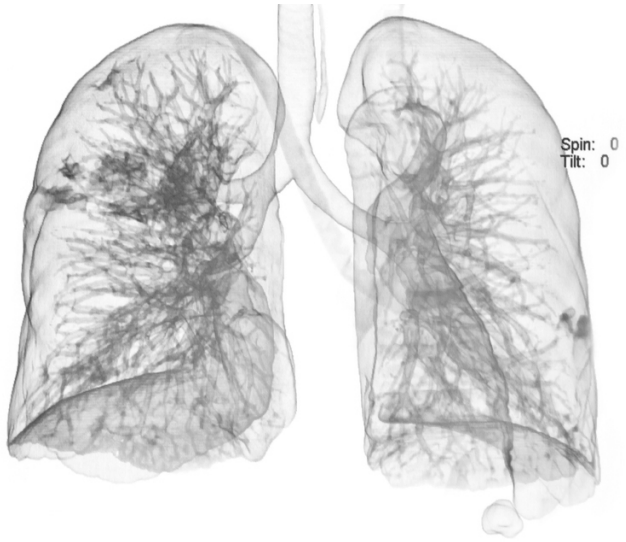
Critical Care



Managing the patient who is critically ill is one of the most demanding challenges for health professionals working in acute care. The patient's life and their future well-being may be irreversibly altered by an incorrect or delayed clinical decision or a diagnosis that is not recognised or considered. Many factors impact on our ability to respond effectively to the critically ill patient including our medical knowledge, training and clinical experience, how frequently we manage the critically ill and local resources such as equipment, drugs, medical and specialty support.

In this first section of the book we explore many of the scenarios that are encountered in managing the critically ill patient including acute airway obstruction, severe respiratory distress, circulatory shock, altered conscious state, cardiac arrest and the mass casualties (disaster) situation. Additional chapters explore preparing for patient transfer / retrieval and the use of bedside ultrasound for assessing and treating the critically ill patient.

These 16 chapters together with the courses written by the book's authors on the LearnEM website have been developed with one goal in mind : to provide clinicians with the knowledge, critical thinking and clinical skills to confidently and competently approach the critically ill patient. It is our hope that these resources will support clinicians to rapidly assess and identify life threatening disease and assist them with the clinical decisions required for initiating management in these challenging and time pressured circumstances.

On-line Resources @ www.learnem.com.au

Clinical case studies, e-tutorials, procedural videos and clinical resources relevant to each of the 10 sections in the ABCDs of Emergency Medicine may be found on the LearnEM website and listed under headings of "Crit Care", "Emerg Med 1", "Emerg Med 2" and "Prim Care" in the top nav bar.

The CPD accredited Courses relevant to critical care include :

1. Advanced Cardiac Life Support (CPR)
2. ABCDs of Resuscitation
3. Advanced Airway Management
4. Non-invasive Ventilation (CPAP/BiPAP)
5. Mechanical Ventilation
6. Bedside Emergency Ultrasound (1) and (2)

Chapter 1

Approach to the Critically ill Patient

Key Points

1. **Approach to the critically ill patient begins by ensuring a safe environment and initiating universal precautions.**
2. **Initial assessment involves a systematic check of the patient looking for immediate risks to vital organ function. This is the "Primary Survey".**
3. **There are five steps in the Primary Survey. At each step, there are clinical signs to check followed by one or more routine interventions.**
4. **The Primary Survey is summarised by the mnemonic ABCDE : Airway, Breathing, Circulation, Disability and Exposure / Environment**
5. **"Resuscitation" is the term given to initiating management to treat problems identified during the Primary Survey.**
6. **As a problem is identified the clinician should take action to correct the life threatening clinical state before proceeding to the next step in the primary survey.**

It is common for clinicians to feel anxious when approaching a seriously ill patient. They may feel overwhelmed, wondering where to begin and how to approach the task. With so many different emergencies it would seem an impossible task for an individual clinician to become competent in managing all of them.

The good news is that the approach to the seriously ill patient always begins in the same place and follows the same basic structure, no matter what the emergency and no matter the age of the patient. This systematic approach to care of the critically ill enables clinicians to identify immediate life threats and to initiate life saving interventions without requiring a detailed knowledge of all possible emergency presentations. This approach to the seriously ill patient is termed the "*Primary Survey*".

Introducing the Primary Survey

Assessment of the seriously ill patient begins by first checking for danger. This involves checking for and removing any threats to your personal safety and the safety of others at the scene. This check should also include initiating universal precautions such as gloves and a consideration of the need for eye protection.

After checking for danger, the next step is to examine the patient. The initial priority is to assess the patient's vital organ functions – their airway, breathing, circulation and to identify any threat to brain function.

Questions that assist the clinician to consider the priorities in the primary survey include :

- Is the airway obstructed ?
- Is the breathing impaired ? Is the patient hypoxic ?
- Are there clinical features of circulatory shock ?
- Are there immediate threats to brain function ?

The Primary Survey provides the starting point for all emergency care. By using a systematic approach to care of the seriously ill patient, much of the anxiety that may arise with the management of these patients is alleviated. In addition, the primary survey ensures that the clinician's attention is focused on assessing and initiating treatment of clinical states that require immediate treatment, improving the chances of the patient surviving the illness.

Primary Survey

The purpose of the primary survey is to assess vital organ function and identify immediate risks to life. It is summarised by the mnemonic "ABCDE".

In the conscious alert patient, the primary survey may be performed by simply asking the question "How are you ?" and shaking the patient's hand. This will often provide much of critical information required for the primary survey. If the patient is able to answer appropriately in their normal voice and without evidence of significant respiratory distress, the airway is patent, the breathing is adequate and a sufficient amount of oxygenated blood is being circulated to maintain CNS function. Shaking the patient's hand allows the clinician to assess for peripheral pallor or coldness suggesting compromised circulation.

In patients with altered conscious state or other evidence of instability, a formal assessment is required. There are five steps to the primary survey. At each step, there are clinical signs to check followed by one or more routine interventions. The procedure for the primary survey is outlined below.

Airway : Look for Airway Compromise

- Check Airway — Listen and feel for air movement / obstructive sounds
  Look for chest rise with inspiration
- Routine Intervention — Apply high flow oxygen
  Protect the cervical spine in trauma

Breathing : Look for Hypoxia

- Check Breathing — Assess the respiratory rate and look for signs of distress
  Auscultate and percuss the lungs
- Routine Intervention — Attach Oximetry and monitor oxygen saturation

Circulation : Look for Circulatory Shock

- Check Circulation — Assess pulse rate, rhythm and volume. Measure blood pressure
  Assess capillary refill and perfusion of extremities
- Routine Intervention — Obtain IV access. Collect bloods / Commence fluids
  Attach Cardiac and Blood Pressure monitoring

Disability : Look for Threats to the Brain

- Check CNS function — Assess conscious state using the AVPU tool[1]
  Check the pupils for size, equality and reaction to light
  Briefly assess for movement of the limbs / posturing
- Routine Intervention — Check the Blood Glucose Level (BGL)

Expose / Environment

- Undress the patient — Prepare for the secondary survey.
  Cover the patient with blankets
- Routine Intervention — Check the patient's Temperature

Resuscitation

Additional interventions may be required to treat problems identified during the Primary Survey. This is termed "*Resuscitation*" and may include initiating basic airway manoeuvres such as suction of the airway, head tilt, jaw thrust, insertion of an oropharyngeal airway or assisted ventilation using a bag and mask or administration of a rapid IV fluid bolus or correction of hypoglycaemia with 50% dextrose.

Resuscitation is initiated during the primary survey. As a problem is identified the clinician should take action to correct the life threatening clinical state before proceeding to the next step in the primary survey.

[1] AVPU is a short hand way of assessing conscious state : A = Alert - eyes open, V = Verbal - eyes initially closed but open to voice, P = Painful - eyes initially closed but responds to painful stimulus eg limb movement, groaning or eye opening, U = unresponsive.

Chapter 3
Acute Airway Obstruction

Key Points

1. **The early signs of airway obstruction can be extremely subtle and include a feeling of increased respiratory work (dyspnoea), a choking sensation (or lump in the throat), alteration in voice or persistent cough.**
2. **Features associated with severe airway obstruction include audible airway noises (such as stridor, snoring), clinical signs of respiratory distress, paradoxical chest movements and impaired neurological function (agitation, drowsiness or confusion).**
3. **In altered conscious state, particular care is required to assess the airway's protective reflexes, which if compromised may result in obstruction and / or aspiration.**
4. **Acute airway intervention is required in patients with severe airway obstruction, severe hypoxia or hypercarbia with altered conscious state.**
5. **Options for airway intervention include basic "airway clearing" techniques (suction, jaw thrust and insertion of an oropharyngeal airway) and invasive techniques such as laryngeal mask airway, endotracheal intubation and needle and surgical cricothyrotomy.**

In the management of the acutely ill or traumatised patient, the assessment and management of the airway is the first priority. As complete airway obstruction, can lead to cardiac arrest in as little as 4 to 10 minutes and irreversible CNS damage within 3 to 5 minutes, the ability to manage the compromised airway is one of the most important (life saving) skills clinicians require in managing the emergency patient.

Protecting or establishing the airway can be extremely anxiety provoking. For many clinicians, airway management is the most frightening aspect in resuscitation of a seriously ill / injured patient. Fortunately, in the majority of cases management of airway obstruction is straight forward and the airway can be cleared with basic airway manouevres. This allows time for further help to arrive and for planning definitive airway management such as endotracheal intubation.

The following chapter focuses on the assessment of the airway, identification of when intervention is required and describes options for managing airway compromise.

Assessment

Diagnosis of airway compromise is clinical. A look, listen, feel approach should be used : *Look* for signs of respiratory distress, *Listen* for airway noises suggesting partial airway obstruction and *Feel* for air movement at the lips.

The table below summarises the important features that may indicate airway obstruction.

Clinical Airway Assessment

Look, Listen and Feel for

- Air movement during exhalation
- Airway noises : stridor / snoring
- Altered Speech (hoarseness, aphonia)
- Signs of respiratory distress
- Signs of CNS hypoxia (drowsiness, agitation, confusion)

Clinical signs of airway obstruction

The early signs of airway obstruction can be extremely subtle and include a feeling of increased respiratory work (dyspnoea), a choking sensation (or lump in the throat), alteration in voice or persistent cough. In the appropriate clinical circumstances (eg anaphylaxis, inhalation airway injury), the clinician must be astute to detect these symptoms and intervene before more severe (and sometimes rapidly progressive) respiratory tract obstruction develops making airway intervention more difficult.

The presence of stridor, snoring, respiratory distress, paradoxical chest movements and/or alterations of the CNS (agitation/drowsiness/confusion) indicate severe airway compromise.

Coma, cyanosis, diminishing stridor or respiratory rate and terminal cardiac arrhythmias (eg bradycardia) are found in profound degrees of airway obstruction causing severe hypoxia. Failure to immediately intervene in these circumstances will result in cardiac arrest and cerebral hypoxic injury.

Altered conscious state – a special case of airway compromise

In the patient with an altered conscious state particular care is required to assess the airway's protective reflexes, which if compromised may result in obstruction and aspiration. In the semiconscious or unconscious patient airway obstruction is most commonly due to the tongue and epiglottis falling against the posterior pharyngeal wall.

In patients with a Glasgow Coma Score < 9 with no rapidly reversible cause (such as opiate overdose or hypoglycaemia) the airway should be cleared using basic airway manoeuvres and hypoxia corrected with the administration of oxygen +/- assisted ventilation. After correcting hypoxia (and stabilising the patient) consideration should be given to protecting the airway by placement of an endotracheal tube or where this is not feasible (eg due to lack of expertise) by placement of a laryngeal mask airway (LMA). An endotracheal tube or LMA is required where doubt exists regarding the ability of the patient to protect their airway.

Management

Clinical situations that require urgent airway intervention include all of the following :

- Airway obstruction or a patient at risk of obstruction (eg due airway burns or epiglottitis)
- Comatose patient (at risk for aspiration and obstruction)
- Severe respiratory failure (to facilitate effective ventilation)
- Raised intracranial pressure (to reduce elevated pCO2)

Techniques

The table below lists the options that may be considered for managing a patient with a compromised airway. These vary from basic "airway clearing" techniques such as suction, jaw thrust and guedel airway to invasive measures such as laryngeal mask airway, endotracheal intubation and cricothyrotomy.

Options for managing the Compromised Airway

- Suction : Clear the airway of foreign material under direct vision
- Basic airway manoeuvres : Open the airway using head tilt, jaw thrust or chin Lift
- Basic airway adjuncts : Consider using an Oropharyngeal (Guedel) or Nasopharyngeal Airway
- Laryngeal mask airway : Consider in a deeply unconscious patient (or after failed intubation)
- Endotracheal intubation : Requires a high level of skill and use of drugs (to facilitate the procedure)
- Surgical airway : Last resort - Needle Cricothyrotomy (Jet Insufflation) / Surgical Cricothyrotomy

The laryngeal mask airway (LMA), although possibly not providing the same level of airway protection as endotracheal intubation, is associated with a very low rate of aspiration. It is ideal to deliver oxygenation where basic airway measures have failed or the airway is at risk (eg unconscious patient) or intubation has been attempted but has not been possible (ie failed intubation). It is particularly valuable to those with minimal experience or training in advanced airway management.

Although needle or surgical cricothyrotomy is a last resort in airway management, it is surprisingly successful even in those with little experience and is associated with a relatively low rate of complications.

Predicting the Difficult Airway

Patients most at risk for airway difficulties include those with obesity, micrognathia, previous head or neck surgery or irradiation, presence of facial hair, dental abnormalities (poor dentition, dentures, large teeth), narrow face, a high or arched palate, a short or thick neck or neck trauma.

Evaluation of the airway should be performed routinely in every patient requiring advanced airway management. Several useful tools are available to assist with assessing the airway for the risk of failed intubation. Two of these, the LEMON tool and the Mallampati tool are outlined below.

The "LEMON" Tool

A useful approach developed to assist clinicians to identify patients at risk for failed intubation is the LEMON tool. The LEMON rule uses a series of five physical assessments to determine the potential for a difficult airway.

LEMON Tool

L = Look externally

Look for facial trauma, large incisors, beard or moustache and large tongue.

E = Evaluate the 3-3-2 rule

- Normal mouth opening of at least 3 fingerbreadths (between the incisors)
- Normal distance from mandible (mentum) to hyoid bone should be at least 3 fingerbreadths
- Normal distance from hyoid to the thyroid notch should be at least 2 fingerbreadths

M = Mallampati score (see the table below)

O = Obstruction / Obesity

Evaluate for stridor, foreign bodies, tumours, trauma with haematoma or injury to the upper airway and other causes for supraglottic obstruction that would impair laryngoscopy. The redundant tissue in upper airway of the obese patient may prevent adequate visualisation of the glottis and an oversize blade may be required.

N = Neck Mobility (limited neck mobility)

Look for trauma or degenerative or rheumatoid arthritis that may limit neck mobility.

Mallampati Airway Assessment Tool

The mallampati tool assumes a relationship between what is seen on direct pharyngeal examination and laryngoscopy. Extend the head and have the patient open their mouth fully and protrude their tongue whilst saying “ahh”. Patients with a high Mallampati grade tend to have poorer visualisation during laryngoscopy.

In the patient who is unable to cooperate for a Mallampati airway assessment (eg unconscious patient), the clinician may gently attempt to open the mouth and using a tongue depressor compare the size of the tongue with the oropharynx. If this assessment reveals a large tongue to oropharynx ratio direct laryngoscopy may be assumed to be difficult.

Mallampati tool

- Class 1 = Visualisation of soft palate, fauces, uvula and posterior pillars
- Class 2 = Visualisation of the soft palate, fauces and uvula.
- Class 3 = Visualisation of the soft palate and base of the uvula
- Class 4 = Only the hard palate is visible. Soft palate not visible at all.

Class 1 and 2 predicts easy laryngoscopy, Class 3 predicts difficulty in visualising the glottis and Class 4 predicts extreme difficulty or possible failure to visualise the glottis.

Acute Disease and Airway Compromise

One of the most important skills in airway management is the ability of the clinician to predict the potential for airway compromise in a patient before the development of clinical symptoms or signs. This allows time to prepare equipment, to call for assistance and plan the procedure.

Essential to anticipating airway problems is a working knowledge of the common diseases or injuries likely to require advanced airway intervention. Pathological conditions likely to result in the need for definitive airway management include trauma, foreign body obstruction, oropharyngeal infections (epiglottitis, croup, deep space infections of the neck) and oedema due to anaphylaxis or inhalational injury. Airway considerations relating to these life-threatening presentations are outlined below.

Trauma

Severe trauma to the face, head, neck and chest will commonly result in the need for definitive airway management. This will generally be managed by endotracheal intubation and require the administration of drugs to facilitate the passage of the endotracheal tube – a procedure termed rapid sequence intubation (RSI).

Indications for definitive airway management in the trauma patient include :

- Suspected airway burns
- Massive facial injuries
- Head injury with GCS < 9
- Multi-system trauma with persistent shock
- Blunt injury to the neck with expanding haematoma or voice alteration
- Bullet / penetrating injuries to the head, neck and thorax

A major consideration in managing the airway in a patient with trauma is the requirement to maintain stabilisation of the cervical spine. The head tilt manoeuvre is contraindicated and endotracheal intubation is performed with in-line immobilisation of the neck. This presents major challenges, even to the experienced clinician, in attempting to visualise the vocal cords and pass an endotracheal tube.

Penetrating and blunt neck injuries, paediatric trauma, cervical spine injury and massive facial injuries pose the most difficulties in airway management. Patients with penetrating and blunt neck injury present specific problems due to altered anatomy, bleeding and risk of sudden deterioration. All patients with gunshot wounds to the neck should be intubated early. A more selective approach may be taken with stab wounds with and intubation is required in patients with evidence or a suspicion of vascular or airway injury.

Blunt trauma to the neck may result in laryngeal fracture and/or transection of the trachea. Management involves a high degree of suspicion. In the patient with mild symptoms close observation may be considered whilst waiting for the ENT surgeon. In severe cases or patients that deteriorate intubation may be attempted using a bougie to cross the partially transected trachea. Surgical cricothyrotomy should not be attempted in patients with laryngeal fracture as the cervical fascia may be the only tissue holding the proximal trachea in the neck. Tracheostomy in the operating theatre by an ENT surgeon is the only alternative in this case.

In the patient with burns from a fire or explosion it is important to identify the presence of associated inhalational (airway) injury. Facial burns, singed nasal hairs, oropharyngeal burns, a change in voice or hoarseness are indicators of possible inhalational injury. Early intubation is essential as oedema may develop quickly and result in airway obstruction that may be extremely difficult or impossible to manage. The development of stridor occurs late and signals impending airway obstruction.

Medical Conditions

A wide variety of medical conditions including respiratory failure, altered conscious state and prolonged seizures may require intubation of the patient to facilitate ventilation or to prevent the risk of aspiration. In some conditions early intervention is essential to avoid the development of significant and occasionally irreconcilable difficulties in airway control. These include anaphylaxis and oropharyngeal infections.

In the patient with anaphylaxis the early signs of airway involvement can be extremely subtle and consist only of an alteration of the voice or a feeling of a lump in the throat. Early treatment with IM Adrenaline will generally prevent the progression of symptoms and avoid the need for invasive airway intervention.

A cautious approach should be taken with patients thought to have epiglottitis. Allow the patient to sit up and call for skilled assistance. Attempts to look in the throat should be avoided (as this may precipitate acute obstruction). As the patient may develop complete airway obstruction without warning they must be observed at all times and all equipment necessary for airway control should be available immediately.

Similar difficulties are encountered in the presence of deep space neck infections such as retropharyngeal abscess, parapharyngeal abscess and Ludwig's angina. Skilled support is necessary and intubation or a surgical airway may be required.

The Paediatric Airway

Children have a number of characteristic anatomical airway features that differ from the adult. These differences not infrequently make the management of the paediatric airway more complicated and include a large occiput, large tongue and high anterior larynx.

Airway - Anatomical Considerations in the Child

- Large occiput
- Larger tongues in relation to the mandible
- More prominent oropharyngeal tonsils / adenoids
- Larger stiffer epiglottis than adults
- Higher more anterior larynx
- Subglottic area : narrowest part airway
- Short and soft trachea

The child's head is larger relative to their body size resulting in flexion of the C-spine in the supine position. Extending the neck further as would be performed in the adult will not assist intubation in the very young child. In very young children the best position for the head is often obtained by placing a rolled up towel beneath their shoulders.

Although children are generally easier to ventilate with a bag and mask (as a rule), they are more difficult to intubate than adults. Children have a large tongue and a higher anterior larynx and together these make visualisation of the vocal cords more difficult increasing the risk for failed intubation or inadvertent intubation of the oesophagus.

One other significant difference relates to the narrowest part of the airway. In adults the vocal cords are the narrowest part of the airway, however in young children the subglottic area (region just below the larynx) is the narrowest part. This explains why children are particularly susceptible to airway obstruction due to viral croup (which affects the subglottic part of the airway).

Careful selection of the appropriate size endotracheal tube is required in the child to avoid causing injury to the subglottic area. It is now recommended that (with the exception of newborns) cuffed endotracheal tubes should be used for all ages in order to reduce the risk for aspiration and enhance effective ventilation (by improving airway seal) and providing a more accurate measurement of end-tidal CO_2 concentration.

Paediatric Endotracheal tube

- Use uncuffed ETT in the newborn. Use cuffed ETT for all other ages
- ETT Size : Use size 3 mm in babies and 3.5 mm in 1 - 2 year olds
- ETT Size = Age/4 + 3.5 (for a *cuffed ETT)* in children $\geq$ 2 years old
- ETT Depth (in cms) = 3 x size of ETT
- The cuffs should not be inflated above 25 cm H_20

Chapter 7
Non-Invasive Ventilation

Key Points

1. **Non-Invasive Ventilation (NIV) provides a means of delivering positive pressure ventilation without the use of an endotracheal tube.**
2. **There are two modalities CPAP (Continuous positive airway pressure) and BiPAP (Bi-level positive airway pressure)**
3. **NIV has been shown to be beneficial in treating patients with moderate to severe respiratory distress with COPD and acute pulmonary oedema**
4. **Contraindications to NIV include upper airway obstruction, pneumothorax, hypotension or shock, excessive drowsiness or facial trauma.**
5. **Begin CPAP with a (PEEP) pressure of 5 – 8 cm H_2O and increase every 5 - 10 minutes by 2 cm H_2O until patient's respiratory distress is improving. Maximum CPAP pressure is 20 cm H_2O.**
6. **Commonly utilised starting pressures for BiPAP are a PEEP of 3 – 5 cm H_2O and pressure support of 5 cm H_20.**
7. **Complications of NIV include pressure necrosis over the bridge of the nose due to the facemask, sinus and ear pain and pneumothorax (rare).**

For patients with severe respiratory distress requiring respiratory support Non-Invasive Ventilation (NIV) provides a means of delivering positive pressure ventilation without the use of an endotracheal tube. Often referred to as "CPAP" or "BiPAP", NIV uses the patient's upper airway and a mask for the delivery of positive pressure.

It has distinct advantages over mechanical ventilation by reducing the need for sedation, potential airway trauma and risk of nosocomial pneumonia and preserves the patient's ability to speak, eat, and cough. It is most frequently used to treat patients with moderate to severe respiratory distress due to chronic obstructive pulmonary disease (COPD) and acute pulmonary oedema (APO).

CPAP vs BiPAP

There are two basic modalities used in Non-Invasive ventilation : CPAP (Continuous Positive Airway Pressure) and BiPAP (Bi-Level Positive Airway Pressure).

Continuous positive airway pressure ventilation (CPAP)

Ventilation using continuous positive airway pressure provides a positive pressure during both inspiration and expiration (ie the same pressure is provided for both inspiration and expiration). CPAP functions to improve oxygenation by recruiting under-ventilated or collapsed alveoli and is most useful in the patient in which hypoxia is the major problem (eg acute pulmonary oedema).

Bi-level positive airway pressure ventilation (BiPAP)

Bi-level positive airway pressure ventilation (BiPAP) provides different levels of pressure during inspiration and exhalation. BiPAP may be thought of as CPAP coupled with additional pressure support during inspiration. The higher inspiratory pressure improves tidal volume resulting in improved ventilation reflected by decreased arterial pCO2. It is most useful in patients where CO2 retention is expected to be a major issue such as in COPD or severe asthma. In general, BiPAP is better tolerated than CPAP because the differential in pressure between inspiration and expiration allows for better patient-ventilator synchrony.

Indications

Chronic Obstructive Pulmonary Disease (COPD)

The majority of research into NIV has focused on its role in COPD. The use of BiPAP in COPD results in more rapid clinical improvement with decreased hospital stay and is associated with lower mortality, decreased complications and lower rate of intubation.

Acute Pulmonary Oedema

CPAP and BiPAP have a well-established role in acute pulmonary oedema and have been shown to reduce intubation rates and result in more rapid improvement of symptoms.

Other uses of CPAP/BiPAP

BiPAP has been used safely to treat moderate to severe asthma. NIV has a bronchodilator effect and may result in more rapid improvement. Limited studies have demonstrated a possible benefit from the use of NIV in pneumonia and pulmonary contusion.

Contraindications

NIV is contraindicated in patients with :

- Upper airway obstruction
- Pneumothorax
- Hypotension or shock
- Excessive drowsiness or coma
- Facial trauma/deformity

Age is not a limiting factor with reports of its successful use in both paediatric and elderly populations. NIV however does require a significant amount of patient cooperation, which may be relatively difficult in the very young or very old.

Initiating Non-Invasive Ventilation

- CPAP: Commence with a pressure of 5 – 8 cm H_2O. Increase slowly by 2 cm H_2O
- BiPAP : Commence CPAP (3 – 5 cm H_2O) and add Pressure Support (5 cm H_2O)

Once a decision has been made to initiate NIV, the mode of ventilation (ie CPAP or BiPAP) should be selected. Use CPAP if the main problem is hypoxaemia (eg CCF), and favor BiPAP (eg COPD) if the main problem is hypercarbia.

In the emergency department, a facial mask is most commonly used to deliver CPAP or BiPAP. The mask has a soft cushion that prevents skin necrosis. Hold the mask in place without securing it at first. Do this until the patient is synchronised with the ventilator. Once this synchrony is achieved, secure the mask with straps, using two fingers under the strap to avoid a tight fit. In the elderly, dentures can be left in place. They will allow for a better mask fit and less air leakage. Loose dentures, however, pose a risk of aspiration and should be removed.

The facial mask is not always well tolerated and impedes speech and communication, limits oral intake and places pressure on sensitive facial structures such as the nasal bridge.

Commencing Pressures

CPAP : CPAP pressure is also referred to as Positive end expiratory pressure (or PEEP). Commence CPAP with a pressure of between 5 – 8 cm H_2O. This will provide one level of pressure throughout inspiration and expiration.

BiPAP : BiPAP adds additional pressure during inspiration. In general, if commencing BiPAP begin with a slightly lower CPAP pressure of 3 - 5 cm H_2O and then add the additional pressure for inspiration by adjusting "pressure support" (PS). Pressure support is commenced at 5 cm H_2O above CPAP. This gives two levels of pressure in BiPAP : During expiration the patient receives CPAP (PEEP) pressure (3 – 5 cm H_2O) and during inspiration the patient receives CPAP + Pressure Support (3+5 = 8 to 5+5 = 10 cm H_2O).

Adjusting CPAP / BiPAP

CPAP : The initial CPAP (PEEP) pressure may be increased by 2 cm H_2O every 5 – 10 minutes monitoring the patient's response. In most patients a (final) CPAP pressure of between 8 – 12 cm H_2O will be adequate to achieve clinical effect. The maximum allowable CPAP pressure is 20 cm H_2O.

BiPAP : In BiPAP only the CPAP (PEEP) pressure needs to be adjusted and the pressure support may be left at the setting of 5 cm above CPAP. Increase the CPAP (PEEP) pressure by 2 cm H_2O every 5 - 10 minutes aiming for a CPAP of between 5 - 10 cm H_2O (and resulting in an inspiratory pressure of between 5 + 5 = 10 cm H_2O and 10 + 5 = 15 cm H_2O). Inspiratory pressures above 20 cm H_2O should be avoided.

Bear in mind that increases in Pressure Support will assist to lower pCO2 (ie improve ventilation), and increases in CPAP (PEEP) will assist to raise pO2 (ie improve oxygenation). The FiO2 is titrated to maintain oxygen saturation above 90%. Humidification and heating generally are not required since the airway mechanisms remain intact.

Monitoring Patients with NIV

Patients receiving CPAP / BiPAP require continuous cardiac monitoring and pulse oximetry. Regular assessments should be made of vital signs, patient comfort, mental status, work of breathing and handling of secretions. Blood gases are useful to assess improvement or deterioration. CXR is indicated when there is a sudden change in the clinical status of the patient.

Improvements in dyspnoea and clinical signs of respiratory distress may be observed as early as one hour after the initiation of NIV. Other useful indicators of successful treatment include a reduction in the respiratory rate and improved level of consciousness, oxygen saturation, and arterial blood gas.

Although NIV is effective for many patients, it is important to know when to discontinue and move to invasive airway management. Indicators of NIV failure include patient intolerance or failure to handle secretions, deterioration of vital signs, failure to improve after 1 - 2 hours and progressive confusion or sedation.

Complications of Non-Invasive Ventilation

NIV may potentially result in significant (sometimes life-threatening) complications including barotrauma (pneumothorax, pneumomediastinum), hypotension (due to reduced venous return) and gastric aerophagy and vomiting (risk for aspiration, airway obstruction). Fortunately, serious complications are rare.

The most common complication is irritation and pressure necrosis over the skin at the mask interface that can be minimised by break periods from NIV and proper cushioning. Other problems include sinus or ear pain, eye irritation and claustrophobia.

Guidelines for Setting up of an Oxylog Ventilator for NIV[2]

- Turn Oxylog **ON**
- Select the required **Oxygen Setting**
- Select **"CPAP"** Mode (used for self-ventilating patients)
- Set pressures : Pressing the settings button, Scroll to find / adjust pressure. Confirm by pressing knob

  Set **PEEP** = 5 cm H2O

  If **BiPAP** required : Set **PS** = 5 cm H_20 (For CPAP alone - set PS = 0 cm H_20)

  Scroll to next setting page : Turn **NIV** to "on"
- **Closely observe** patient for hypotension, deteriorating respiratory status
- Slowly **increase PEEP pressures** by 2 cm H_2O every 5 - 10 minutes until symptoms improve
- Do **NOT** use pressures > 20 cm H_2O

  Most patients on CPAP are managed in 8 - 12 cm H_20 range

  Most patients on BiPAP are managed with inspiratory pressures of 10 - 16 cm H_20
- Reassure your patient and monitor pressures

[2] Adapted from guidelines developed by Ms Jayne Waters, Naracoorte Health Service