients who have had traumatic or non-traumatic cranio-cerebral injury most at risk
- Changes to intrathoracic pressure impairs cerebral perfusion pressures
- Intrathoracic pressure increases with PPV and PEEP. As ICP rises, cerebral perfusion can decrease secondary to drop in cardiac output as a consequence of
increased intrathoracic pressures. PPV has no adverse effects on ICP in individuals with normal cerebrovascular haemodynamics.

What can be done to correct this problem?

- If possible, avoid suctioning
- Rapid Sequence Intubation with lots of sedation and analgesia
- Cluster care to decrease auditory, tactile and painful stimulus to decrease ICP
- Consider raising head of bed 30 degree if not contra-indicated (i.e. spinal precautions)
- Decrease TV and increase RR.
- Hyperventilation or hyperoxygenation is not recommended

**Gastric Distension**

**Identify**

- Distended, tight, abdomen – on occasion can see a “gastric bubble” on x-ray. This pocket of air can “splint” the diaphragm and make it difficult to inflate the lungs
- The airway doctor/nurse may report difficulty administering O2 via BVM
- The ventilator may alarm high peak airway pressures

**Explain reasons why**

- Gastric distension may occur as air is swallowed or forced down into the stomach during use of a BVM etc before insertion of an ETT

**What can be done to correct this problem?**

- NGT or orogastric on straight drainage

(Byrd, 2017)
Nursing Considerations for the Intubated & Ventilated Patient

Patients on a ventilator are nursed 1:1 so that the patient can be monitored closely and quick responses made to alarms. Both ventilation and haemodynamic observations are recorded 15 minutely whilst the patient is in ED.

A systematic approach should always be used to assess and reassess an intubated patient.

Airway

- ETT position and size are checked at the beginning of each shift and each time the patient is moved. The position (cm at lip or teeth) is important to establish if the tube has migrated in/out.
- The ETT position is checked on a chest x-ray (post RSI). The end of the ETT should sit 2-5cm above the carina.
- It is important to know the size of the patients ETT in case of an emergency re-intubation.
- Make sure the ETT is secured well.
- Cuff Pressure – cuff pressure must be measured with a manometer each shift and recorded. If the pressure is too high in the cuff it can cause damage to the trachea. If the pressure is too low air will leak around the tube and the risk for aspiration is increased.
- Moving the Patient – to ensure the ETT is secure during repositioning of a patient, bed transfers etc, a nurse or doctor will hold the ETT to prevent dislodgement or accidental extubation.
- The maintenance of oral integrity is mandatory for ventilated patients. Ensure that the ETT stays at the same position.

Breathing

- Auscultate chest - listening for equal air entry in both lungs and adventitious breath sounds.
- Observe chest for equal expansion and respiratory patterns e.g. evidence of paroxysmal movement.
Ventilator

- Always check and set ventilator alarms at:
  - Beginning of each shift
  - Post intubation
  - Commencement of artificial ventilation
  - When you take over the care of an intubated patient.

Extubation in ED

Extubation is rarely carried out in the ED and should only be decided on by an experienced ED doctor or intensivist. For example, this may occur after consultation with a patient’s family if the patient has a terminal illness or if there is an advanced health directive insitu. If the decision is made to extubate a patient who requires ongoing airway management, medical and nursing staff who are qualified to re-intubate if required, are present and prepared.

When a patient who is intubated in ED dies, all invasive equipment such as the ETT must remain insitu until it is decided whether or not it is a coronial investigation by the treating emergency doctor.

(Life in the Fast Lane, n.d.)
Transport of the Ventilated Patient

Preparation is the key.

- Confirm time of patient transport and the destination
- Familiarise self with patients history/ current status
- Ensure ETT is secure and document position
- Confirm and check ventilator settings
- Aspirate oral/ nasogastric tube and record on fluid balance (if required)
- Ensure adequate IV fluids/ medications for transport
- Check transport equipment
  - Adequate O2 supply in transport cylinders
  - Suction and suction catheters available
  - Adult or paediatric transport bag
  - Stethoscope
  - Monitoring equipment
  - Transport defibrillator
- Determine need for analgesia/ sedation/ paralysis prior to departure
- Ensure notes are transferred/copied – originals to remain at JHC
- Reconfirm destination is ready to receive patient/ Ambulance expected time
- Confirm Medical escort and establish rapport

During Transportation

- Monitor patients haemodynamic status 15 minutely unless indicated more frequently
- Ongoing airway and respiratory assessment including ETT position and ventilator settings
- Document any medication, fluid or blood product administration
- Only suction ETT if required
- Ensure return of all equipment to ED
**Rapid Sequence Induction Checklist**

**Prepare Patient**
- Optimize preoxygenation
- Consider High Flow Nasal Prongs
- Optimize position
- Optimize haemodynamics
- Consider fluid bolus
- Consider pressors
- Assess for obvious airway risks
- IV adequate and patent, 2 x IV access if possible
- Fall monitoring
  - ECG
  - NIBP short interval
  - Sat's Probe
  - Capnomography
- Equipment checked
  - Suction on & under mattress
  - BMV
  - 2 x ET tubes (only open 1) and LMA
  - 2 laryngoscopes
  - Bougie or stylet
  - ETCO2 monitor
- Drugs
  - RSI drugs drawn up, Labelled
  - Emergency drugs
  - Fast intubation drugs

**Prepare Equipment**
- Rescue devices and surgical airway identified and located (do not open)
- Team leader verbalise any expected complications e.g.
  - Cardiovascular collapse post RSI
  - Pneumothorax with high airway pressures
- Team leader ask for questions from the team

**Prepare Team**
- Identify and name
  - Team leader
  - Airway doctor
  - Airway nurse (R1)
  - Cricoid (if applying it)
  - Drug doctor
  - Procedure nurse (R2)
  - C Spine (if required)
  - Scribe
- Team leader deliver plan and difficult intubation plan
- If help required, verbalise method of contacting
  - Duty Consultant
  - Anaesthetist ext 9121

**Prepare Trouble**

*Developed by Resuscitation Focus Group July 2015 updated January 2017*
Appendix B

Guide to Using Non-Invasive Ventilation on the Oxylog 3000+

**STEP ONE**
Attach an appropriately sized dragger NIV mask to the ventilation tubing
Masks available in Small, Medium, Large in the Resus Storeroom

**STEP TWO**
Turn the Oxylog onto Spn CPAP mode

**STEP THREE**
Turn NIV on

**STEP FOUR**
Set the CPAP or BiPAP settings

**CPAP**
- Set the required CPAP by setting a PEEP
- Turn the Pressure Support (Psupp) to 0mmH₂O

**BiPAP**
- Set the EPAP by setting a PEEP
  (i.e. 5cmH₂O EPAP = 5cmH₂O CPAP)
- Set the IPAP by setting the Psupp. The Psupp is the difference between the IPAP and EPAP
  (i.e. 15cmH₂O IPAP - 5cmH₂O EPAP = 10cmH₂O Psupp)

**STEP FIVE**
Set the FiO₂ with the dial button
References


