PARTNERSHIP IN CRITICAL CARE DEPT. WAIKATO

CRITICAL CARE WAIKATO HOSPITAL

WORKBOOK

NAME:

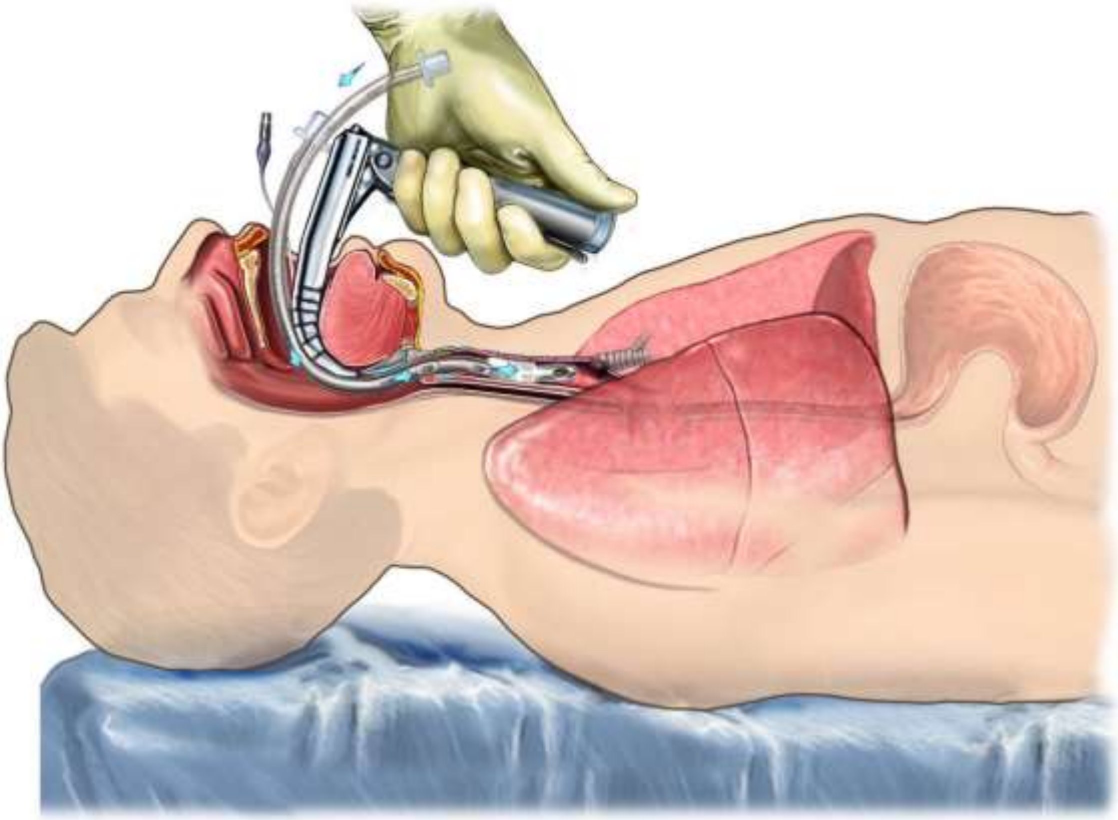
Te Hanga Whaioranga Mō Te Iwi
Building Healthy Communities

Waikato District Health Board

Section 3

Respiratory interventions & care of the mechanically ventilated patient

Intubation



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Insertion of a cuffed artificial airway (an endotracheal tube or a tracheostomy tube) is the gold standard for airway protection. The principal reasons for performing this procedure are: 1. to protect the airway of someone with a lowered level of consciousness (e.g. absence of a cough, gag or swallow reflex) 2. Respiratory failure in a patient requiring the support of a ventilator and removal of secretions by ET suction and 3. For major operations and procedures, such as cardiac surgery.

Most intubations involve the use of a laryngoscope to help the intubator to view the vocal cords so that an endotracheal tube (ETT) can be inserted through the cords and into the trachea.

In the vast majority of cases, drugs will be administered to facilitate this process. They include a sedative to put the patient to sleep (such as propofol, etomidate or midazolam) and a neuromuscular blocking agent to paralyse the patient's skeletal muscles (such as suxamethonium or rocuronium). It is also essential to consider having available drugs or IV fluids to support the patient's blood pressure, as this often falls rapidly once the sedative and neuromuscular blocking drugs have been given. These drugs might include noradrenaline (if the patient has a central venous line), phenylephrine (if the patient has only a peripheral intravenous cannula) or IV fluids such as normal saline. The choice of the appropriate drugs and IV fluids is at the discretion of the medical team who will request and prescribe them if needed.

A minimum of four people is required to perform an intubation in this critical care unit:
1. the intubator (usually a registrar or consultant) who stands at the head of the bed
2. An assistant to the intubator, who stands to the patient's right and prepares and

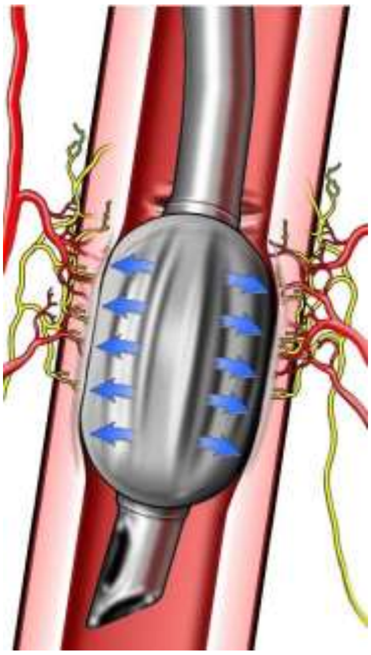
passes equipment to the intubator (e.g. the ETT, etc.) 3. A person to administer the intubation drugs (they will be positioned close to the patient's IV access), and 4. If cricoid pressure is ordered, the fourth person will apply this when asked. They are positioned to the patient's left. Because cricoid pressure, once applied, is not very mentally demanding, this person can also watch the monitor for changes, especially falls in blood pressure or oxygen saturation.

For more detail on the above procedure, please refer to the following service specific procedure: 'Artificial Airway – Endotracheal Intubation'

Care of the patient with an endotracheal tube

Once the ETT has been inserted and its positioning has been confirmed by a combination of $EtCO_2$ waveform analysis, chest auscultation and a chest x-ray, the tube can be secured by following this service specific procedure: Artificial Airway – Securing Oral Endotracheal Tube. To avoid pressure areas and discomfort to the patient, secure the tube slightly away from the corner of the mouth. The tube tapes are changed every day, at which time the tube is moved across towards the opposite side of the mouth.

The cuff of the ETT needs to be adequately inflated so that it provides a seal within the trachea to facilitate positive pressure ventilation and to reduce the risk of aspiration of any fluid which may be sitting above the cuff. However, if the cuff is over-inflated, there is a risk of pressure damage to the tracheal mucosa. For these reasons, it is essential to carefully manage ETT cuff pressures, using the following procedure 'Artificial Airway – Tracheal Cuff Pressure Management'. There is also an educational video about this on the ICU Education Hub.



Cuff Manometer

Care of the mechanically ventilated patient

Usually, once the patient has been successfully intubated they will be connected to a ventilator. There are a number of different modes that can be used to ventilate the patient, and the choice of the most appropriate mode depends on a number of factors, such as the level of consciousness of the patient, their lung compliance / resistance, cardiovascular stability etc.

There are many different ventilation strategies used to try to achieve the best outcome for patients. There are also different varieties of ventilators, each with their own selection of modes. There is also significant variance between clinicians regarding their preferences for different ventilation strategies and, in addition, trends and fashions in ventilation vary over time. However, despite these many variables, here are some examples of some 'typical' ventilation strategies used for a variety of patients:

1. A patient with a traumatic brain injury (with healthy lungs).

In this clinical situation, the primary goal is to rest the patient's brain to minimize brain swelling. As a result, this patient will usually be heavily sedated and the ventilation will be controlled. The patient will not usually initiate any breaths; all the breaths will be administered and initiated by the ventilator. The doctor will set the **rate**, or **frequency** (e.g. 12 breaths per minute) and the **tidal volume** (this is usually 6-8mls per kg, so for a 75kg person this might be a tidal volume of 575ml). The tidal volume is the amount of oxygen/air moving in and out of the lungs with each breath. If, as in this example, you set a rate of 12 and a tidal volume of 575ml, this will result in a **minute volume** of 12 x 575 = 6,900ml (6.9L). Incidentally, with traumatic brain injury patients it is essential to maintain the PCO_2 within a narrow range, and the minute volume will be titrated carefully to achieve this.

A typical mode used to deliver the above ventilation would be SIMV volume control. With this mode, you can set a mandatory rate and tidal volume and the ventilator will deliver this. This mode also allows the patient to breathe spontaneously if appropriate, but in this clinical situation (in the critical first few days), we would normally sedate the patient so heavily that they would not initiate any spontaneous breaths.

2. A patient waking up after surgery (with healthy lungs)

If a patient had had a major operation, such as an abdominal aortic aneurysm repair, then our goal will be to wake, wean and extubate the patient as soon as it is clinically safe to do so. They might initially be on SIMV as described above, but then, when the patient begins to awaken, they might begin to initiate some spontaneous breaths. Once they begin to appear as if they could breathe spontaneously, then the medical team might change them onto a spontaneous mode, such as '**spont**' or '**pressure support**'.

In these modes there is no set rate. The patient initiates every breath. The ventilator is able to detect the fact that the patient is breathing, and each time it detects a breath it 'helps' the patient to take the breath by delivering some 'pressure support', which makes it much easier for the patient to breathe. The amount of pressure support is dialled into the ventilator. The higher the pressure support, the easier it is for the patient to take the breath. A typical pressure support setting would be 10cm of water, but this varies.

With ‘pressure support’ or ‘spont’ mode, it is essential to be vigilant in case the patient has an excessively slow respiratory rate or becomes apnoeic, or becomes tachypnoeic and develops respiratory distress (the ventilator will alarm if the alarm settings have been entered appropriately). Some spontaneous modes have a back-up so that, if the patient becomes apnoeic, it will cut in and deliver mandatory breaths. It is essential to know whether or not the mode in use has this back-up facility.

Once the patient is on minimal pressure support and looks comfortable, with good saturations and ABGs, on minimal oxygen, a decision may be taken to extubate them.

3. <u>A patient with severe pneumonia / ARDS</u>
In this case, the primary problem is the lungs, and ventilation can be very challenging (please refer the sections on pneumonia / ARDS in this handbook for more information about these diseases). Extensive research over the last 20 years has shown that patients with ARDS benefit from having small tidal volumes and high **PEEP**. It is thought that the small tidal volumes reduce the damage caused by overstretching the lungs. PEEP means ‘positive end expiratory pressure’. In normal respiration, our alveoli usually close at the end of each breath, but PEEP maintains a higher than normal pressure in the alveoli at the end of expiration. This means they are less likely to collapse and remain collapsed (atelectasis) and also that gas exchange can occur throughout the respiratory cycle. It also reduces the work of breathing required to reopen collapsed alveoli, so it ‘rests’ the lungs.

Most (probably all) ventilated patients in ICU will have some PEEP applied (usually around 5cm water for uncomplicated patients), but patients with very sick lungs, such as ARDS patients, may have significantly more than this (e.g. 15cm water).

Patients with ARDS sometimes have a mode of ventilation called ‘Bilevel’ or ‘Duopap’, in which case, instead of dialling in a tidal volume, the medical team will set 2 levels of PEEP. A high PEEP (e.g. 30cm water) and a low PEEP (e.g. 15cm water). As the PEEP changes from the low to the high PEEP, gas enters the lungs (inspiration) and when the PEEP returns to the lower level expiration occurs. These patients will often require sedatives to tolerate this unusual breathing pattern.

<u>Modes of ventilation & ventilation terminology</u>
The above 3 examples provide a general idea of the rationale for choosing a particular ventilator mode. Below is a list of some of the main ventilator modes with a brief description of each, and some of the terminology used when describing ventilation:

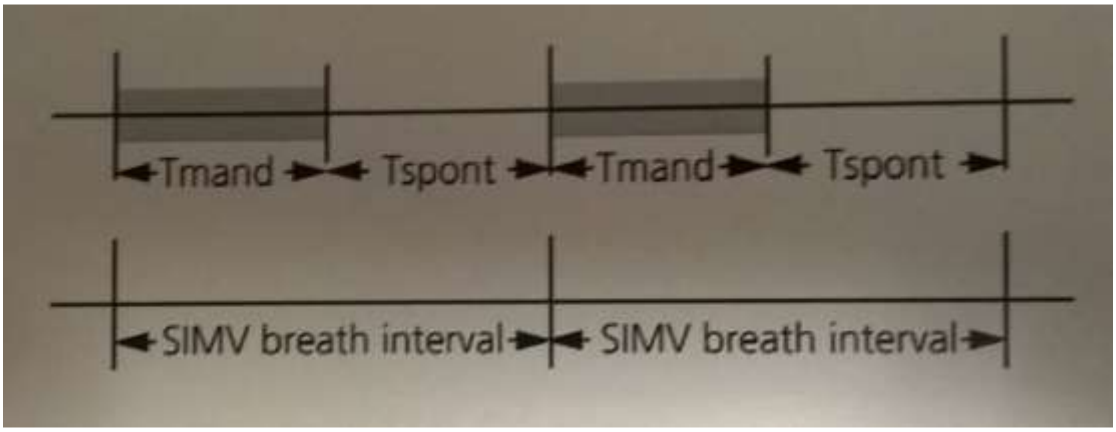
<u>Hamilton G5 Ventilator Modes</u>

1. **SIMV**
With SIMV, you set the respiratory rate (frequency) and the tidal volume. (e.g. 10 x 600ml). If the patient does not breathe spontaneously, the ventilator will simply deliver these 10 breaths per minute. However, if the patient attempts to take a breath, the ventilator will allow him to do so.

As you can see in this example, there are 10 breaths programmed per minute, so, in this case, there is a ‘window’ of 6 seconds, called the ‘SIMV window’, or the ‘SIMV breath interval’. The SIMV window is split into 2 halves, the ‘mandatory window’ and the ‘spontaneous window’ (see diagram below).

During the ‘mandatory window’, the ventilator waits for a short time and if the patient attempts to take a breath in this period then he will be given a full mandatory breath, synchronised with his inspiratory effort. If the patient doesn’t take a breath during this time, a full mandatory breath will be given.

Next comes the ‘spontaneous’ window; If the patient attempts to take a breath during this period then he will be allowed to do so, and the size (volume) of the breath will depend on the patient’s own respiratory effort, assisted by whatever level of pressure support has been set.



2. **P-SIMV**
This mode is exactly the same as SIMV, except that instead of setting a volume, you set a pressure. Of course, setting a pressure will result in a volume being delivered to the patient. The higher the pressure level that is set, the larger the volume that will be delivered. But because a fixed volume is not set, the delivered volume may vary from breath to breath. It may also vary significantly if there is a change in the patient's lung compliance or resistance (e.g. if they develop a pneumothorax or bronchospasm). Therefore, it is essential to remain vigilant to ensure that an adequate, consistent tidal volume is given. It is also important to have an idea of what an appropriate tidal volume would be for any given patient. As a rough guide, this would be 6-8ml/kg of their ideal body weight, but it is a good idea to ask the medical team to specify their preferred target tidal volume range.

So, if pressure-controlled ventilation requires extra vigilance, why do we use pressure control? Why don't we give volume-controlled ventilation every time? The answer is that there are some theoretical advantages associated with pressure controlled ventilation (lower peak airway pressures, a more even gas distribution, improved patient-ventilator synchrony, and earlier weaning than volume-controlled ventilation), but no differences in mortality have been shown (Up-To-Date, 2014). Pressure controlled ventilation is, however, the usual mode chosen **in paediatric ventilation (See Paediatric Module Handbook for more details).**

3. **Pressure support mode (SPONT)**
In this mode, the ventilator is able to detect when the patient initiates a breath, and this triggers a level of pressure support which 'helps' the patient to breathe. The higher the level of pressure support set, the easier it will be to take the breath. This is sometimes compared to the feeling of taking a breath with your head sticking out of a car window, it is much easier to take a breath because the air is 'pushed' on its way by the flow of air.

As mentioned above**,** with pressure support mode, it is essential to be vigilant in case of bradypnoea, tachypnoea or apnoea. The Hamilton G5 has a back-up mandatory mode that will cut in if the patient has a prolonged apnoea.

4. **ASV (adaptive support ventilation)**
This is a sophisticated, 'intelligent' mode of ventilation. Once you have entered the patient's height and sex, the ventilator calculates an appropriate minute volume and asks you to decide what percentage of this minute volume is to be delivered to the

patient. This is usually 100%, but in certain special circumstances the medical team may choose to increase or decrease this percentage (e.g. 90% for a patient with ARDS, 110% for a febrile patient).

After this, the ventilator will calculate the rate and the tidal volume to be delivered. It can deliver mandatory ventilation (like SIMV), but then it automatically switches to become a spontaneous mode once the patient starts to initiate breathing.

5. **DuoPAP and APRV**
These two modes are very similar. In these modes, the ventilator switches automatically and regularly between 2 levels of pressure control (known as P high and low, or P high and PEEP/CPAP). As mentioned above, this mode is usually selected for patients with lung pathology (e.g. ARDS). If the patient is awake enough to take spontaneous breaths, then they can do so at any stage in the cycle (during the the high P or the low P). It is normal to set pressure support to make the patient's spontaneous breaths feel a little more natural or comfortable.

What is the difference between DuoPAP and APRV? The difference is mainly in the ways that the operator sets up the two modes. For more detail please refer to the Hamilton G5 Operator's Manual page B17.

6. **Noninvasive ventilation (BiPAP)**
Noninvasive ventilation, otherwise known as BiPAP, is a means of supporting spontaneous breathing in an unintubated patient, using a tight-fitting face mask. For more on this please refer to the BiPAP chapter.

<u>Puritan-Bennett Ventilator Modes</u>

1. **SIMV**
This is the same as the Hamilton G5 SIMV. As with the Hamilton G5, the mandatory breaths can be either volume-controlled, or less commonly, pressure-controlled.

2. **Pressure support mode (SPONT)**
This is the same as the Hamilton G5 mode

3. BiLevel
This is the same as DuoPAP on the Hamilton G5

4. **Tube Compensation**
Anyone with an ETT in situ will find it slightly harder to breathe than an unintubated person, because of the extra difficulty involved with sucking air through narrow tubing.

So, once a patient has been weaned off pressure support, they may still have an increased work of breathing, and it is difficult to tell whether this is because they are still ventilator dependent, or just because of the extra work of breathing involved with overcoming the resistance of breathing through an ETT. The idea of Tube Compensation is that it gives just enough pressure support to overcome the resistance of the tube, so that the clinician can get an idea how the patient's breathing would be if they were to be extubated.

To set this up on the P-B choose the 'spontaneous' button and select 'TC', then enter the size of the tube and select either endotracheal tube (ET) or tracheostomy (TT).

Comparison of ventilator modes by brand

Hamilton G5	Hamilton T1	Puritan Bennett
(S)CMV	-	AC-VC
SIMV	-	SIMV (VC)
P-CMV	PCV+	AC-PC
P-SIMV	-	SIMV (PC)
APV SIMV	SIMV+	SIMV-VC+
APVCMV	(S)CMV+	VC+ (PRVC)
-	PSIMV+	-
SPONT	SPONT	PS
DUOPAP	DUOPAP	BiLEVEL
APRV	APRV	BiLEVEL

Ventilation Terminology

In addition to the modes, there are also some terms which it is important to understand:

1. Rate / frequency

This is the number of breaths per minute. These can either be mandatory ('set') breaths, spontaneous breaths, or the combined total of mandatory plus spontaneous breaths

2. Tidal volume

Tidal volume is the volume of oxygen/air that enters the lung with each breath. Sometimes there is a difference between the displayed inspired and expired volumes, due to technical issues such as leaks. We usually record *expired* minute volumes on our 24-hour chart.

3. Minute volume

The total amount of gas moving in and out of the lungs during one minute. This is calculated by multiplying the rate by the tidal volume.

4. Pressure support

Pressure support is a pressure level that is set to assist the patient when taking a spontaneous breath. Pressure support depends on the ventilator being able to detect the patient's spontaneous respiratory efforts.

5. Trigger

A pressure-supported spontaneous breath is triggered either by flow or by pressure. When we breathe, we create a negative pressure which sucks in air. If a patient is on a ventilator and initiates a breath, the ventilator either detects this as a negative pressure or as a flow of gas going towards the patient. If the respiratory effort is strong enough to be detected, then this will trigger a pressure supported breath to assist the patient. Sometimes the trigger is not set sensitively enough to detect the spontaneous effort, and the patient's breath will therefore not be assisted by pressure support. Sometimes the trigger is too sensitive and can be triggered too easily by things other than the patient (e.g. swinging ventilator tubing containing excessive water). This can lead to ‘autotriggering’, where the patient gets a rapid rate of pressure-supported breaths that they are not initiating. If you suspect that this is happening with your patient, please ask for immediate help from an ACNM / senior nurse / technician.

6. PEEP
‘PEEP’ is ‘positive end expiratory pressure’. On expiration, the patient breathes out against a set level of positive pressure. One might think that this would make it harder to breathe out (which indeed it is), but the benefit is that this positive pressure keeps the alveoli open on expiration, instead of them collapsing into a closed position. This ‘splinting’ of the alveoli is thought to have three advantages:

1. Gas exchange can take place throughout the whole respiratory cycle, rather than just during the inspiratory phase

2. If the alveoli do not close because of the positive pressure splinting them open, then the patient is spared the work of reopening them on inspiration

3. If the alveoli do not close there is less risk of them remaining collapsed (i.e. atelectasis).

Usually PEEP would be set at 5cm H_2O but this may need to be increased in some patients. In this case you should consider that the increased PEEP may result in a lowered cardiac output, higher airway pressures and impaired cerebral venous outflow (which could increased intracerebral pressure).

7. FiO2
This means ‘fraction of inspired oxygen’ and refers to the oxygen percentage which you set on the ventilator. As a general rule, you should aim to maintain the patient’s oxygen saturations and / or PO_2 at or slightly above the prescribed parameter. Of course, oxygen is essential for life and hypoxia is dangerous, but excessive oxygen administration has several toxic effects, so it is important to titrate it carefully to the prescribed parameters.

Endotracheal suction
Tracheal suctioning is used to remove secretions and mucus plug formation. This maintains tube patency and avoids tube blockages. Suctioning can be a potentially harmful procedure and should only be done when indicated**.**

It should be tailored to the individual patient and based on thorough respiratory assessment rather than performed as a routine care (Tamburri, 2000; Wilson, 2005).

Indications for suctioning

- Audible or visual signs of secretions in the tube
- Course breath sounds on auscultation

- Signs of respiratory distress, increase or decrease in RR, HR and BP
- Decreasing oxygen saturations
- Inability to clear the tube by coughing out the secretions
- Request by the patient for suction

If some or all of these are apparent, it may be that secretions are trapped in the upper airways and cannot be cleared without tracheal suctioning

Frequency of suctioning will differ with each individual. Patients with newly placed tubes and those with increased sputum production may require suctioning more often. The appearance of suctioned secretions should be carefully observed and noted, and any adverse changes communicated to the medical team e.g. blood stained or yellow/green secretions may indicate infection and/ or trauma of the airway. It may be appropriate to take a sputum specimen for MC&S (if requested) and antibiotics may be considered.

After suctioning, the nurse should reassess the patient to ensure that the procedure has been effective in improving the patient's secretions and easing any respiratory distress.

Considerations when suctioning

Suctioning can be a traumatic, frightening and painful experience for the patient and it is important that they are prepared. A clear explanation prior to the procedure and reassurance during each suctioning event is essential to assisting the patient to remain calm and reduce potential related problems such as increased intracranial pressure and hypertension.

If the patient is on a ventilator or receiving oxygen therapy, suction-related hypoxia can be minimised by hyper-oxygenating for 2 minutes prior to suctioning. The correct sized suction catheter should always be used, and it is important not to prolong the suction episode to reduce the adverse effects of suctioning. An aseptic technique and an awareness of infection control risks are also essential (Thomson, 2000).

Suctioning can be an exhausting experience for the patient and they will need time to recover between suction tube passes. Post suctioning assessment (chest auscultation, respiratory rate, work of breathing) should be carried out to ensure the primary objective of suctioning was met (Day, Farnell et al, 2002).

Catheter Size

It is recommended that the size of the catheter should not occlude more than half of the internal diameter of the tube (Barnett, 2005).

If the catheter size is too large, an increase in negative pressure occurs within the lungs and the patient is put at risk of hypoxia and alveolar collapse. If the suction catheter is too small it will be difficult to aspirate the secretions effectively, risking tube occlusion (Wilson, 2005).

Suggested formula for ET suction tube size is:

(ETT size minus 2) x2

Example: ETT size 8mm: (8 minus 2 = 6) x 2 = 12Fg

Recommended suction catheter sizes

Tube size (in mm)	6.0mm	7.0mm	7.5mm	8.0mm	8.5mm	9.0mm
Suction catheter size (Fg)	8	10	10	12	12	14

<u>Suction depth</u>

It is recommended using minimally invasive tracheal suctioning in which the suction catheter is inserted to the length of the tube only. The suction catheter is inserted to the carina and the retracted 1-2cm before suctioning is performed, or the length of the suction catheter is estimated by measuring an identical endotracheal tube. Avoid vigorous suctioning as this can cause mucosal injury and vaso-vagal stimulation.

<u>Suction Pressure</u>

Excessive suction pressures can cause trauma to the airways. It is therefore important that the suction setup and pressure is checked and set at the correct level prior to the patient’s arrival, and each time the patient is suctioned.

High suction pressure can cause tracheal mucosal damage and alveolar collapse. Pressures of 100mmHg are shown to clear secretions as effectively as pressures of 200mmHg with less resulting trauma (Wilson, 2005). An excessively low pressure can result in ineffective movement or clearance of secretions leading to tube blockage.

Recommended suction pressures:

Adults: 80-120mmHg

Children: 50-80mm Hg

NB: Occlude the suction port to assess suction pressures

(Roman, 2005; Ireton, 2007)

Suction is only to be applied once the catheter is at the correct depth and it is being withdrawn, **not during insertion**.

Suction Timing:
Suctioning withdraws the oxygen from the lungs. Increasing the duration of suction time can significantly reduce the patient's oxygen levels leading to hypoxia.

Therefore, it is recommended that the episode of suctioning from the time of introduction of the catheter into the tube to until its removal from the tube should be no longer than:

Adults:	10 seconds
Child:	3 seconds

(Thomson, 2000; Ireton, 2007; Barnett, 2005)

Please refer to the following service-specific document: 'Artificial Airway - Endotracheal / Tracheostomy Suctioning'

Weaning and extubation
Planning for weaning of ventilation should begin as soon as possible after ventilation is initiated. Patients may be assessed daily for readiness to wean. With long term ventilation weaning can be a stressful experience. The effectiveness of the diaphragm and accessory muscles depends on both the length of the muscle and the speed of contraction. If these muscles have not been used then fatigue may be an issue as both of these factors will be affected by the changes which happen with lack of use.

Weaning may need to be suspended if signs of respiratory distress develop such as high respiratory rate and low tidal volume.

Once the patient has recovered to the point where he or she is a candidate for extubation, then the process can be followed as described in the service-specific document: 'Artificial Airway - Extubation'

Complications of intubation and ventilation

Mechanical ventilation is often a life-saving intervention, but carries potential complications including the following:

- **Ventilator associated lung injury (VALI)** is one term for damage to lungs from ventilation. This may be trauma from high volumes causing over-expansion of the alveoli, loss of surfactant, inflammation or damage from high FiO_2. Patients with conditions such as ARDS will be more prone to VALI. Prevention of VALI is by limiting plateau pressure, using low tidal volumes, and use of PEEP to avoid collapse of the alveoli and thereby minimising cyclical expansion.

- **Lowered cardiac output**. Hypotension is often an issue when ventilation is started. Initially this is often thought to be due to the drugs used at intubation, such as sedatives. Hypotension can also be due to decreased venous return through the positive pressures used in ventilation. Along with the direct effect of hypotension are also effects such decreased urine output and reduced peripheral pulses. Treatment is usually with vasopressors.

- **Fluid retention**. Decreased venous return to the heart is perceived by receptors as fluid deficit. This leads to an increase in ADH and therefore fluid retention and oedema.

- **Pneumothorax** can result from the increased positive pressure within the lungs, **diaphragm atrophy** may be caused by underuse of the muscle while the ventilator takes over the work of breathing, and **oxygen toxicity** can result from excessive oxygen administration.

- **Ventilator associated pneumonia (VAP)**. Pneumonia can be acquired by the ventilated patient as a result of oropharyngeal colonisation, gastric colonisation, and aspiration.

Prevention of ventilator associated pneumonia

Of the above-mentioned complications, the one which probably deserves the most attention is ‘ventilator associated pneumonia’, or ‘VAP’, because effective nursing care can make a huge contribution to the prevention of this very serious complication. The pathophysiology and management of VAP is described in more detail in the ‘Pneumonia’ chapter of this book, but the key strategies for VAP prevention are outlined below:

1. **Avoid intubation if possible** (the decision to intubate a patient is made by the medical team, but it is essential for nurses to be aware that intubation should be avoided unless essential).

2. **Minimise sedation**. We all know that it is often easier to care for a patient if he/she is sedated. However, there is clear evidence that outcomes are improved if sedation is kept to a minimum. If possible (if not contraindicated), try to manage the patient with minimal sedation. Aim to keep the level of sedation consistent with the

medical team's prescribed SAS (sedation and agitation score). There should also be a daily sedation interruption timed to coincide with the doctor's ward round (unless contraindicated).

3. **Maintain and improve physical conditioning**. Early exercise and mobilisation result in earlier extubation, decreased length of stay and increased rate of return to independent function.

4. **Minimise pooling of secretions above the ETT cuff**. In some units they use special ETTs with extra (subglottic) drainage ports so that secretions can be removed from above the cuff. If these secretions are removed by suction, there is less chance of secretions descending past the cuff and into the lungs, which is known to be a cause of VAP. In this ICU, we do not have ETTs with subglottic drainage ports. However, secretions above the cuff can nevertheless be reduced by ensuring that oropharyngeal suction is performed frequently (usually with oral cares and/or following suctioning), to minimise accumulation of fluid at the back of the mouth that might otherwise slip down onto the top of the cuff.

5. **Elevate the head of the bed to 30-45^{o}**. Elevating the head of the bed (unless contraindicated) is known to reduce rates of VAP. Sometimes it is difficult to achieve 30-45^{o}, but as a general rule, if there is no good reason why not, elevate the patient's head to some extent, preferably to >30^{o}. The rationale for this is that sitting them up reduces the risk of regurgitation of fluid (especially NG feed) from the stomach into the airway.

6. **Perform oral care with chlorhexidine**. Reducing the bacterial colonisation of pooled oral secretions reduces the incidence of VAP. For details on the recommended procedure for providing oral care for ICU patients, please refer to the service-specific procedure: Oral Hygiene.

7. **Maintain cuff pressure between 20-30 H_2O**. Maintaining a minimum cuff pressure of 20cm H_2O reduces the risk of aspiration of contaminated fluids sitting above the cuff.

(SHEA/IDSA, 2014, Up-To-Date, 2014)

Nitric Oxide

Nitric oxide is a therapy used for patients who are poorly oxygenated despite a high FiO_2. The nitric oxide flows into the ventilator circuit and is then inhaled as a selective pulmonary vasodilator. Because it is inhaled, it reaches the ventilated alveoli only. Once it reaches these ventilated alveoli, it triggers vasodilation in the pulmonary capillaries, which increases the blood flow to these ventilated alveoli, improving gas exchange. Theoretically, this leads to better ventilation / perfusion matching. Nitric oxide is not used routinely as it has not been shown to directly affect outcome, mortality or ventilator days although it does improve oxygenation in some patients.

Care of the patient with Nitric Oxide:

- The system must be set up by an ICU technician

- The patient must not be disconnected from the ventilator unless in an emergency situation, in this situation the cylinder must be turned off

- Be aware that changes in minute volume will change the concentration of nitric oxide delivered to the patient and adjustment may be needed to keep within range

- Monitoring will include documentation of nitric dioxide and Methaemoglobin. Nitrogen dioxide is a toxic gas produced when nitric oxide combines with oxygen, producing nitric acid when combined with water. Methaemoglobin, as discussed in previous sections is haemoglobin which is unable to carry oxygen

Please refer to the service specific document: Nitric Oxide Inhalation in Adults

Prone positioning

This is another treatment which improves oxygenation in the short term, but there is debate over whether it improves long term outcome. The mechanism for the improvement in oxygenation is not clear but it may be due to decompression and improvement in ventilation of the lower lobes as these are largely on the dorsal side of the chest. In the supine position there is ventilation and perfusion mismatch as both blood flow and alveolar collapse are greatest in the dependent portions of the lung. With prone positioning the weight of the heart and the diaphragm are shifted and ventilation perfusion matching is improved.

Care of the patient with prone positioning:

- Oral and eye care must be continued as per protocols

- When a person is turned prone, ventilator pressures may initially increase but usually settle over time

- ETT securement is especially important in prone positioning, because in the event of an accidental extubation, emergency reintubation would be extremely difficult

Please refer to the service specific document: Prone Positioning

Underwater seal drainage (UWSD)

An underwater seal drain is placed to remove air, fluid or blood from the pleural space while maintaining the negative pressure between the pleura. The column of water acts as a barrier to preventing air entry into the pleural space. The drain may also be attached to wall suction.

Care of the patient with an underwater seal drain

- The water level in the drain will fluctuate during respiration when the drain is removed from suction. If a patient is ventilated the level will be “pushed down” by the positive pressure during inspiration, if self-ventilating then the level will be “sucked up” by the negative pressure

- Bubbling should only be seen during expiration. Continuous bubbling indicates a leak in the system, or may be a sign of a bronchopleural fistula in the patient

- If in doubt as to whether suction is appropriate for the patient then check in the notes or with medical staff as at times suction is contraindicated

- On receiving a patient with an UWSD, check that the connections are secure, that there is water at the right level in the chamber, that suction is connected and turned on if appropriate, the drainage level is recorded and that the drain is not clamped (unless prescribed).

Please refer to the service specific document: Chest Drain Management and the Lippincott Guideline: Chest tube drainage system monitoring and care