Additional information to accompany audio presentations

PACU Airway Learning and Teaching Resource

Presentation : Basic Sciences

A. Function of airway in gas transport:

- Airway enables transport of **oxygen** from atmosphere to lungs and carbon dioxide from lungs to atmosphere : this process is external respiration.
- From the lungs, oxygen is transported in the blood attached largely to haemoglobin in the red blood cell, to the body organs, tissues and cells.
- Cells use oxygen as energy source – biochemical reactions involve oxygen. 80% oxygen burns in sugars, fats and proteins to form chemical energy which then becomes **Adenosine Triphosphate or ATP**. Carbon dioxide and water are the waste products from this reaction. This process known as **metabolism.** This process is internal respiration.

Oxygen + Fuel = Energy [ATP] + Carbon Dioxide + Water

- ATP is essential to fuel the enzymic processes compatible with life :
  - digest food, trigger respiration, manufacture hormones and proteins ……

- Airway obstruction leads to hypoxaemia [low partial pressure of oxygen in blood] and hypoxia [lack of oxygen to tissue cells]. If hypoxia is sustained tissues become ischaemic and die [infarct].

- The air we breathe is comprised of a variety of molecules of which only 20.9% is oxygen. The average person

breathes in approximately 432 liters of oxygen per day (this is equivalent to 1216 cans of soda). The tissues of the body need a minimum of 352.8 liters of oxygen per day, and this is assuming the person is at rest.

- **The brain, which is only 2% of the body mass, needs almost 20% of the oxygen that is brought in. If the brain doesn't receive oxygen for more than 3 minutes, the cells will begin to die. Once brain cells cease to function, permanent damage sets in.**

- The airway enables ventilation of the lungs with fresh inspired air to maintain alveolar ventilation. Efficient alveolar ventilation enables oxygen and carbon dioxide to transfer across the alveolar-capillary membrane.

- Carbon dioxide is the waste product of metabolism. It must be eliminated from the body at all times to maintain acid-base balance. Distortion of acid-base interferes with normal cell function.

- Airway obstruction will cause hypoventilation and loss of alveolar ventilation leading to build up of carbon dioxide and respiratory acidosis.

- **The airway is the vital passage that allows gas transfer to and from the lungs. It must be kept clear at all times. It is always the first priority in emergency care [ABC]. Breathing cannot take place unless airway is clear. Circulation with no fresh supply of oxygen is pointless.**

B. Airway structures and function in gas transport :

- **Nasal passages** : Consist of an external structure separated by cartilage to form the nostrils and the internal structure made up of three elevations [turbinates] which in increase the surface area. The tract is lined with a moist mucous membrane with fine hairlike projections known as cilia, which serve to collect debris. Mucous also helps to trap particles of dust and bacteria. Air is warmed, moistened and humidified in these passages before it reaches the nasopharynx. This is important as cold, dry air damages the lungs.
  This is a highly vascular area. Bleeding may be caused by nasal intubation and or trauma associated with ENT, or dental surgical procedures [Nasal Polypectomy, Reduction of Nasal Turbinates, Rhinoplasty ….].

- **Oral cavity** : passageway for food : fluid and air. The tongue is a very large muscular organ which prepares food for swallowing**.** Salivary glands moisten the oral cavity and chemically digest food. Hypersalivation caused by GA may obstruct airway. The hard palate provides a roof for the oral cavity. The soft palate at the back of the oral cavity terminates in the uvula which secretes saliva and has a role to play in swallowing. The walls of the oral cavity comprise fleshy cheeks, while the floor comprises of muscles attached to the mandible. Soft tissue at the back of the throat may cause partial airway obstruction. Teeth are used for mastication and are set in gums. The oral cavity comprises a highly vascular area. Bleeding can obstruct the airway as well as foreign bodies [i.e. throat packs used in ENT surgery].

- **The tongue :** Relaxation of tongue is the principle cause of airway obstruction. This is because the tongue is held in place, and performs its function of preparing food to swallow, by the action of a complex set of muscles. If these relax the tongue falls to the back of the oro-pharynx causing obstruction.

- **Skeletal structure of the oral cavity :** comprises the mandible [jawbone] on which the tongue and floor of mouth is attached. This is the only movable skull bone and allows the mouth to open and close and food to be chewed. The mandible is held in place by muscles which, when slack allow the mandible to fall backwards, taking with it the tongue and causing obstruction.

- **Tempero-mandibular joint :** connects the mandible to the temporal bone and allows the mandible to move. In obstruction if this joint is pushed forward at 90 degrees the jaw and tongue with it will be move forward, the tongue will be pulled back from the throat [oro-pharynx].

- **Pharynx** : a five inch muscular tube that acts as common passageway for food/fluids and air : made up of three sections : naso : oro : laryngo - pharynx. Each area communicates with vital airway structures, nose, oral cavity and larynx. Food passes down the pharynx to enter the oesophagus on swallow. Air passes down through the larynx and into the lower airway via the glottis [vocal cords].

- **Larynx** : a complex structure of 9 bands of cartilage. It has three main functions. To protect the lower airway and ensure that foreign material does not pass down to the lungs. To enable breathing, allowing the passage of air to pass to and from its delicate structure. To enable voice production as air passes through the glottis. It contains the following important structures:

- **Epiglottis** is a leaf shaped cartilage that folds over the glottis [aperture between the vocal cords] on swallowing, ensuring that food/fluid does not enter lower airway. Airway obstruction and /or aspiration may occur if the patient regurgitates/vomit while the swallow reflex is still inactive following GA.

- **Vocal cords** are two bands of smooth muscle which open [abduct] and close [adduct] to allow speech. The action of the intrinsic laryngeal muscles which are innervated by the inferior laryngeal nerve brings this about. The **glottis** is the aperture between the cords and is the narrowest part of adult airway : air MUST pass unobstructed through this delicate structure. Irritation or damage to the cords as a result of general anaesthesia may lead to oedema or laryngospasm both of which are dangerous causes of partial or total airway obstruction.

- **Thyroid cartilage** is a prominent landmark of the larynx [Adams apple]. Below the thyroid cartilage is the cricoid cartilage. In between the two cartilages lies the crico-thyroid membrane : if the airway is occluded above this level – a emergency opening is made into this membrane [crico-thyroidotomy] to get air and oxygen into the patient.

- **Gag reflex :** a reflex contraction at the back of the throat when the roof of the mouth, back of the tongue or throat are stimulated by a foreign object. The reflex is Innervated by glossopharyngeal and vagus nerve action on the pharyngeal muscles [which contact] and soft palate [which rises]. Designed to prevent foreign matter passing down the throat into the lower airway. In general anaesthesia this reflex is lost and the airway is vulnerable.

- **Swallow reflex:** a vital reflex that prevents food and fluid passing down into the trachea and the lungs. When food reaches the pharynx the epiglottis folds over the trachea and the naso and oro-pharynx close. The upper oesophageal sphincter opens to receive the food which passes down to the stomach via the oesophagus. This vital mechanism is lost in general anaesthesia where food/fluid can regurgitate up from the stomach and slide down the unprotected trachea into the lungs causing potential lung damage [aspiration].

- **Cough reflex:** another complex mechanism whereby foreign matter is expelled from the lower airway and the lungs are protected. Essentially is involves increased pressure in the lungs forcing open the closed glottis and releasing the

air at high speed taking with it any irritants away from the lower airway. This mechanism is lost and the patient will not be able to cough up irritants after general anaesthesia.

- **Trachea** : start of lower airway. Comprises bands of horse shoe shaped cartilage to maintain it's semi rigid structure open to allow the passage of gases to and from the lungs. The cartilage rings are not fused to allow room for the oesophagus structure which lies behind the oesophagus. The cartilage is supported by smooth muscle.

- **Left and right main bronchi** : at the carina [the bifurcation of the trachea] the left and right main bronchi deliver air to the left and right lungs fields. These major bronchi all contain cartilage. The right main bronchus is straighter than the left. The risk of intubating the right lung occurs only if endo-tracheal tube is pushed too far. Both trachea and main bronchi are lined with a layer of epithelial cells with cilia projecting from them. These cells secrete a mucous sheet that floats above a thin saline layer. Adults produce up to half a cup of mucous daily. This mucous is continuously transported in an upward direction away from the lungs by the cilia movement. This removes dust particles to the pharynx where they are swallowed. Smoking paralyses these cilia, mucous becomes thicker and the risk of developing chest infections post anaesthesia is considerable.

- **Bronchi – terminal bronchioles** –oxygen passes along a tortuous network as airways branch off and become smaller : there are about 23 forks in the path along this route! In the smaller airways [bronchioles] cartilage is replaced by smooth muscle. Bronchioles contain no cilia or mucous glands. The bronchioles are innervated by the autonomic nervous system which causes bronchoconstriction and dilation. Sympathetic nervous stimulation may cause bronchospasm [constriction] in the post anaesthetic patient if patient has irritable airways or is allergic to certain anaesthetic drugs.

- **Alveoli :** An enormous amount of alveoli [300 million in each lung] enable gas exchange across the alveolar-capillary membrane. This massive number of small clumps of alveolar sacs enables maximises the area for vital gas exchange. The alveolar network is served by a dense supply of pulmonary capillaries in the lungs. Capillary and alveolus lie adjacent to each other and their membranes are one cell thick. This facilitates gas exchange. Oxygen enters the pulmonary blood circuit for transport around the systemic vascular system. Carbon dioxide enters the alveoli to be breathed out. For effective gas exchange to occur the alveoli must be clear and able to expand on inspiration.

Risk of airway obstruction:

General anaesthesia causes loss of consciousness with a resultant loss of the protective reflexes; gag, swallow and cough. The airway is vulnerable to blockage by foreign material. Muscle tone slackens and the tongue falls back to the back of the oro-pharynx and obstructs the airway. Nasal intubation can cause trauma and bleeding into the naso-pharynx. Intubation, either oral or nasal, can traumatise the glottal area, resulting in partial or full closure of the vocal cords.

ENT and dental surgical procedures may cause bleeding which can lead to airway obstruction. Certain procedures, i.e. Microlaryngoscopy may traumatise the glottis leading to partial closure. The risk of a dental or throat pack obstructing the airway is real.

Throughout this airway pack we will identify **known risks to airway obstruction**, how they are managed in anaesthesia, how assessed in PACU and how they are prevented from becoming complications by airway management.

Presentation : Anaesthesia and Surgery

Pre-Assessment : Here the patient is seen by the anaesthetist and has the chance to ask questions about their surgery. The anaesthetist will need to decide what mode of anaesthesia and airway to use intra operatively to ensure patient safety throughout the procedure. This will depend on a number of variables :

- Surgery : complexity, body part involved, likely length of procedure will be assessed. The more complex, prolonged procedures will require general anaesthesia [G.A.] Where GA is not indicated, surgery may be performed under neuroaxial, regional or local anaesthesia. In these anaesthetic modes, the patient is awake throughout with pain controlled by a combination of nerve blocks and analgesia.

- Patient factors, weight, age, medical, surgical or anaesthetic history will also influence the decision to choose one or other mode of anaesthesia and airway. Any one of these factors may increase the anaesthetic risk level to the patient and the anaesthetist will factor in these factors in developing his anaesthetic plan.

- Airway specific assessment : Obese patients have fleshy folds of mucous membranes which make occlusion more likely. Teeth may be loose and dislodged easily. The Mallampati score entails asking the patient to stick out their tongue and visualise the back of the oro-pharynx. This gives an indication of how easy it will be to intubate with endo tracheal tube. Smokers damage the cilia that waft mucous up the trachea. They are more prone to bronchospasm. If the patient is having ENT or dental surgery, specialist endotracheal tubes will be used for access.

General Anaesthesia comprises three stages: induction, maintenance and reversal.

A. Induction of General Anaesthesia :

- Induction renders the patient unconscious and is brought about by a combination of:
  1. anaesthetic drug/agents to render the state of unconsciousness [egs Propofol or Sevoflurane].
  2. analgesia to prevent physiological stress on intubation [eg Morphine].
  3. short acting muscle relaxant to relax the vocal cords if intubating with endo tracheal tube [egs Suxamethonium or Rocuronium].

  From the point of induction the airway is at risk of obstruction as the jaw is slack and the tongue will fall to the back of the oropharynx blocking the airway until full consciousness returns with normal reflex activity and muscle tone. The protective reflexes, gag, swallow, cough are lost from the point of induction and the patient can no longer protect the airway and lungs from foreign bodies as the epiglottal function fails.

- From induction the airway is maintained by the use of laryngeal mask airway [LMA], i-Gel or endo-tracheal tube airway [ETT]. LMA is now used routinely but for longer, more complex surgery, the ETT will be chosen. The LMA cuff sits superior to the glottis. The LMA will not protect the patient from foreign material entering the trachea and causing aspiration. The ETT passes through the glottis and rests superior to the carina of the lung. The balloon ensures that foreign matter will not pass down the trachea and aspiration will not take place. For longer, more complex surgery the ETT provides gold star airway protection. Clumsy intubation may irritate the cords leading to post extubation laryngospasm.

B. Maintenance of General Anaesthesia [Triad of Anaesthesia]

The maintenance of general anaesthesia describes the period immediately post induction until the reversal of anaesthesia at the end of surgery.

The Triad of Anaesthesia is a combination of drugs and agents used to maintain the state of unconsciousness throughout the maintenance phase of the surgery. The mixture of hypnotic, narcotic and muscle relaxant maintain the depth of anaesthesia, control pain and relax the muscles sufficient for the surgeon to handle the tissues and for the anaesthetist to settle the patient on the ventilator. The mixture of drugs ensures that no one drug is given in excess and that the patient is kept at a light level of anaesthesia, enough so that he is not aware of the procedure, but not too much putting him at a deep and possibly dangerous level of unconsciousness. This approach is called '**balanced anaesthesia'**.

Drug class	Drug/agent name	Action	Residual effect into PACU
Hypnotic Maintains unconscious state	**Volatile agent:** Isoflurane Sevoflurane	Relaxes patient & maintains unconscious state	Prolonged unconscious state : relaxation of tongue & risk of airway obstruction Prolonged loss of protective reflexes
Narcotic Provides Analgesia	**Opioid:** Fentanyl Morphine	Controls pain, relaxes patient on ventilator	Prolonged unconscious state : relaxation : risk of airway obstruction
Muscle relaxant Paralyses muscles	**Muscle relaxant:** Atracurium : Alcuronium	Paralyses muscles to ventilate lungs & facilitate surgery Cuts down need to give large dose of narcotic or hypnotic	Residual muscle relaxation : risk of obstruction

Table of Classification of drugs used in the Triad of Anaesthesia, their action and possible residual effect in PACU

In addition to the mixture above, Nitrous Oxide is given to sedate and relieve pain. Oxygen is always delivered. If the patient is particularly anxious, sometimes Midazolam is also administered.

The anaesthetist must ensure that patients airway, breathing and circulation are optimised during the procedure. Monitoring of oxygen saturation, end tidal $C0_2$ [$ETC0_2$] will alert the anaesthetist if the patient has an airway problem, or is not ventilating adequately [low $Sa0_2$ and raised $ETC0_2$]. Haemodynamic monitoring and careful fluid balance will alert anaesthetist of cardiovascular problems.

C. Reversal of General Anaesthesia

- Reversal agents : these drugs reverse the effect of the drugs given in the Triad : allow patient to wake, regain muscle tone and protective reflexes.

Drug	**Action**	**Effect**
Neostigmine	Reverses long acting muscle relaxant	Restores muscle tone
Naloxone	Reverses effect of opioids	Stimulates the patient to wake and breathe
Doxepram	Stimulates the respiratory centre	Stimulates the patient to wake and breathe
Flumazenil	Reverses effect of midazolam	Wakes patient

Table of Reversal Agents, their action and effect

The reversal stage can be complicated. If the patient is woken too early – he may develop laryngospasm. Ideally, if the anaesthetist has balanced the anaesthetic cocktail correctly the patient should wake on the table at the end of the procedure. However, very often he remains semi or unconscious until well after his arrival in PACU and will require careful airway management.

Risks of post anaesthetic airway obstruction :

A. Residual effect of drugs and techniques used in GA

- The combination of drugs and agents used in general anaesthesia may cause airway obstruction in the post anaesthetic phase for the following reasons.

- Hypnotics and narcotics may lead to a prolonged state of unconsciousness in the post anaesthetic period. Relaxed muscle tone may lead to airway obstruction by the tongue. Protective reflexes are lost, the patient cannot swallow, cough or gag and aspiration may occur in the unprotected airway. Muscle relaxants contribute to muscle weakness during this phase, even when reversed.

B. Use of airway adjunct:

Endo-tracheal tube : Following induction endo-tracheal intubation is performed to protect the airway. The ET tube passes through the glottis – and rests above the carina. Aspiration is prevented by the inflated balloon at distal end of the endotracheal tube. Trauma due to clumsy intubation or extubation may cause irritation to the vocal cords resulting in laryngospasm in the post anaesthetic period.

The laryngeal mask or i-Gel is now frequently used to maintain the airway. The LMA / i-Gel do not penetrate the glottis and sits above the larynx incorporating the epiglottis : they do not prevent aspirate from entering the lungs in

vomit /regurgitation. They largely prevent the tongue from obstructing the oro-pharynx. They are less likely to cause spasm – but may still do so.

Oropharyngeal airway : may provoke spasm if too long at back of oro-pharynx.

C. Surgical Procedures :

- Dental, ENT and Facial Maxillary surgery all pose a threat to the airway in the post anaesthetic period due to :
- Trauma to specific structures [i.e micro-laryngoscopy].
- Bleeding into the naso and oropharynx which may occlude the airway or set of laryngeal spasm [dental : ENT].
- Shared airway [dental : ENT].
- Swelling : oedema : haematoma : i.e. thyroidectomy which may occlude the airway.
- Tight occlusive dressings to neck area which may occlude the airway.
- Nerve damage : thyroidectomy [recurrent laryngeal nerve damage impacts on vocal cord function].

Presentation : Airway equipment

Medical equipment, safety monitoring and advanced airway devices play an increasingly large part in the safe delivery of care in the PACU. Learning and understanding this equipment, its use, function and safe handling will optimise patient care. This subject can initially appear to be a dry one but understanding how equipment works will be a vital part of your role as a PACU nurse. Again, an understanding of the organisation aspects of equipment is very important, routine equipment checking, procedural documentation, proper training and unit organisation are all of paramount importance in ensuring excellent patient outcomes.

This presentation on routine and emergency airway equipment is divided into 5 sections :

1. Airway adjuncts
2. Oxygen delivery systems
3. Suction equipment
4. Monitoring
5. Emergency airway equipment

1.Airway adjuncts:

These devices have been developed to assist with airway management. The best way to consider them is that they are extensions of the chin lift/jaw thrust manoeuvre, except for the endotracheal tube (ETT). Airway equipment should inter-connect along the 15mm/20mm sizing. This gives the system redundancy and safety.

Oropharyngeal [Guedel] Airway

A simply designed, plastic device that sells 750 million units per year world wide. They are sized by lining up the tail with the tragus (lumpy bit at the front of the ear) and the side of the mouth. If in doubt, oversize. The aim is to raise the soft tissues [tongue] away from the back of the throat to optimise gas flow.

They have a flange one end to stop the device from advancing into the airway. They have a lumen and a soft suction catheter tube can be inserted to suction the back of the oropharynx. Some are used as bite blocks but be careful of dental injury.

Nasopharyngeal airway

These are well tolerated but be careful regarding nasal injury. Can help with suctioning and oxygen delivery. They are for longer term use for the awake patient that cannot support a guedel. They are not seen in use as much as the guedel airway.

Laryngeal Mask Airway and iGel [Supraglottic devices]

Invented and developed by Archie Bain, these devices are collectively called Supraglottic Devices. The first generation is the laryngeal mask airway [LMA] and the second is the iGel. Second generation devices are increasingly cited in airway literature from Difficult Airway Society and NAP 4 [see bibliography].

They are effectively the logical end point of the chin lift/jaw thrust technique. They sit apposed to the larynx and provide high-level protection and ease of ventilation of the patient. They are easy to insert and remove. For patients with difficult airways they can be used as a rescue technique for ventilation so they have a use in emergency airway management too.

They have a top end connection 15/20mm which connects to catheter mount and mask, a patent lumen and a curved end that secures around the larynx. Some devices have a port for a Nasogastric tube to help decompress the stomach. Theses come in variable sizes and are used when the patient may need full or assisted ventilation. They are shaped to be able to stop reduce an air leak when gas is under pressure.

The difference between the two is that the iGel has no cuff to inflate.

Endo-tracheal tube

This is the gold standard for airway security. The 15/20mm port connects to other airway devices and catheter mounts. The tube is made from PVC with a balloon tip to secure the airway below the vocal cords. The balloon can be deflated via the port that is released using a standard 10 ml syringe.

2. Oxygen Delivery Devices

Oxygen is one of the most important drugs in critical care. Understanding it and its delivery is essential to the PACU training. The hospital holds oxygen in two main ways: The VIE (vacuum insulated evaporator), this is the large (usually white) cylinder out the back of the hospital that contains litres of liquid oxygen. The manifold where large J cylinders of oxygen are linked to the wall system and can help support the oxygen supply if the VIE is unable to.

The wall supply of oxygen presents with a non-interchangeable Schrader valve. Practice inserting this oxygen flow meter into the wall fixing. An oxygen specific flow meter is inserted to open the valve. The bobbin within the flow meter indicates the flow of oxygen through the meter. Oxygen flow meters without the bobbin are frequently used now.

Humidification : oxygen needs to be moist on reaching the lungs, so long term use of oxygen requires humidification.

Oxygen cylinders

These are made of steel and depending on size contains a set volume of gas. A Borden pressure gauge is used to display the volume of gas left in the cylinder. Most are fitted with a nozzle for attached oxygen tubing. Special Schrader valves exist for pressurised systems.

Gas flow, pressure and percentage of oxygen. There is no a linear relationship between litres and percentage of oxygen delivered, the delivery of oxygen is actually quite complex and many factors affect it. Tubing, gas flow, viscosity, resistance from the patient and the delivery system [mask, cannulae] all impact on actual percentage of oxygen delivered. So when we say 15 litres delivers 60% oxygen this is not what the patient receives due to all the above variables [tubing, gas flow etc]. The percentage of oxygen given is only a guide but gives practitioners something to anchor on.

Nasal Cannula

Used for patients who need supplemental oxygen, are awake, and tolerate nasal cannulae.
These deliver oxygen of about 24% to patients with a flow limitation of 4 litres. They are well tolerated by patients but can irritate the nostrils of some.

Hudson mask

This is a variable oxygen delivery device. The actual percentage of oxygen delivered will be variable and dependant on the patient. The adjustable elastic is important as many patients have ill-fitting masks causing discomfort or slippage. Between 5-10 litres gives up to 35-40% $Fi0_2$. $Fi0_2$ = fraction of inspired oxygen or the concentration of oxygen in the gas mixture. Oxygen flow should be at least 5 l/min to prevent rebreathing of $C0_2$.

Venturi mask

These devices deliver a fixed fraction of oxygen with the correct flow of oxygen as per colour. These masks are suitable for patients with chronic obstructive airways disease [COPD] where over use of oxygen can knock of the hypoxic stimulus to breathe on which they depend.

Non-rebreathe mask

The presence of a uni-directional oxygen reservoir and a non-return exhalation valve allows a higher fraction of oxygen to delivered to the patient. Ranges from 60-80%.

Bag-Mask-Valve [BVM]

This device has a one way valve and a self filling bag that can be used with a gas flow or air. To continue to deliver gas to the patient the bag needs to be compressed. It is a 2 litre bag so only depressing it ¼ will give you an adult ventilation. This system does not deliver any PEEP or Positive End Expiratory Pressure to maintain the alveoli open [see emergency care notes].

Mapleson C Circuit [Water's or Re-breathe circuit]

C circuit is used to provide manual positive pressure ventilation. It needs a fresh gas flow to achieve this. The circuit is fitted with a Heidbrink Valve with variable aperture. When the valve is open the patient can initiate breaths and the anaesthetist can clearly see how much respiratory effort he is capable of making. When fully closed, the anaesthetist needs to initiate all breaths. It is more sophisticated than the BVM as it allows the anaesthetist to 'feel' the resistance in the patient's lungs and to adjust the flow according to the lung compliance.

3. Suction

Suctioning is a vital skill in post anaesthetic care, and can be life saving in removing fluid secretions from blocking the airway. Suction equipment must be checked to be working on each shift and tubing, catheters found at each bedside.

Wall suction is set to a standard pressure in the UK of – 60 kPa. The vacuum regulator can be adjusted to alter the power of the suction normally set at 35 litres/minute. Excess liquid is trapped and the regulator connected to the collection canister. The vacuum wide bore tubing is used to attach either a Yankauer sucker or soft suction catheter. Changing the canister and tubing will be laid down in unit policy on suction which the nurse should be familiar with. Usually the suction bottle is cleaned daily, and the tubing and Yankauer sucker changed between patients, or after soiling. They must be changed every 24 hours minimum.

Suctioning the oropharynx with a **Yankauer sucker** is a clean, not a sterile technique. Care not to cause trauma to the soft tissues of the oropharynx or to dislodge clots post dental/ENT surgery. You always need to see the top of the catheter to ensure it is not being pushed deeper into the mouth and traumatising the tissues. The sucker should be used with care, especially when the tip cannot be visualised. Catheter and tubing should be flushed through [with sterile water of NaCl] and used repeatedly on the one patient and then disposed.

The **soft suction catheters** come in a variety of French Gauge sizes. Sizes 14-16 are commonly used in adult practice. They allow suctioning into the oropharynx via the guedel airway aperture. Usually they are now manufactured with finger/thumb valve incorporated, easy to occlude when the catheter is inserted thus stopping suction action at this stage. On removal the finger is removed from the valve so that suction is working, pulling back the fluid secretions. Soft suction catheters can be used in a clean technique when used in the oro-pharynx. They can also be used in sterile technique when suctioning down the endo-tracheal tube using open suction technique. Sterile gloves must be worn for this technique and the catheter discarded after one use. Closed circuit suction devices are now used routinely for endo-tracheal suction.

Since the Covid pandemic all suctioning procedures put the nurse at high risk. Hospital policies on personal protective equipment and suctioning procedures must be followed.

4. Monitoring

Pulse oximetry

Is a non invasive test that provides real time information on oxygen saturation of haemoglobin in the blood. It rapidly detects even small changes in the how efficiently oxygen is being carried to the tissues and indicates airway or respiratory problems that prevent this quickly. The probe is attached to the finger [care that patient does not have nail varnish applied which can interfere oximetry]. A digital reading giving the percentage of saturation is given with heart rate. One cannot be more than 100% saturated. Falling saturation to lower 90's denotes either airway, or respiratory complications.

Capnography

Is now increasingly used in the PACU to monitor end tidal carbon dioxide [normal range : 4.0 – 5.7KPa]. If the airway is occluded carbon dioxide will not be efficiently exhaled and build up in the blood stream. This equivalates to $C0_2$ expired on each breath which can be measured by capnography. Capnographs can be integrated with pulse oximeters or non-invasive blood pressure machines. They provide early indication of respiratory depression where $Sa0_2$ appears within normal limits.

Cardiac monitoring

Is an integral part of airway and respiratory assessment. If the airway is occluded, or respirations diminished, then oxygen will not reach the tissues. The heart and circulation compensate by increasing the flow of blood to the tissues. A reflex tachycardia and increase in blood pressure will be seen.

The cardiac monitor will incorporate ECG, HR real time readings, and non-invasive blood pressure recordings. Real time ECG trace reveals arrhythmias which may signify lack of oxygen to the myocardium.

5.Infection Control [Unit organisation and training policies]

The PACU is a high risk area for infection. Exhaled air, secretions, body fluids, wounds all pose a threat to those that work in this area. Since Covid, meticulous attention is must paid to personal protective equipment. Refer to your local hospital policy for the latest guidelines, policies on unit infection control and personal protective equipment.

At the least gloves, aprons, masks and visors should be worn when nursing the patient and performing a high risk intervention [suctioning, airway management, mouth care].

Scrupulous attention to the environment is equally important. The equipment must be regularly cleaned, together with the trolleys, furniture and all surfaces. The sluice and bed pan washer, incinerator must be checked and cleaned daily. Disposal receptacles for masks, suction catheters, gloves, gauze, tissues should be by every bedside.

Department policies & checks to ensure that equipment is rationalised, kept and stored in well marked places must be ongoing.

Training on all equipment should be built into the unit competencies / ongoing learning resources.

6.Emergency airway equipment and techniques

This encompasses intubation with ETT and emergency insertion of supraglottic airway, and the use of the BVM and Water's circuit to provide positive pressure ventilation. Ensuring successful outcomes in emergency situations is a much about calm management as skilled performance. Too many people round the bedside and lack of clear direction simply wastes valuable time. Each member of the team should be aware of their role. Unit management should include practice runs for emergency intubation from time to time.

The emergency airway trolley has everything needed for the situation clearly labelled on the front of each drawer in logical order. All PACU staff need to be familiar with this trolley. A couple of ET tubes [sized 7.0 - 8.0] should be cut down with connector attached for use in emergency when time is wasted fixing connectors onto the tube. All airway equipment that has been pre-prepared must be covered to prevent foreign bodies entering the equipment : [https://www.cas.mhra.gov.uk/ViewandAcknowledgment/ViewAlert.aspx?AlertID=103088]
The laryngoscope should be tested for light, the ET tube lubricated and instruments handed to the anaesthetist. Suxamethonium should be ready for administration. The ET tube will pass through the cords and rest in the trachea above the carina. Attached to a catheter mount, and bag device, the tube will be tested for position by auscultation of the lung fields.
The airway may be secured with the use of LMA or i-Gel.

Positive pressure ventilation is achieved with the bag-valve-mask. Squeezing the bag pushes oxygen at pressure into the patient lungs. The bag automatically inflates. This does not allow any respiratory effort from the patient. An oxygen reserve ensure that a high percentage of oxygen is delivered [80%]. If the patient is not intubated the mask will be attached to the bag, the seal on the mask must be intact, any leak of gas will disrupt the oxygen flow into the lungs. A two person operation is ideal, one to maintain jaw thrust and hold the mask secure, the other to bag the patient [i.e. prior

to intubation]. Once intubated the BVM will be attached to the end of the ETT or with a catheter mount to connect. A PEEP valve and HEPA [High Efficiency Particulate Air] filter is part of the circuit. The filter traps 99.7% of particulates 0.3 microns or larger. The PEEP valve maintains the airways open at the end of expiration. PEEP stands for Positive End-Expiratory Pressure. It is used in conjunction with mechanical ventilation. At the end of exhalation PEEP maintains the patient's airway pressure above atmospheric level by exerting a pressure that opposes passive emptying of the lung. This is achieved by maintaining a positive pressure flow at the end of exhalation.

The Water's Circuit has a Heidbrink valve incorporated with a variable aperture. It allows the patient to take spontaneous breaths when open. When closed breathing is wholly instigated by the operator. The valve also allows the anaesthetist to feel the airway resistance and modify his bag squeeze accordingly. The Water's circuit is attached to a mask for the non-intubated patient, and directly to the ETT or LMA when in situ. It is used largely by the anaesthetist.

There should be a BVM by each bedside ready for use. Sometimes a Water's circuit is also available.

Presentaton : Airway assessment

Nursing process : assessment

- Assessment always precedes intervention and evaluation in the nursing process. Nursing process cycles [assess : intervene : evaluate] occur fast in the immediate post anaesthetic phase when the airway is at risk. The nurse should remain by the bedside until the patient airway is safe.

Prioritise airway assessment

- Airway is always the first priority for assessment on patient reception. Without a clear airway, breathing will not entrain enough gas to ensure adequate alveolar ventilation of the lungs. Oxygen delivery to the tissues will be impaired and there will be a build up of carbon dioxide which cannot be properly expired.
- Look, listen, feel technique ensures that all signs of airway patency are assessed in deciding if the airway is clear.
- Continuous airway assessment is required until the patient is fully awake with a return of muscle tone and protective reflexes.
- In order to recognise signs of obstructed airway, first it is essential to identify signs of a clear airway in normal health.

Recognition of clear airway: look : listen : feel

Looks:

- Misting on mask : as air is exhaled the warm vapour will mist the mask, this is the definitive test for airway patency – observable even when the patient is hypoventilating.
- Colour : pink mucous membranes [conjunctivae/lips] denotes efficient delivery of oxygen to tissues.
- Saturation of oxygen : each molecule of haemoglobin carries 4 molecules of oxygen : if the haemaglobin is within normal range and fully loaded with oxygen – the patient will be 100% $Sa0_2$. Pulse oximetry gives a real time indication of respiratory status.
- Rate & depth of breathing : adult range 12-16 bpm. A clear airway and efficient depth of respiration will deliver adequate alveolar ventilation to deliver oxygen to the tissues and eliminate carbon dioxide from the body. Minute volume = amount of air exchanged over one minute. Tidal volume = air exhaled in one breath around 500mls. TV X RR = MV [normally around 6000 mls of air].
- Pattern of breathing : if the airway is clear, and respiration efficient, breathing is unforced as air is sucked into the lungs as the rib cage rises and diaphragm descends. On expiration air is exhaled as the rib cage passively recoils back and diaphragm rises.
- There should be no use of the Sternocleimastoid and Scalene muscles of the neck.
- Tracheal tug [a downward visible pull of trachea] should not be visible.
- Cardio-vascular status : BP and HR within reasonable parameters and not compensating for airway obstruction or respiratory difficulty.

Listens :

- If the airway is clear there will be no noise of breathing. Noisy breathing is only heard with an obstructive airway. Silence may denote complete obstruction denoted by silence and other fast presenting other signs of acute hypoxia.

Feels :

- As with mask misting, this is a definitive method to ensure the airway is clear. Warm exhaled air will be felt at mouth or nostrils on expiration.

Assessment of obstructed airway : look : listen : feel

Looks:

- Prolonged unconscious state indicates that airway at risk. Muscle tone may be weak and protective reflexes not re-established.
- Pallor leading to cyanosis. Pallor indicates poor perfusion of oxygen to tissues which may indicate obstruction along with other signs. Examine the mucous membranes of the conjunctivae and lips to determine if pallor is central [i.e. primary airway/respiratory] problem. Pallor may also be caused by a primary cardio-vascular disorder so it is important to establish this. Cyanosis is a late indication of hypoxia denoting 3 gms of deoxygenated Hb present [advanced obstruction leading to total occlusion].
- Limited misting on mask due to limited exhalation of air. In total obstruction no misting is present.
- Falling $Sa0_2$: 95% upwards is a normal 'safe' margin of oxygen saturation. Saturation of oxygen below this reading must be questioned. How much $Fi0_2$ is being delivered, has the patient a known respiratory disorder? If obstruction is severe [or total] the $Sa0_2$ will fall fast below 90% as oxygen dissociates rapidly from Hb [as the falling $Pa0_2$ fails to load oxygen onto the Hb molecule].

- Altered respiratory rate and depth : fast, shallow respirations [tachypnoea] may be seen as the patient tries to pull in air against the airway obstruction. If obstruction prolonged this pattern may change to slow breathing rate [bradypnoea] together with shallow breaths may be associated with obstruction if the work of breathing against a partially closed airway alters the rate and depth of breathing.
- Irregular pattern of breathing. Paradoxical breathing [see saw pattern] is a sign of severe airway obstruction as the chest wall and diaphragm move out of sequence in order to pull air into the lungs.
- Use of accessory muscles : the scalene and sternocleimastoids muscles are engaged to lift up the rib cage further to pull air into the lungs if obstruction occurs.
- Tracheal tug : downward movement of the trachea at base of neck is a sign of significant obstruction as the patient struggles to entrain air.
- Unstable CVS : if airway obstruction and hypoxaemia present the cardio-vascular system will attempt to compensate by delivering more blood to the tissue. BP and HR will be elevated.

Listens:

- Snoring : caused by tongue / soft tissue occluding the oro-pharynx is a clear indication of partial obstruction.
- Gurgling : denotes the presence of clear fluid [saliva] or bleeding into the oral cavity an indication of partial obstruction.
- Crowing [stridor] : signifies a partially closed glottis due to irritation : spasm of the vocal cords.
- Wheezing : signifies lower airway constriction and obstruction to free passage of air.
- Silence, along with other signs of deterioration denotes complete airway obstruction : this is first line emergency.

Feels :

- Limited feel of warm air exhaled signifies partial obstruction to passage of air. No feel of air, with other signs of rapid deterioration, indicates total obstruction : a first line emergency.

Assessment of risk factors:

Observing risk factors should be carried out alongside assessment of clinical signs in order to pre-empt airway obstruction before it occurs. The following should be noted routinely on patient reception.

- Conscious level may be an indication of clear airway. If patient awake and can swallow & cough it means that his muscle tone and protective reflexes are functioning normally. If the patient is drowsy, semi or unconscious, the airway is still in danger.
- Patient position : in the supine position the airway falls to the back of the oro-pharynx in the drowsy, semi or unconscious patient.
- Patient weight : if the patient is obese with the risk of obstruction is increased due to layers of fatty tissue in the upper airway.
- Surgery : dental and ENT surgery carry an increased risk of bleeding and or foreign bodies [packs] which may obstruct the airway.
- Endotracheal intubation may traumatise the vocal cords leading to spasm and obstruction.

Risk factors may accumulate : the obese, unconscious patient, supine, with no airway adjunct, having undergone ENT surgery is at a high risk of obstruction.

Presentation : Airway management

Nursing process : intervention

- Intervention follows assessment of the airway in the nursing process. Evaluation then informs the nurse whether the intervention has been successful, or whether another intervention needs to be tried.

- While the airway remains unprotected and at risk of obstruction, the cycle of assessment : intervention : evaluation needs to be repeated continuously until the airway safe. If significant obstruction occurs, hypoxia will quickly result.

- Airway interventions in this section denote several different techniques to clear the airway. They do not necessarily follow a strict order. Assessment will inform the need for any one of the interventions detailed below.

Please note, this presentation covers routine airway management. In the next presentation, airway management for specific airway complications will be covered.

First routine airway management for the normal recovery must be considered. If the patient is awake and alert on return, then the airway is already safe. If drowsy, semi or unconscious surveillance is needed until he wakes up, ejects any airway adjunct and assumes control of his airway. Minimal intervention may be required to remove the airway.

Normal recovery : removal of airway adjuncts :

- The LMA/SAD sits over the top of the larynx and prevents the tongue from occluding the oro-pharynx. The LMA/SAD should be left in situ until the patient is awake enough to reject. Sometimes it is necessary to apply jaw thrust as well as using the LMA [in the obese patient : or one with thick : short neck].

- The correct moment to withdraw the LMA/SAD is usually when the patient is sufficiently awake to self eject. At this point the LMA/SAD should be removed gently with the cuff inflated if possible to bring up secretions on withdrawal. If masseter spasm exists, it may be necessary to deflate the cuff [or if patient has unstable dentures].

- Intubated patient : the anaesthetist should be responsible for care of the intubated [with ETT] patient if the unit does not employ advanced practitioners. Extubation may provoke spasm and the need for rapid re-intubation.

Staged management of airway complications: if the patient develops airway complications, the following 'staged management' will give general guidelines to aid decision making in what can often be a tense period.

Stage one : Routine airway interventions :

This section identifies the interventions that the nurse makes routinely to ensure the airway does not obstruct, or to correct obstruction where it occurs. Normally using any or more of the above techniques will clear the airway leading to a normal recovery.

- All patients have oxygen administered in the early post anaesthetic period [$Fi0_2$ 28-35%] via a mask or T piece. In any airway/respiratory complication increase $Fi0_2$ to maximise oxygen delivery to the tissues [full flow 15L with reservoir bag gives 60% $Fi0_2$] via face mask or T piece.

- Chin lift : jaw thrust : both lift the tongue from the back of the oro-pharynx. Jaw thrust is the gold standard airway intervention, by pushing the mandible forward at an angle of 90 degrees - the tongue also travels forward. This is a priority airway intervention, if chin lift/jaw thrust do not alleviate obstruction then a oropharyngeal [guedel] airway may also be inserted.

- Use airway adjunct : oro-pharyngeal if jaw thrust alone insufficient to lift tongue from back of oro-pharynx.

- Naso-pharyngeal tube is usually inserted in the patient who has chronic airway obstruction and who needs longer term airway assistance.

- Patient position : the recovery position [left lateral] will allow the tongue to fall forward with gravity [head down] if secretions are copious or patient shows signs of regurgitation and aspiration into the unprotected airway. The left lateral position is chosen to facilitate re-intubation if necessary [less danger of intubating the right main bronchus if the left side is dependent].

- Suction oral cavity with soft suction catheter / Jankaeur.
  Suction the oro-pharynx using a soft catheter. Care should always be taken if patient bleeding to allow clotting to take place.

All of the above interventions may be initiated and evaluated to prevent or treat airway obstruction. There is no fixed order for intervention techniques.

In the event that despite trying these interventions the patient displays any of the following signs, then help must be called.

Sign of airway obstruction	**Degree of obstruction**
Falling $Sa0_2$ below mid 90's	Limited air flow
Limited misting on mask or feel of breath	Limited air flow
Noisy breathing [snoring, gurgling, crowing]	Signs of obstructive air flow
Increased work of breathing : use of accessory muscle, tracheal tug	Severe obstruction
Paradoxical breathing pattern	Severe obstruction
Pallor leading to cyanosis	Severe obstruction
No noise of breathing	No flow of air – total obstruction
Unstable cardio-vascular signs	Severe obstruction

Table of signs & degree of airway obstruction

Call for help – move onto Stage Two

- At any point where the nurse is unable to unsure of how to make sense of the signs she observes, or is unsure what intervention to make, then help must be summoned immediately. If the situation is acute, the emergency call system must be activated. Hand ventilation via bag-valve-mask must be initiated.*

- Summon help by pulling emergency button [or local device] : calling out for help from PACU team as it will take more than one person to organise resuscitation.

- Team member to get emergency intubation trolley and [with all the equipment & drugs for intubation at hand : drug that may be used include : neostigmine : Suxamethonium : Doxepram : Naloxone : Flumazenil.

* *Even for the experienced practitioner it is sometimes difficult to diagnose the primary cause of airway obstruction. It may be secondary to central respiratory depression, where delayed return to consciousness is accompanied by slow, shallow respiratory effort. If the assessment demonstrates a deteriorating clinical picture, then this is not the point to engage in speculation as to the exact nature of the problem. Remember there is only around 3-4 minutes until the brain is damaged.*

Stage two : hand ventilation

- Airway management using hand ventilation via bag-valve-mask to deliver oxygen.

- In critical airway [breathing] scenarios positive pressure ventilation [hand ventilating with bag-valve-mask] will attempt to force a high % of oxygen into the patient lungs. Using bag-valve-mask with reservoir bag gives a concentration of around 90%.

- It is safer to use two people to bag the patient : one to apply jaw thrust and fix mask onto face – the other to bag.

- The patient should be monitored as far as possible ; apply ECG electrodes if none fixed and monitor cardio-vascular performance.

- A team member should be deployed to prepare the equipment on the emergency trolley : draw up drugs that may be needed.

- When help arrives – someone will need to coordinate the team and to ensure that all other patients are being looked after.

Stage three : emergency intubation of the trachea

- This is a team approach. One nurse should assist the anaesthetist, another be at hand to fetch anything needed. A third should supervise the team to look after all other patients in the unit.

- The nurse assisting the anaesthetist should ensure that equipment is prepared, laryngoscope working, ETT prepared [cut down and balloon integrity checked], syringe to inflate – tie to secure ETT ready. Catheter mount to attach the

end of the ETT to the oxygen circuit. Stethoscope to check the ETT position. Suxamethonium may administered to relax the cords for intubation. Drugs need to be recorded, and vital signs noted throughout.

Presentation : Specific Airway Complications

4 airway complications are given here. These four complications are relatively common and can be life threatening. Management of these complications requires experience and is not undertaken by the novice PACU practitioner without skilled supervision and assistance.

1.Aspiration

- Aspiration is a high risk, low-frequency occurrence in the PACU. It can trigger laryngospasm, severe pneumonia leading to ARDS. Aspiration accounted for more deaths than failure to intubate or ventilate in the Royal College of Anaesthetists 4th National Audit Project [NAP4] data.

- Aspiration is the taking in of foreign material to the lungs setting up chemical inflammatory process which, if severe can lead to life threatening pneumonia.

- The trachea lies immediately anterior to the oesophagus. In normal health, food, fluid and air enter the pharynx from where air passes down to the trachea and the lungs, and food, fluid enter the oesophagus and the stomach. This is possible because on swallow, the epiglottis folds over the glottis preventing food entering the trachea while the sphincters that protect the oesophagus and stomach open to allow food to enter the stomach. Normally these sphincters [upper and lower oesophageal sphincters] are closed.

- In general anaesthesia large volumes of gastric content increase the pressure within the stomach while in laparoscopy rising intra-abdominal pressures also cause intra-gastric pressure to rise. Both the upper and lower oesophageal sphincters relax and allow food contents to escape from the stomach, move up the oesophagus and be

vomited up, or regurgitated into the unprotected airway. Remember GA causes loss of swallow and epiglottal function. Depending on the volume aspirated, the acid contents produce chemical inflammation and infection leading to pneumonia.

- Aspirate may contain large food particles, clear acidic fluid or contaminated material, also foreign bodies, teeth or blood may be aspirated.

- Risk assessment is key to managing this complication. Those at risk of aspiration are those known full stomachs, or history of gastro-oesophageal disease, obese or pregnant patients, those with neurological disease and emergency procedures with inadequate fasting times. Surgical factors can add risk, upper GI surgery, lithotomy [head down] position and prolonged procedures lasting more than 2 hours.

- For all patients starvation is a necessary procedure to minimise aspiration. For those at risk gastric acidity is reduced by giving antacids, H_2 antagonists [Ranitidine] or Protein Pump Inhibitors [Lansoprazole] preoperatively. This will minimise the risk of acid damaging the lungs. These patients should be intubated sitting up and rapid sequence intubation done for all trauma patients. An NG tube will enable gastric drainage. Care taken to leave the ETT in situ until the return of the protective reflexes. Positioning on the left side will lessen the danger of aspirate entering the lungs via the straighter Right Main Bronchus.

- These patients should be identified prior to surgery and preventative measures taken. All emergency cases should be intubated using rapid sequence technique, elevation of the head together with an NG tube. For high risk elective patients starvation, administration of antacids [H_2 Histamine Antagonists] : all designed to minimise the risk of aspiration. Post surgery minimising risk includes maintenance of the ETT or LMA until the patient is awake and

airway reflexes have returned and positioning the patient on the left side or with the head to the side. The supine position renders patients liable to aspiration.

- Any episode of vomiting or regurgitation the patient should immediately be placed on the side head down to aid drainage. Recognition that aspiration has occurred is not always easy. Suspect aspiration if there are gastric contents in or around the mouth. Depending on the severity of the aspiration the patient may develop audible wheeze, tachypnoea, tachycardia, cough and $Sa0_2$ will fall. A severe episode may lead to hypoxaemia, atelectasis, interstitial oedema and eventually to ARDS [Acute Respiratory Distress Syndrome].

- If aspiration is suspected it should be treated as an emergency, the patient may need reintubation, suctioning and mechanical ventilation. The trachea should be suctioned once the airway is secure and ideally before ventilation is started to prevent distal displacement of aspirated material. Aspiration more common affects the right lung as the right main bronchus is more vertical than the left. Arterial blood gases assist in planning respiratory management of the patient. A chest XRay is obtained but findings may be inconclusive initially. Tracheal secretions should be cultured and antibiotics prescribed if positive. Early bronchoscopy may help prevent distal atelectasis if particulate matter has been aspirated. The patient should be transferred to an acute facility.

Ref: https://academic.oup.com/bjaed/article/14/4/171/293792 [attainable online]
Robinson, M. & Davidson, A., [2013] Aspiration under anaesthesia:risk assessment and decision-making. *Continuing Education in Anaesthesia Critical Care & Pain.* Vol.1 Issue 4, August 2014 pp 171-175

2.Laryngospasm

Most practitioners will have dealt with this complication. It can range from mild to acute. While mild spasm may be tolerated by the patient, with good nursing support, the acute scenario is highly stressful for the patient and nurse and should be considered life threatening. Spasm should always be considered an emergency – even if mild.

This involuntary closure of the vocal cords may cause partial or complete closure of this critical 'gateway to the lower airway'. Caused by secretions or stimulation to the glottis or irritation of the laryngeal reflexes on emergence from anaesthesia and extubation. The significant sign in spasm is inspiratory stridor, the crowing noise the patient makes when air passes through partially closed vocal cords. This is unique to laryngospasm. Other signs of hypoxia are evident, falling saturation, pallor, raised HR and BP - all signs of respiratory stress. If severe, paradoxical chest movement, use of accessory muscles denotes that the patient is trying desperately to inspire air. If not corrected severe hypoxia, hypercapnia and associated cyanosis occurs. If the patient displays all of the above signs with no noise, then spasm has shut the cords tight together and no air is passing through. Action must be immediate.

- If very mild the spasm may pass with experienced nurse management. All first stage airway management interventions may be tried [increase oxygen, chin lift, jaw thrust, very careful suction if patient sounds 'wet']. Jaw thrust on its own may break the spasm by bringing the jaw forward. Even at this early stage however, the practitioner must be aware that spasm may increase. Call for help and ensure that the Bag-Valve-Mask is ready, the emergency intubation trolley is at hand and Suxamethonium prepared. Emergency intubation may have to be performed. The patient should be well supported head up if conscious, to maximise respiratory excursion. At all times the patient must be reassured that the spasm is being managed and will pass. Lignocaine may be administered to break the spasm.

- The anaesthetist will try to break the spasm by bagging oxygen and air under positive pressure with the use of BVM or Water's Circuit. This should force open the cords and allow gas to reach the lungs. If the cords are shut tight, and the patient has had ENT/Dental surgery it may be that a blood clot is sitting on the cords. Visualisation with laryngoscope and very careful suction will remove the clot.

- If none of the above relieve the situation the patient may have to be re-intubated. Vocal Cords are paralysed with Suxamethonium and ETT placed. From here the patient will need short term ventilation.

- Reintubation carries it owns problems as raises the question of what will happen when extubation takes place again.

Ref : Gavel, G. Walker, R. (2013) Laryngospasm in Anaesthesia. Continuing Care in Anaesthesia, Critical Care & Pain. August 26th 2013.

3.Residual Paralysis

This is a common post operative complication and can lead quickly to acute airway and respiratory compromise. The pharmacology underpinning this condition is quite complex and needs careful explanation.

Muscle relaxants paralyse all muscles in the body, including the respiratory muscles and those of the larynx. While effective, the patient must have a managed, secure airway, and assisted ventilation. Muscle relaxants are used to relax the laryngeal muscles and vocal cords to enable intubation and also to maintain the state of paralysis during surgery to enable the surgeon to handle the body tissues, also to facilitate assisted ventilation, ensuring the patient does not try to

breathe against the ventilator. A short acting, depolarising drug, Suxamethonium is used to assist intubation. Long acting non-depolarising agents such as Rocuronium, Mivicurium maintain paralysis through surgery.

In order to understand precisely how the above agents work we need to examine the action of Acetylcholine, a neural transmitter the action of which causes muscle movement. At the neuromuscular junction, Acetylcholine jumps from the motor end plate to the muscle receptors causing fasciculation [movement]. Acetylcholine is then broken down by Acetylcholinesterase which terminates muscle activity ready for the next wave of excitation occasioned again by Acetylcholine.

Suxamethonium works by **competing** with Acetylcholine jumping across the neuromuscular junction and occupying the motor end plate terminals. It causes fasciculation [movement] of the muscles like Acetylcholine, but unlike Acetylcholine is not broken down by Acetylcholinesterase. Normally this action stops muscle movement in time for the next wave of fasciculation. Now however, the patient remains paralysed until the effect of the drug wears off – up to 15 mins but often shorter. There is no need to reverse this agent. Suxamethonium is a short acting, depolarising agent.

The long acting muscle relaxants [Rocuronium, Vecuronium] are **non depolarising** and work by **competing** with Acetylcholine by binding with the muscle receptors thus preventing Acetylcholine from crossing over the muscle. Repolarisation cannot occur.

Residual paralysis is the reappearance after surgery of the pharmacologic actions of a **non depolarising** skeletal muscle relaxant that was administered during surgery. Even if a non depolarising muscle relaxant is reversed sufficiently at the end of a procedure, residual paralysis can still occur up to 8 hours post surgery.

These non-depolarising agents do not reverse spontaneously and are reversed by Neostigmine. This increases the amount of Acetylcholine at the neuromuscular junction, therefore leading to the relaxant being outcompeted and washed away restoring normal transmission from neuron to muscle fibre. Usually this dose is administered at the end of surgery, paralysis is reversed, allowing the patient to breathe on his own, and control his muscles. Sometimes however, the dose is inadequate, or does not reach the vein. Or the procedure is cut short quickly, and the Neostigmine is ineffective.

The recovery nurse routinely checks that full muscle power has been restored by asking patients to lift their head from the pillow and hold for 5 seconds, squeeze the hand, or stick out their tongues. All proof that they have no residual muscle weakness.

The classic signs of residual paralysis, once seen, are always remembered by the PACU nurse. The patient limbs may be twitching, jumping, the limbs flail, out of control. The airway is slack and there may be signs of obstruction. If the airway and breathing are thus compromised, signs of hypoxia will be evident. If the respiratory muscles are involved, or airway compromised and the patient is awake they will be extremely frightened, feel out of control, control their limbs or take enough air into their lungs. This is an emergency and the nurse should summon help. The nurse must stay with the patient, reassuring her that this will get better, to calm down and practice taking a breath in – and letting it out. If necessary breathing should be supported with bag-valve-mask positive pressure ventilation. The patient should be sitting up to facilitate respiratory excursion. The anaesthetist may test muscle response by using a nerve stimulator. He will administer a further half dose of neostigmine [0.3mg iv]. A full dose would potentiate the block and cause bradycardia so the dose is given in stages. Usually this resolves the problem immediately. If still unresolved after 5 minutes then the safest option is to sedate and reintubate and ventilate the patient. Usually any neuromuscular blockade will have worn off in an hour.

If Rocuronium is used Sugammadex will reverse this drug.

Ref: Plaud B et al [2010] : Residual paralysis after emergence from anesthesia. *Anesthesiology* April 2010, Vol.112, 1013-1022.
Download at https://pubs.asahq.org/anesthesiology/article/112/4/1013/10654/Residual-Paralysis-after-Emergence-from-Anesthesia

4.Bronchospasm

Bronchospasm is not a common complication in PACU but nevertheless a significant problem which must be dealt with immediately. It may appear in its own right or be a component of another problem such as anaphylaxis or aspiration.

Bronchospasm is the narrowing of the bronchi and bronchioles from smooth muscle contraction. It may be the result of pre-exisiting asthma : allergy or anaphylaxis : histamine release : mucous plugging, aspiration, pulmonary oedema : or foreign body aspiration. Smokers produce copious mucous secretions and are a high risk of bronchospasm as cilia which normally clear the bronchi of secretions, are destroyed, leaving the airways sticky and filled with mucous which can set off hyperactivity and spasm.

Any patient with a history of asthma or COPD or smoking must be risk assessed prior to surgery and anaesthesia. Drug sensitivities should be assessed [for instance NSAID induced bronchospasm may be a risk]. Smokers should be encouraged to stop smoking for 6-8 weeks prior to surgery. If possible general anaesthesia and intubation should be avoided and regional anaesthesia provided. If general anaesthesia is necessary, preoperative bronchodilators, steroids, chest physio may all be appropriate.

The patient who smokes heavily often has a 'plethoric' look, purplish, red face and airways can sound 'wet' even when breathing normally. If spasm occurs classic signs are cough, prolonged expiration, expiratory wheeze, dyspnoea, use of accessory muscles and tachypnoea. The patient may become cyanosed if severe with falling saturations of oxygen and rising $ETCO_2$. Bronchospasm is very stressful for the patient attempting to cough. He should be sat semi recumbent to allow for respiratory excursion and given reassurance. As with other complications the problem may be mild to acute. Nebulised Salbutamol will ease mild bronchospasm.

Acute bronchospasm where there is no noise of wheezing is sinister as there is no air flowing along the bronchial tubes. Treatment includes removal of identified cause, oxygen administration, inhaled bronchodilators and Adrenaline. Administration of bronchodilators such as Salbutamol may be sufficient to treat mild bronchospasm. For acute spasm Adrenaline is needed to bronchodilate the airways. Depending on the cause Dexamethasone may be appropriate. Secretions should be suctioned. If a foreign body is suspected of causing spasm – this should be retrieved under bronchoscopy. It may be necessary to re-intubate the patient and give ventilatory support. With ongoing symptoms a chest xray should be taken to exclude pulmonary oedema. Regular therapy, bronchodilators, steroids, physiotherapy should be arranged and the patient sent onto a high dependency unit. If the event was triggered by serious allergic reaction the patient should be referred to a specialist allergy centre for further investigation.

Ref : Looseley A. [2011] Management of bronchospasm during general anaesthesia : Update in Anaesthesia. www.anaesthesiologists.org pp 17-21. Available online : https://www.wfsahq.org/components/com_virtual_library/media/3fe4887e14541ff43fc8b0d7c6c477f8-Bronchospasm-During-Anaesthesia--Update-27-2011-.pdf

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Professional PeriAnaesthetic Organisations Resources

Diffcult Airway Society [DAS] [das.uk.com]
Works with the Royal College of Anaesthetists to prepare audit, guidelines and teaching materials:

Check out these new DAS/RCoA teaching materials for the Novice Anaesthetist:

- Pre-oxygenation and Basic Airway Management
- Supra-glottic device insertion
- Endo-tracheal intubation
- Extubation
- The Larynx [shows exactly how the larynx works]

DAS presentations from Annual Scientific Meetings are also available from this website. Specific to airway topics, these can be very interesting.

Royal College of Anaesthetists [RCoA] [www.rcoa.ac.uk]
R + DAS : National Audit Project series

- National Audit Project 4 : Major Complications of Airway Management in the United Kingdom [2011]
- RCoA : The Guidelines for the Provision of Anaesthetic Services [GPAS] Chapter 4 : Guidelines for the Provision of Postoperative Care.

Association of Anaesthetists [AAGBI] [anaesthetists.org]

- UK National Core Competencies for Post-anaesthesia Care 2013

- Immediate Post-anaesthesia Recovery 2013 supplement

American Society of PeriAnesthesia Nurses [ASPAN] www.aspan.org
Leading society for post anaesthetic care nursing globally with well established resources on :
research, quality audit, education, clinical initiatives, competencies, curriculum. ASPAN hosts an excellent annual conference, webcasts and seminars. ASPAN publishes Breathline and the Journal of PeriAnesthesia Nursing [JOPAN] as well as Standards and a competency based orientation program for the Registered Nurse in the PeriAnesthesia setting.

Specific articles :

Laryngospasm :
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YouTube videos

Basic Sciences

- Swallowing Reflex, Phases and Overview of Neural Control, Animation [2.59mins] Alila medical Media : https://www.youtube.com/watch?v=YQm5RCz9Pxc

- How do we cough? The mechanism of Coughing : Cough Reflex Animation : Learn Human Body : [1.33 mins] Science Art.
  https://www.youtube.com/watch?v=usAqJoVYVSc

Anaesthesia and Surgery

- How does anaesthesia work [3.24]
  Anaestheticshttps://www.youtube.com/watch?v=1iVWSsIaXGw

- Anaesthesia - General Anaesthesia [3.13 mins] https://www.youtube.com/watch?v=65h8N4j9MIc Moorfields Eye Hospital NHS Foundation Trust

- How does anaesthesia work : Steven Zheng [4.55mins] : https://www.youtube.com/watch?v=B_tTymvDWXk TED-Ed

- Laryngeal Mask Airway Insertion [2.57mins] EM Capetown thttps://www.youtube.com/watch?v=vNvymbRD5b4You tube videos

- Endotracheal intubation [6.54 mins] https://www.youtube.com/watch?v=8AOB2PtHfVM SKÅNES UNIVERSITETSSJUKHUS LUND

- Primary FRCA OSCE : Airway Assessment [www.ETTube.co.uk] [6.39] complete anaesthetist airway assessment ps://www.youtube.com/watch?v=Dqn5tRtha_I

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  Goes through pre-assessment, induction, maintenance and reversal of GA.

- Anaesthetic pre-operative assessment and the pre-operative visit : UCLCentre for Anaesthesia [podcast] [5.11] https://www.youtube.com/watch?v=LzOFBh-tzXg

- Larygnospasm, a potentially dangerous protective reflex [6.13mins]
  https://www.youtube.com/watch?v=i0_EjX4RPFQ
  Christine Whitten, M.D.
  Anyonecanintubate.com
  Excellent clinical video

- Laryngospasm: Sudden, Terrifying Difficulty Breathing [4.55mins]
  https://www.youtube.com/watch?v=nPtdkqOLLP4

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- Swallowing Reflex, Phases and Overview of Neural Control, Animation [2.59mins]
  https://www.youtube.com/watch?v=YQm5RCz9Pxc
  Alila Medical Media
  Excellent