Montagu Clinical simulation centre

The Recognition and Management of the Seriously Ill

(RAMSI)

FRED & ANN
Green's
LEGACY

Doncaster and Bassetlaw Hospitals **NHS**
NHS Foundation Trust

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INTRODUCTION

Welcome to the Recognition and Management of the Seriously Ill (RAMSI) Course. Through this course you should gain the skills required to recognise and care for the acutely ill patient. We will help you develop a systematic approach to these patients so that you can intervene as appropriate and safely take forward the patients care. We will not only cover the knowledge required but look at how anticipation, communication, teamwork and organisation are essential for the management of these patients. The importance of safety in healthcare will be highlighted and common precipitants of medical error will be identified.

The purpose of this handbook is to offer guidance and support and is not definitive. It is intended to give a helpful overview of a patient's general status following the ABCDE approach, allowing you, the healthcare professional, to see the global picture. If you are in any doubt seek immediate senior advice or assistance. This handbook is designed to be a "living" document to which you can add local protocols, personnel notes etc.

This one day multidisciplinary course utilising the concept of simulation based training, has been developed to assist Doctor's, Nurses and Physiotherapists in caring for acutely unwell ward patients. The issues that you will meet during the course have been identified from a needs assessment undertaken by the Outreach team at Doncaster & Bassetlaw Hospitals NHS Foundation Trust. It is designed to address the real issues facing you in our rapidly changing Health Service.

How will Simulation be involved in your training?

The management of an acutely unwell patient can be incredibly stressful for all members of the healthcare team, not least the patient and their family. The re-creation of clinical events to simulate crisis situations, gives staff permission to "manage" that event, identify potential errors, investigate the concepts behind effective leadership and teamwork, and provides a safe environment to explore strengths and areas for improvement in our own practice.

For you to get the most out of simulation based training all scenarios will be video recorded, and then re-played to the whole group. There will be a facilitated debrief which will encourage you to reflect on how the team performs in a stressful situation, and analyse why you do what you do, and how this ultimately affects the care that your patient receives.

The effective use of teamwork in caring for a seriously unwell patient can make a difference to the patient outcome. Appropriate quick action, global assessment and declaration of an emergency are key aspects of good patient management, and these principles will be incorporated into the scenarios and subsequent debriefs.

Whilst not every delegate will be able to participate in each scenario there is significant potential to learn from observing others and reflecting on and discussing their performance.

Confidentiality is assured and all recordings are kept securely at the Clinical Simulation Centre, where only immediate faculty staff have access to them.

To summarise…

The overall aim of this course is to prepare practitioners for any eventuality involving the seriously ill ward patient, and just in case you were thinking "It won't happen to me", here is an example of this mentality from history:

"When anyone asks me how I can best describe my experience of nearly forty years at sea, I merely say uneventful. I have never been in an accident of any sort worth speaking about… I never saw a wreck and have never been wrecked, nor was I ever in any predicament that threatened to end in disaster of any sort."

Edward J. Smith
Captain of the Titanic

AIRWAY

The aim of this chapter is to allow practitioners to assess and support a patient's airway.

> **Primary Survey**
>
> **Assess Airway**
>
> Verbal Response (variable if tracheostomy in-situ)
> Look, Listen, Feel
>
> **Support Airway**
>
> Patient positioning, chin lift, jaw thrust
> Suction $\pm$ saline instillation
> Consider Airway Adjuncts:
> > Nasopharyngeal Airway
> > Guedel Oropharyngeal Airway
>
> Tracheostomy:
> > Change/clean inner tube
> > Inflation/deflation of cuff
> > Removal of cap/phonation valve
>
> **Supplemental Oxygen**
>
> see Breathing chapter
>
> **Secondary Survey**
>
> Is senior help needed – ENT, Anaesthesia
>
> Definitive airway management (Intubation, tracheostomy, new tracheostomy tube, decannulation)

Causes of Airway Obstruction:

- Loss of muscle tone in the soft tissues of the soft palate, epiglottis and tongue
- Secretions, vomit, blood
- Foreign bodies, dentures
- Tumours
- Direct trauma
- Oedema secondary to burns and anaphylaxis

Airway assessment:

Verbal response: An appropriate, clear verbal response reassures us that at that point the airway is not in immediate danger.

Look: Respiratory rate, patient position, use of accessory muscles, cyanosis, see-saw movement of chest and abdomen.

Listen: Noisy respiration suggests partial obstruction, absence of sound total obstruction. Gurgling (secretions), snoring (soft tissues), stridor, wheeze.

Feel: Air movement presence or absence at mouth or nose, chest movement.

Basic Airway Management:

Simple interventions using basic equipment is often all that is required to ensure a clear airway. First remove any obvious foreign body. Well fitting dentures may be left in-situ as they may aid maintenance of the airway or ventilation. Then consider some basic airway interventions.

Suction: A wide bore rigid sucker should be used to clear secretions (Yankauer).

Chin lift: The fingers of one hand are used to gently lift the mandible upwards to bring the chin anterior. The thumb may be used to depress the lower lip.

Jaw thrust: With a hand on each side the angles of the lower jaw can be pushed forward to displace the mandible anteriorly. This is useful if a cervical spine injury is suspected as it is less likely to hyperextend the neck.

Position: Patients, if conscious, will adopt the position most comfortable for them. If unconscious and spontaneously breathing then place in recovery position.

Airway Adjuncts

These aid the maintenance of airway patency in the spontaneously breathing or ventilated patient. They may occasionally make obstruction worse or cause trauma, bleeding, gagging, vomiting or impact further an unrecognized foreign body.

Nasopharyngeal Airway

Better tolerated by semi-conscious patient.
Sizes 6mm to 8mm in adults

Oropharyngeal Airway (Guedel)

Sizes 0 (Black) to 4 (Red), Average adult size 2 (Green)

Adult Guedel Airways

Oxygen Therapy

The principle indication for oxygen therapy is correction of hypoxaemia

Symptoms: Breathlessness
Headache
Nausea

Signs: Confusion and agitation
Cyanosis
Tachypnoea
Tachycardia
Low oxygen saturation on pulse oximetry

See Breathing Chapter for detailed oxygen therapy description.

TRACHEOSTOMIES

Tracheostomies can (and do) cause many problems, especially as staff are less familiar with this airway, so are covered in greater detail within this handbook. A tracheostomy is a surgical opening in the anterior wall of the trachea to facilitate ventilation.
A tracheostomy reduces upper airway anatomical dead space as air flows directly into the trachea and bypasses the nose, pharynx and larynx. Warming, humidification and filtering of air no longer occur naturally as a result of this bypass.

Indications for tracheostomy

A tracheostomy can be inserted for a number of reasons;

- To facilitate weaning from positive pressure ventilation

  - Usually expected to be a temporary tracheostomy

- To secure an airway in upper respiratory tract obstruction

  - If obstruction is unrelieved then loss of the tracheostomy will result in loss of the airway

- To secure an airway in patients with surgery or injuries to the head and neck, enabling reconstructive surgery. Again if the tracheostomy becomes dislodged then the airway may be lost or difficult to recover.

- To facilitate removal of respiratory secretions

  - Often a "mini-trach"

- To minimise aspiration risk by protecting the airway

  - Patients with absent cough reflex or loss of laryngeal function such as those with a Bulbar Palsy will need a cuffed tube to protect their lung against aspiration. Even if they appear to have a patent airway.

- To enable long term ventilation

Caring for a patient with a tracheostomy

When responsible for the care or management of a patient with a tracheostomy you should always know the history of the patient and any future management plans. You should always ascertain;

- When and why the tracheostomy was performed
- Were there any difficulties with insertion or problems since insertion
- Is there a tracheostomy tube in situ and what kind of tube is it
- Is the tube temporary or permanent
- Management plan for the tracheostomy/tube
- What would you do in an emergency

Techniques of tracheostomy

Percutaneous tracheostomy

A tracheostomy tube is inserted between the first and second or second and third tracheal ring using a dilation approach. This procedure is quicker than the surgical tracheostomy and can be performed in the critical care setting.

Surgical Tracheostomy

This procedure is used in head and neck surgery and in patients where abnormal anatomy precludes a percutaneous tracheostomy.

Cricothyroidotomy (Mini-tracheostomy or 'mini-trach')

A small diameter tube is inserted via a percutaneous approach into the cricothyroid membrane. This procedure is performed as an emergency for airway obstruction or electively for sputum retention. The patient is still able to cough, speak and swallow. The internal diameter of the tube is only 4mm, the largest suction catheter that can be passed is a size 10.

Tracheostomy tube types

Single lumen/unlined tube

Single lumen/unlined tubes are often the initial tubes to be inserted via the percutaneous procedure. Sputum can adhere to the inner lumen of the tracheostomy tube and as a result increase the patient's work of breathing and can lead to airway obstruction. Any patient with a single lumen tube requires close monitoring and nursing care. For this reason the patients are generally cared for in a specialist environment

Double lumen/lined tube

Double lumen/lined tubes have an inner cannula that can be removed regularly for cleaning to avoid airway obstruction with sputum.

Some inner cannulae are disposable and some re-usable. If re-usable, always ensure there is a spare inner cannula available to insert while cleaning the tube that has been removed. Always ensure the inner cannula is the correct size.

Shiley double lumen tracheostomy tube with inner cannulae

Adjustable flange/Extended length tubes

These tubes are designed for patients with deeper tracheas, for example, obese patients. The adjustable flange means the tracheostomy tube can be adjusted to the desired length.

Cuffed tubes

The cuff is towards the distal end of a tracheostomy tube and acts as a balloon that can be inflated and deflated. When the cuff is inflated air only passes in and out through the tracheostomy. When the cuff is deflated air passes both through the tracheostomy and around the tracheostomy and through the upper airways.

The cuff should be inflated;

- When patients are receiving positive pressure ventilation
- When patients are at high risk of aspirating
- During resuscitation

An inflated cuff exerts some pressure on the tracheal wall. If this pressure is too high tracheal damage can occur. Cuff pressure should be checked daily using a manometer. It should not exceed 25mmHg. Always refer to the tube manufacturer's recommendations.

Single lumen cuffed tracheostomy tube

Cuffless tubes

A cuffless tube does not have a cuff that can be inflated inside the trachea. Air passes in and out through the tracheostomy as well as around the tracheostomy and through the upper airways. It can be inserted if the patient does not require positive pressure ventilation or protection from aspiration. Cuffless tubes can be used when weaning patients from their tracheostomy.

Fenestrated tubes

A fenestrated tracheostomy tube has one hole, or several smaller holes in the posterior wall of the outer lumen. Both cuffed and cuffless tubes can have fenestrations. The fenestrations allow air to pass through the tracheostomy and via the upper airway. Fenestrated tracheostomy tubes assist weaning and when used in conjunction with a phonation valve allow speech.

Fenestrated tubes have an unfenestrated inner cannula and a fenestrated inner cannula. **Always use the unfenestrated inner cannula for suction. This avoids tracheal trauma.**

In a cuffed tube always deflate the cuff when using the fenestrated inner cannula.

Tracheostomy Weaning

In many patients the tracheostomy is only temporary. Removal of the tracheostomy when it is still required will be harmful and so a step by step process known as weaning should be followed. The patient must be breathing spontaneously and have a lined tracheostomy with a fenestrated outer tube in position.

Ensuring Upper Airway Patency

- Cuff deflation – to allow passage of air through the upper airways

- Insertion of fenestrated inner tube

- Application of phonation valve – one way valve that closes on expiration so all air passes via the upper airway

N.B. The application of a phonation valve onto a cuffed tube can cause increased work of breathing due to the expiratory resistance provided by the deflated cuff. If this is the case insert a smaller, cuffless tracheostomy tube.

Confirming Adequate Ventilatory Reserve

- Application of phonation valve for at least 24 hrs

Ensuring that the tube is no longer required

- If not already done then insert a smaller cuffless tracheostomy tube

- Application of decannulation cap or tube for at least 24hrs

- Decannulation if no suction required in last 24hrs

- The stoma needs to be covered with an impermeable dressing to maintain an adequate seal. The stoma should close and heal without surgical intervention

Trouble shooting

Tube Occlusion

Assess patient to identify urgency of problem.

- Administer oxygen therapy and call for assistance

- Suction via the tracheostomy +/– saline instillation

- Remove and clean inner tube if present

- If tube still occluded and cuff inflated, deflate cuff

- **Call for help** as tube may need to be changed

Tube displaced/falls out

Assess patient to identify urgency of problem

- **Call for help**

- Oxygen therapy via stoma

- Use of tracheal dilators if tracheostomy <5 days old

- If patient not breathing consider mask to stoma ventilation or occlude stoma and mask to mouth ventilation.

Respiratory/Cardio-respiratory Arrest

- **Call for help**

- Administer basic life support

- Attach rebreathe bag or ambubag to tracheostomy via catheter mount

- In a cuffed tube ensure cuff is inflated

- If ventilation via tracheostomy tube ineffective deflate cuff, occlude the tube and try mask to mouth ventilation

PATIENTS WHO HAVE HAD A LARYNGECTOMY HAVE NO CONNECTION BETWEEN THEIR TRACHEA AND UPPER AIRWAY. RESUSCITATION SHOULD <u>ALWAYS</u> BE VIA THEIR STOMA

Bleeding from tracheostomy tube

In the case of profuse or heavy bleeding;

- **Call for help**

- Inflate the cuff

- Suction as required

References

1. Wiliam C Pruitt; Michael Jacobs. Basics of Oxygen Therapy. Nursing; Oct 2003; 33,10; pg 43.

BREATHING

This chapter summarises the general assessment and management of respiratory problems and includes the management of a number of specific conditions.

Primary Survey

Assess breathing: look, listen, feel
pulse oximetry

Support breathing: optimal position
oxygen therapy
secretion clearance

Secondary Survey

ABG's, CXR, review history
Determine if further treatment, non-invasive or invasive ventilation is required

Assessment

The key functions of breathing are to oxygenate the blood and to remove Carbon Dioxide. Assessment is focused on identifying inadequacy of either of the primary functions and looking for reversible causes of that inadequacy.

Look

- Position of patient

- Respiratory rate and pattern

- Use of accessory muscles, effort or clear distress

- Cyanosis

- Symmetry

Feel

- Central trachea

- Surgical emphysema

- Symmetry and adequacy of expansion

- Percussion

Listen

- Stridor

- General air entry

- Wheeze

- Crackles

Investigate

- Pulse oximetry
- Blood gases
- Chest X-ray

Review

- Current treatment
- Recent therapy changes
- Relevant historical results of investigations

Note

An acute change in respiratory rate is generally the earliest sign of a change in respiratory function.

Pulse Oximetry only assesses oxygenation which can remain good in the face of severe respiratory failure with hypercarbia, *especially if patient is receiving high concentration oxygen.* Its other weakness is that the reading can be affected by a number of factors which if unrecognised can have serious consequences. (see Appendix 1 Pulse Oximetry).

Blood gases are the only way to assess both aspects of respiratory function (see Appendix 2 Blood Gas Analysis).

Systematic Respiratory Support

Respiratory support can be considered in the following categories:-

a. General Support

- Positioning the patient

Sitting up is best. The use of accessory muscles can be facilitated by the patient being able to rest their arms on a support such as a bedside table.

- Physiotherapy to encourage clearance of sputum (see sputum retention)
- Analgesia if pain is limiting the ability to deep breathe or cough
- Treating any respiratory disease aggressively and specifically
- Ensuring good muscle function
  - Improving the nutritional status of the patient

b. Increasing Oxygenation

It is essential that patients are treated with optimal oxygen therapy. Allowing patients to remain acutely hypoxaemic can result in significant clinical deterioration.

To guide appropriate delivery of oxygen therapy Trusts often develop a Patient Group Direction for titration of inspired oxygen in the spontaneously breathing patient.

Oxygen Masks

At rest in normal people the rate at which air is inhaled varies throughout the respiratory cycle up to 30 l/min. If oxygen is supplied from a wall flow meter, the maximum flow rate of which is 15 l/min. The shortfall is made up with entrained air if an inappropriate device is used. Thus the selection of device is crucial.

- Nasal Cannulae only results in a small increase in the inspired oxygen concentration (to a maximum of 24%). Nasal Cannulae are most useful for patients who may benefit from a small increase in inspired oxygen but have no demonstrable defect in oxygenation. Flow rate should be a maximum of 4lpm to avoid nasal irritation.

- Standard Hudson Facemask – despite what it says on the packet is only capable of delivering 35% in a slowly breathing patient at rest e.g. for a post operative patient who requires oxygen supplementation. Tachypnoeic patients lose the pause between expiration and inspiration thus breathing in the exhaled air still contained within the mask. When the patient pulls the mask off complaining that the mask is suffocating them, they are probably right! Remember that the minimum recommended flow rate for these masks is 5 litres per minute.

Hudson Oxygen facemask

- Fixed Performance Masks – are based on a Venturi system that entrains air into the mask to deliver a fixed concentration of oxygen into the mask. These masks are probably best suited to those patients who require fixed concentration oxygen and are being closely monitored. However they may help to assist interpretation of ABG's in a small number of patients.

Fixed performance mask with different concentration venturi attachments

- Masks with a Reservoir Bag (note there is a one way valve and so these masks are "Non-rebreathe bag masks" and NOT "rebreather bags"). The bag increases the reservoir of oxygen that collects during exhalation and any expiratory pause. If the reservoir exceeds the patient's tidal volume (500 to 700mls for the average adult) then the patient will receive nearly 100% oxygen. These are the best system for acutely tachypnoeic patients who are profoundly hypoxic.

Oxygen mask with reservoir bag

- High Flow Oxygen. A high flow delivery system such as the Whispaflow or the Vital Flow Generator will deliver a fixed concentration of oxygen into a facemask at a rate that exceeds the maximum inspiratory flow rate, thus guaranteeing that the patient can only breathe the predetermined gas concentration. These systems can be potentially dangerous because of the high flow rates and should only be set up by competent individuals.

*Wispaflow high flow delivery system
(without patient breathing circuit connected)*

- If the patient remains hypoxic then Continuous Positive Airway Pressure (CPAP) will recruit alveoli and improve hypoxia. CPAP can be administered by Mask or Hood.

c. Improving Removal of Carbon Dioxide

Carbon dioxide clearance is dependent on the amount of effective ventilation. If Carbon dioxide levels are high the patient is hypoventilating and so methods of improving clearance involve artificial means of augmenting ventilation.

- If the Patient is hypercarbic and has a respiratory acidosis then Non Invasive Ventilation will help to increase tidal volumes and to remove the Carbon Dioxide.

- Persistent problems with hypoxia or hypercarbia at this stage require invasive ventilation.

d. Correcting Complex defects in ventilation.

Usually requires invasive ventilation.

Sputum Retention

Patients who are having difficulty expectorating sputum, or who are unable to expectorate at all, are at increased risk of infection, airway damage and respiratory failure.

There are a number of causative factors that should be considered in any patient who won't or can't cough.

Dehydration

Dehydrated patients can have thick, sticky sputum that is difficult to clear.

- Optimise systemic hydration, orally or intravenously

- Consider humidification of oxygen therapy if on >24%

- Consider saline nebulisers

Humidification system for oxygen

Position

Patients in slumped positions have a much weaker cough. This has a significant effect on sputum clearance.

- Ensure they are as upright as possible in bed or sat out in the chair if this is safe to do so.

Pain

Sputum clearance may be affected by patients experiencing pain as a result of thoracic or abdominal surgery, rib fractures or pleuritic chest pain. Analgesia should always be addressed first before attempting sputum clearance techniques.

- Ensure good quality analgesia

- Spare opiates as far as possible as they are cough suppressants

- Consider local anaesthetic blocks including epidurals

Wheeze

Patients with asthma or chronic lung disease may have airway narrowing which is preventing sputum clearance.

- Ensure bronchodilators are optimised before attempting sputum clearance techniques.

- Weakness/Fatigue

Patients with neuromuscular disease, chronic lung disease or in respiratory failure may not have the muscle power or energy to clear their sputum.

Reduced Conscious Level

Patients with altered conscious level will not clear their sputum consistently or effectively. If sputum retention is causing respiratory distress or worsening respiratory parameters this patient group may require oral or nasal suctioning.

For any patients experiencing difficulty expectorating sputum or sputum retention refer to the physiotherapist for further assessment, advice and treatment.

MANAGEMENT OF CHEST DRAINS

Indication for chest drainage

A chest drain is a tube inserted through the chest wall between the ribs and into the pleural cavity to allow drainage of air (pneumothorax), blood (haemothorax), fluid (pleural effusion or pus (empyema), out of the chest. In any one patient it is essential to understand what their particular drain is trying to achieve.

Insertion of chest drains

Chest drains come in a range of sizes suitable for a variety of purposes (typically 12-36Ch) and may be inserted via an open surgical incision (thoracostomy) or using the seldinger technique incorporating a wire guide and dilator system. Simple spontaneous pneumothoraces and non-viscous effusions may be drained with relatively small calibre drains (12Ch) but traumatic pneumothoraces, haemothoraces and empyemas will need larger drains, typically 26Ch and above. Older style chest drains are still supplied with a sharp trocar that was originally intended to aid insertion. Their use for insertion of a drain in a stabbing motion through skin, muscle and pleura is not to be recommended as it is difficult to control in all but the most experienced of hands and can easily result in damage to both intra-thoracic and intra-abdominal organs. Open incision with blunt dissection deep tissues and forceps or introducer-guided insertion of the drain is the preferred technique at all times. Alternatively seldinger wire guided insertion may be appropriate in some circumstances.

The effective drainage of air, blood or fluids from the pleural space requires an adequately positioned drain and an airtight, one-way drainage system to maintain subatmospheric intrapleural pressure. This allows drainage of the pleural contents and re-expansion of the lung. In the case of a pneumo or haemothorax this helps restore haemodynamic and respiratory stability by optimising ventilation/perfusion and minimizing mediastinal shift. The commonest system is the underwater seal (see below).

There are several different drains available which have differing numbers of drain holes at the business end. This may range from three to seven and markings on the drain may measure either from the end of the drain or from the most proximal drain hole.

Understanding these differences when inserting the drain or checking its position later is very important.

All drain holes need to be in the thoracic/pleural cavity for the drainage system to work adequately. If drain holes are situated within the subcutaneous tissues air or fluid may escape into the tissues and cause surgical emphysema or collections of potentially infected fluid. Worsening surgical emphysema is uncomfortable, interferes with clinical examination of the patient and at its worse may track up to the neck and face potentially causing airway embarrassment. If the drain is displaced or inadequately inserted and any drain holes appear outside the chest wall there is no effective seal and air may enter the drain and into the pleural cavity allowing the lung to collapse, worsening or creating a pneumothorax.

*Surgical emphysema from chest drain site causing significant facial and periorbital swelling.
(Harry Voesten, Netherlands, Trauma.org)*

The underwater seal

The basic requirements are a suitable chest drain with minimal resistance, a fluid reservoir and a collection chamber. The drainage tube is submerged to a depth of 1-2cm in the water of the reservoir/collection chamber. This ensures minimum resistance to drainage of air and maintains the underwater seal even in the face of a large inspiratory effort.

The chamber should be kept below the level of the chest as significant sub-atmospheric pressures (up to -80cmH2O) may be produced during obstructed inspiration. Keeping the bottle below the level of the chest prevents fluid being sucked back up into the chest during inspiration. Drainage can be allowed to occur under gravity or suction may be applied (see overleaf).

Simple underwater seal bottle showing fluid level and drainage tube

The underwater seal acts as a one-way valve through which air is expelled from the pleural space and prevented from re-entering during the next inspiration.

Retrograde flow of fluid may occur if the collection chamber is raised above the level of the patient. The collection chamber should be kept below the level of the patient at all times to prevent fluid being siphoned back into the pleural space.

If the drainage tube is allowed to slip out of the water then air easily passes back up the tube during inspiration and the lung will collapse.

Absence of oscillations/swinging may indicate obstruction of the drainage system by clots or kinks, loss of sub-atmospheric pressure or complete re-expansion of the lung.

Obstructing clots may need to be removed from the drain itself with forceps and if the drain tubing to the bottle is obstructed the bottle and tubing can be replaced. Clots that cannot be removed from the drain itself may necessitate re-insertion of a new drain.

Persistent bubbling throughout the respiratory cycle indicates a continuing broncho-pleural air leak.

Some simple bottle systems (Portex Chest Drain Bottle 500/1500ml) are supplied with a red screw fit bottle cap and a red cap to cover the suction port for disposal. These must only be used for disposal of the bottle and contents as they effectively seal the air outlet. You should **never** see a red cap on a bottle that is in use.

What to Monitor and What to Record?

This depends on the reason for the drain's presence. A drain inserted for a fluid collection such as an effusion or empyema will need the volume and nature of the drain fluid recording. This should be recorded on the fluid balance and chest drain charts unless a combined chart is being used. The frequency of observations depends on local policy and medical request. Drains inserted just for fluid should not swing and should not bubble so the presence of these features is abnormal and should be recorded.

Drains inserted for pneumothorax or haemothorax are a different matter. The presence of air bubbling out of the drain should be recorded, as should swinging of the fluid level in the drain tube. These features indicate that the drain is still doing its job. Absence of bubbling and/or swinging indicates either the drain has done its job and the lung is re-inflated, or more worryingly that the drain has become displaced and is no longer functional. Bubbling and swinging are both dependant on an intact underwater seal and so can only be picked up if the drain tube extends below the water level in the bottle. It is worth getting down on your hands and knees to actually look at the bottle closely to confirm function. Bubbling and swinging should be assessed with the patient deep breathing and if possible coughing. Assessment with relaxed tidal breathing will not necessarily reveal continued air leak. Assessment on deep breathing and coughing also has the benefit of assessing adequacy of analgesia.

A drain inserted for drainage of a haemothorax (+/– pneumothorax) also needs blood loss recording accurately. With fractured ribs most bleeding is from the intercostal vessels, which slows down as the lung reinflates. However continued bleeding into the drain bottle is indicative of pathology that may need thoracic surgical intervention! After thoracic trauma more than 1500ml of blood into the bottle initially or continued bleeding of greater than 200ml/hr requires discussion with the thoracic surgeons. Blood loss should be recorded on the fluid balance chart and any sudden increases in drain volume require medical review.

See Trust Chest Drain Chart.

Chest Drains – To Clamp or not To Clamp?

Clamping a pleural drain in the presence of a continuing air leak (continued bubbling) may result in a tension pneumothorax or possibly worsening surgical emphysema. The authors do not recommend clamping of drains at any time if it can be avoided but recognise that some surgeons and physicians still prefer to clamp drains for a period of time prior to removal and then repeat the chest x-ray. This is supposedly to pick up small air leaks that may otherwise be difficult to identify. If the tube is clamped it should be under the direct supervision of a respiratory physician or surgeon on a ward with experienced nursing staff. A patient with a clamped tube should not leave the specialist ward environment. Instructions should be left that should the patient become breathless or develop surgical emphysema then the drain tube must be immediately unclamped and the medical team alerted.

Changing the drain bottle

When changing the drain bottle because it is overfull, temporary clamping of the drainage tube may be necessary to prevent ingress of air into the pleural cavity. However it is acceptable to clamp the tube between thumb and forefinger. This has the advantage of removing the risk of inadvertently leaving the tube clamped. To our knowledge nobody has ever left his or her fingers clamping a drain tube without noticing! Local policy should be followed with regard to asepsis and infection control.

Suction

A patient who is free from pain, to the degree that an effective cough can be produced, will generate a much higher pleural pressure differential than can safely be produced with suction. This combined with a functional underwater seal will result in re-inflation of the lung.

If a patient cannot re-inflate his own lung or persistent air leak is preventing re-inflation, high volume, low-pressure 'thoracic' suction in the range of 1-5kPa (approx 10-50cmH$_2$O) can help. Prescription of suction is a medical responsibility.

Purpose made low grade suction adaptors (max 30kPa) should be used when applying to a chest drain. DO NOT use standard high volume, high-pressure suction adaptors, as these can be extremely dangerous. Suction that is not working properly or is turned off without disconnecting from the drain bottle is the equivalent of a clamped drain so when suction is no longer needed disconnect from the drainage bottle.

Close surveillance is therefore required by nursing staff trained to recognise faults fitter the drainage and suction system. It is better to remove suction than to use a faulty device.

Ambulatory Chest Drain Systems

These incorporate a drainage bag with an integral flutter valve at the entry to the bag. They do not require an underwater seal to prevent air entering the pleural space from outside via the drain and are not dependant on being below the level of the patient to allow air to drain from the pleural space. Their name suggests that mobility of the patient is better than with an underwater seal and they are very useful when transferring patients between units.

Figure 2. Portex Ambulatory Chest Drain System

It is portable, does not need to be kept upright and provides hygienic drainage of the drain effluent. It consists of a PVC flutter valve within a drainage bag. Originally designed for battlefield use, these Portex bags have been tested successfully following thoracic surgery in both an inpatient and outpatient setting. The bag is flexible, works in any position and can easily be worn under clothing. It provides a convenient, hygienic solution, which allows early mobilisation and discharge from hospital.

One disadvantage is the inability to connect to suction. Therefore the lung must be adequately expanded off suction prior to connection to the ambulatory bag. The capacity of the bag is approximately 1700ml, slightly less than most bottle systems that collect 2000 to 2500ml. As this volume is actually quite inconvenient to carry the bag has been designed to allow easy emptying via the vent port. Though this requires inversion of the bag, the flutter valve remains

functional throughout the manoeuvre. Disconnection, kinking of the tubing or obstruction by lying on the bag are potential dangers.

How to connect an ambulatory drainage bag

1. Inject 20ml of air into the drainage tubing to test the flutter valve. The leaves should be seen to open as the air passes and close spontaneously.

2. Ensure the tubing is properly fitted to the anti-kink device.

3. Connect the tubing to the chest drain with a male-to-male connector.

4. Adjust the shoulder strap to length.

5. A cough will produce movement in the leaves of the valve, completely opening if there is an air leak.

Dos and Don'ts of Chest Drains:

- Don't raise the drain above the level of the chest.

- Don't clamp the tubing (pinch the tubing during bottle changes).

- Do dress the site and secure the tubing.

- Do assess the drain regularly for swinging, bubbling, and blockages.

- Check for bubbling with patient talking and also coughing if possible.

- Do assess the site for air leaks and surgical emphysema and infection.

- Do assess the respiratory and cardiovascular status.

- Do monitor and document the amount and type of drainage.

- Use bag system when transferring patients between sites.

CIRCULATION

This chapter aims to review key aspects of circulatory physiology, assessment and clinical management. It is intended to give the reader elementary understanding of the principles that should underpin clinical practice with regard to these topics in the acutely seriously ill.

Primary Survey

Assessment	- Pulses present, character and rate
	- Capillary refill time
	- Blood pressure
	- JVP/CVP
Possible sources haemorrhage	- abdomen/chest/fractured pelvis or long bones
	- external haemorrhage/drains
Possible sources fluid loss	- vomiting/diarrhoea/stoma loss
Urine Output	
IV Access	- blood samples and IV fluid

Secondary Survey

Bloods	- U&E/FBC/clotting/group and save /ABG/lactate/mixed venous oxygen saturation
ECG	- rhythm, rate
CXR	

In line with the A - B - C - D - E approach advocated in this publication assessment of circulation should encompass consideration of organ perfusion including renal perfusion and function. For this reason the latter part of the chapter considers aspects of renal function, assessment and immediate management in the acutely seriously ill.

Circulatory Function and Failure

The key function of the circulatory system is to deliver oxygen (bound to haemoglobin) and energy (e.g. glucose) to the cells of the body in order that they can perform their vital and specific functions.

Shock can be described as a state of inadequate tissue perfusion. Thus there is inadequate oxygen and energy delivery to the tissues resulting in cell and organ dysfunction and the increase in circulating by-products

such as lactic acid. Cellular injury resulting from poor perfusion may be reversible if recognised and treated early but will progress to irreversible cellular injury if prolonged. Thus it is important to understand some key concepts about circulatory function, to be able to recognise poor tissue perfusion and shock, and to be able to intervene promptly.

The ideal circulatory system has an adequate pressure within it (BP) and it has an adequate amount of blood being pumped around the body (cardiac output). Thus there is a balance to be struck in order to get an adequate pressure as well as flow. Whilst blood pressure has to be above a certain threshold for tissue perfusion to occur, the BP alone should not be the sole focus of the clinical assessment, or indeed the factor which might lead to the clinical judgement that tissue perfusion is adequate.

BP is the product of cardiac output (CO) and the resistance offered by the blood vessels – known as systemic vascular resistance (SVR):
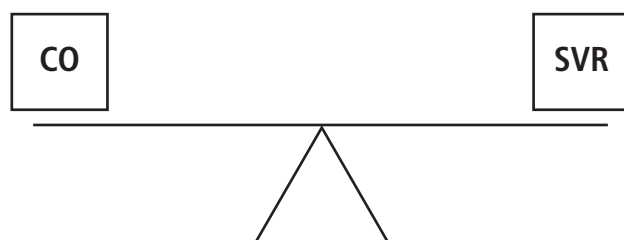
If the blood vessels offer little resistance (e.g. as in anaphylaxis or severe sepsis) the cardiac output will increase but there will not be enough pressure in the system to push blood into the organs and perfuse them.

If the cardiac output falls (e.g. with the 'pump' failure that occurs after Myocardial Infarction) – the SVR will rise to compensate, perhaps maintaining a normal BP but there will be a reduced amount of blood ejected from the heart and delivered to the organs.

A balance of pressure and flow is required and understanding this is key to interpreting assessment findings and making decisions about clinical management. However, before clinical management is discussed it is useful to review assessment techniques and investigations as well as some of the features of shock as they present in the clinical situation.

Circulatory Assessment

In the clinical situation, when assessing a patient divide the assessment into two phases. The first will be a primary survey as part of the A-B-C-D-E approach.

Primary Survey

The key question that should be uppermost in your mind is:

"Is tissue perfusion adequate?"

The following parameters will be useful in helping you decide:

Blood Pressure Low BP often results in poor tissue perfusion BUT a 'normal' BP can be seen in a shocked patient.

Heart rate Often elevated in a system with a low circulating volume BUT beware that tachy-arrhythmias causing reduced cardiac output may be the cause of 'shock'. ALSO those on ß-blocking drugs may fail to generate a tachycardia even when hypovolaemic. Be aware of the other reasons for a tachycardia e.g. pain, fever, anxiety.

Capillary refill time (CRT) Is an indicator of peripheral perfusion. It should take 2-3 seconds for an area of skin, where pressure is applied for 5 seconds, to return to its previous colour. Ensure that the hand used is elevated to heart level to avoid capillary filling from the venous system. In a cold environment – try the anterior chest wall or forehead – it is more reliable. Prolonged CRT indicates poor perfusion. However, brisk filling can be seen in the hot peripherally vasodilated septic patient.

Other things to note:

Dry skin with poor skin turgor (tone) – indicates dehydration.

Skin temperature – cool at the peripheries and warming towards the trunk indicate poor perfusion hypovolaemia or poor cardiac function

Central venous pressure/Jugular venous pressure – elevation may indicate circulatory overload or cardiac failure; reduced pressure may indicate hypovolaemia or relative hypovolaemia in a patient with vasodilation in sepsis. A target CVP should be 8-12mm Hg (11-16cm H_2O) in the septic or hypovolaemic patient.

Flat hand veins – indicate hypovolaemia.

Reduced urine output (<0.5mls/kg/hr) – may indicate poor renal perfusion.

Anxiety, confusion or reduced consciousness – may indicate poor cerebral perfusion.

Rapid onset of cold clammy skin – may indicate cardiac failure as the cause.

These parameters will enable you to begin your judgements about whether perfusion is adequate and whether you need to intervene **NOW**!

If you suspect that hypovolaemia is present a 250ml bolus of crystalloid or colloid is indicated – stat (as fast as possible with a 50ml syringe and 3-way tap or pressure bag). The effects should be monitored and the bolus may be repeated up to 4 times whilst calling for senior medical help. Such severe circulatory problems require further investigation and a considered plan of further action should be documented.

Secondary Survey

Following primary, rapid assessment and intervention in the case of suspected poor perfusion/shock the secondary survey should include consideration of the following investigations:

ECG – to rule out any acute cardiac event, to assess the cardiac rhythm (or arrhythmia) and as a baseline in the case of further deterioration.

CXR – may be useful indicating pulmonary oedema or pulmonary infection – a common cause of sepsis in the hospitalised patient.

Bloods

U&E – May indicate renal dysfunction from poor perfusion or electrolyte disorders that require correction. Abnormal levels of potassium and magnesium may lead to cardiac arrhythmias. Elevated Urea (+/– Sodium), may indicate dehydration.

FBC – May indicate anaemia from bleeding or elevated WBC in sepsis.

Clotting – If you suspect bleeding.

Group and save or cross match, if you suspect bleeding or the need for surgery (e.g. an acute abdomen).

Troponin – If MI is suspected or needs to be excluded.

Blood tests of special significance if assessing for circulatory shock:

Lactate: elevation indicates reduced tissue perfusion. > 2 is abnormal and may indicate poor perfusion. If >4 this indicates circulatory shock and requires urgent intervention with IV fluids +/– inotropic drugs or vasopressors. (Promptly refer to critical care for advice).

Oxygen Saturation of Blood taken from a Central venous line: This indicates mixed venous saturation and the delivery and utilisation of oxygen at the tissue level. Values <70% indicate inadequate oxygen delivery and/or elevated oxygen utilisation. This may require urgent intervention with IV fluids +/– inotropic drugs, vasopressors or blood transfusion (Promptly refer to critical care for advice).

Rivers et al (2001)

Key Aspects of Clinical Management

Detailed guidance on a range of individual clinical disorders of circulation is beyond the scope of this chapter, however, it is useful to consider some key aspects of clinical management.

Oxygen delivery

As stated above a key function of the circulatory system is to deliver oxygen to the tissues. Markers of inadequate oxygen delivery (e.g. elevated Lactate and reduced mixed venous oxygen saturations) are associated with poor outcome. These should be promptly recognised and measures taken to optimise tissue oxygenation. There are limited ways in which this can be achieved and they will be briefly described here. Whilst aspects of respiratory care have been discussed in another chapter – commencing and titrating oxygen therapy and optimising gas exchange within the lungs should be optimised as a preliminary and adjuvant element of managing circulatory dysfunction. Managing hypovolaemia will be of limited physiological benefit if the oxygen content of the circulation is low. Part of this also involves ensuring that Haemoglobin is adequate since 99% of oxygen is carried bound to Haemoglobin in the circulation.

Managing Circulating Volume

There are two aspects to this. Firstly, adequate intravascular volume is required within the circulation to ensure that the heart is filled in diastole. This 'preload' will facilitate optimum myocardial contractility and cardiac output of blood to the tissues. (However, circulatory overload will overstretch myocardial fibres and cause acute heart failure). Secondly, the volume within the circulation has to 'fill' the intravascular compartment. If the volume is low regional diversion of blood will leave some areas without adequate perfusion. This is especially the case in sepsis which is characterised by major changes in the vascular tone of capillaries resulting in redistribution of blood to non-vital organs.

There is around 5-7L of intravascular circulating volume (75ml/kg). This gives little scope for intravascular volume losses before significant physiological consequences result. If there is a loss of 750-1500ml the blood pressure may be unchanged and the urine output may fall slightly. Key changes will be a tachycardia (>100/min) and a CRT >2 sec, the patient may be a little anxious.

Losses greater than 1500ml will result in changes in BP – including narrowed pulse pressure and hypotension, oliguria, severely delayed CRT and further mental status changes including agitation or lethargy and reduced consciousness.

If you suspect hypovolaemia at primary survey – give volume of crystalloid or colloid. The greater the volume loss the greater the advantage from giving colloids. You can probably afford to give anyone with signs and symptoms of hypovolaemia 1000ml of fluid. Good practice would be to give 250ml stat (50ml syringe and 3-way tap) and assess for effects before repeating. In this way you will see significant but brief changes in haemodynamic parameters, but also avoid overloading the patient in cardiac failure. If there is no improvement after a *rapid* 250ml bolus and the patient has a tachycardia consider an ECG and CXR before further volume replacement.

At secondary survey begin to investigate likely causes of hypovolaemia. If this is accompanied by dehydration ensure that a plan for rehydration is made taking into account previous and ongoing body water and electrolyte losses. The following table should be used as a general guide for which fluids to use for volume replacement and rehydration.

Loss	Comparison with Blood	Replacement Fluid
Excess urine	Lower Sodium	Dextrose Saline Or 0.45% Saline
Sweat	Lower Sodium	Dextrose Saline Or 0.45% Saline
GI tract	Normal Sodium and Potassium	Hartman's or Normal Saline + Potassium
Serous fluid	Normal Sodium Protein loss	Hartman's and Consider Albumin
Blood	Same	Colloid initially then Blood

Vasopressors

Vasopressors (e.g. Noradrenaline) should not be used outside of critical care units where they are given via a central vein and monitored minute by minute for their effects. However, it is useful for the non-critical care practitioner to understand when the use of vaspressors might be indicated and thus when referral to critical care is necessary.

If volume replacement is about 'filling' the vascular compartment, vasopressors are about reducing the size (capacity) of the vascular compartment, and increasing the systemic vascular resistance (SVR) thus increasing blood pressure. Volume resuscitation should always be the first line of therapy for the hypovolaemic and/or hypotensive patient, but in some instances this is not enough. In cases where hypotension is refractory to volume replacement, for example in severe sepsis where the systemic vasculature is dilated by inflammatory mediators, vasopressors may be needed to restore normal vascular tone (and systemic vascular resistance). A common example is where blood pressure is improved by volume replacement but urine output remains low. In this case a higher mean blood pressure may be needed to perfuse the kidney.

Inotropic drugs

'Inotropy' refers to the forceful contraction of muscle – in the case of the circulation – myocardium. Some drugs are positive inotropes in that they act to increase the contractility of the myocardium which is desirable in the failing heart. Digoxin is an example of a positive inotrope, however, when 'inotropes' are discussed in the context of critical care and the critically ill the drugs include intravenous Epinepherine (Adrenaline) and

Dobutamine. Like vasopressors these should only be used after restoring circulating volume to normal (otherwise they may precipitate cardiac arrhythmias) and within critical care units where they are given via a central vein and monitored minute by minute for their effects.

If volume replacement has failed to restore adequate circulatory parameters, perfusion and organ function it may be necessary to commence vasopressors or inotropes and a referral to critical care is advised.

Arrhythmia management

This is a large and complex topic area, however, it is important to make a few brief points here. Firstly, arrhythmias are not uncommon in the acutely ill, especially the elderly. They can be both a cause and a consequence of serious illness and physiological impairment of the circulation. Anyone who is acutely ill and has a tachycardia, bradycardia, or who has chest pain or palpitations should have a 12-lead ECG. Advice on management of arrhythmias should be sought sooner rather than later if they are thought to be compromising circulation. There are detailed and complex algorithms outlining the key management of narrow complex tachycardias, broad complex tachycardias, atrial fibrillation and bradycardias by the Resuscitation Council (UK). These should be on posters in all acute clinical areas for reference – however, they are not a substitute for expert opinion.

Monitoring and Evaluation

All therapies should be closely monitored in the critically ill in order to evaluate their effects. A second and very important point is that therapies should be commenced in order to achieve explicitly stated physiological goals (e.g. Urine output >30ml/hr). When these are stated – the whole multidisciplinary team has something to guide their actions and judgements. Importantly this will inform decisions about when to escalate treatment or that further treatment is futile. In both of these cases expert senior medical opinion is required.

ACUTE RENAL DYSFUNCTION

This section has been included here for two reasons. Firstly, this is a common clinical problem that staff in the acute care areas will come across. Secondly, it appears here because, in many instances, the reason that urine output is diminished is because renal perfusion (and probably systemic tissue perfusion) is inadequate.

Renal dysfunction is a relatively common and often-preventable occurrence in the acutely ill hospitalised adult. If undetected or untreated this can lead to acute renal failure. Acute renal failure is the final common pathway for a great number of very different diseases and for this reason a comprehensive review of renal failure is not presented here.

Renal dysfunction may present in a number of different ways. Very often this includes a decreased urine output and/or deranged Urea and Creatinine. This may be an isolated and simple problem such as an obstructed catheter, or it may be a manifestation of a systemic problem such as circulatory shock. In managing this problem it is important to understand why urine output is reduced. The key principles of assessment and timely intervention are of great value in preventing the sequelae of acute renal failure.

Distinguishing the cause of acute renal dysfunction can directly prompt intervention to address the most likely cause or range of contributory factors. This section does not consider specific renal disorders, rather it advocates a broad approach to the patient who presents with reduced urine output.

Primary Survey

Within the primary survey urine output should be evaluated as part of 'C – circulatory' assessment or within the 'E – exposure' aspect. Look for a catheter bag hanging from the bed – and evaluate what volume is in the bag and note its colour since dark urine may indicate concentrated urine (however, drugs and jaundice also cause dark urine). The most useful thing is to know over what time period the urine volume has been passed. Ideally hourly assessment should be recorded in the seriously ill.

Key things to do at primary survey in a patient who appears seriously ill (especially with compromised circulation) are to have the patient catheterised, if not already, and request that the urine be measured for the next hour.

Whilst renal function is important and dysfunction can cause many system problems there is little more to do at primary survey, which should be a rapid assessment, than to initiate accurate urine measurement.

Secondary Survey

It is at this stage of the assessment that greater depth of assessment and problem identification and evaluation can be undertaken. In a patient who appears to have reduced urine output ($<1/2$ml/kg/hr or <500ml/ 24 hour – is below minimum obligatory volume) ensure the following:

- If not already done – *catheterise.*

- *Accurately measure hourly urine output* in order to evaluate urine output volumes.

- *Assess for and manage simple outflow obstruction* (e.g. blocked catheter). This often presents with a sudden drop in urine volume unrelated to other physiology. Palpate the bladder, confirm by bladder ultrasound or by observing free flowing urine following bladder washout. If in doubt always do a bladder washout and/or change the catheter.

- *Optimise renal perfusion* – key considerations:

  - Treat hypotension (administer fluid boluses as necessary).

  - Call for expert medical help to treat cardiac arrhythmias that are compromising blood pressure.

  - Review/discontinue anti-hypertensive drugs, negative inotropes and drugs known to impair renal perfusion (e.g. NSAIDs, ACE inhibitors).

  - Consider need for inotropes/ vasopressors.

  - Considering diuretics (only after optimising renal perfusion).

Following initial assessment and intervention a senior member of medical staff should formulate a collaborative management plan including further investigations.

BLOODS

Blood tests are an often painful part of hospital life – ask a patient! Blood tests are not a panacea for all, however, the information they reveal can indicate health or a disturbance in the daily business of living. Healthcare professionals are used to working with clinical indicators peppered with past experiences and hunches, and they know that a single test must not be viewed alone. Sometimes a single result can be sufficient on its own (malaria, glandular fever, etc.) or will make the diagnosis earlier than clinical indications (e.g. pregnancy test) but typically the bigger picture must be taken into account. Laboratory tests are a contributing factor to more than 80% of diagnoses and are frequently used to monitor the progress of treatment.

As with any investigation in medical practice, the ultimate responsibility for chasing and acting on the results should rest with the person who ordered the test. If the samples are wrong or the result of a blood test is not checked and acted upon, then there is no point performing the test in the first place. Also, one should consider which tests are necessary for the management of an individual patient, rather than performing a blanket screen. Ask yourself if the result of a test will alter the patients' management, with regard to their current problem. If the answer is no, consider whether the test is actually necessary.

In a busy clinical setting, the role of obtaining a test result may be undertaken by a variety of members of the multi-disciplinary team. It is imperative that everyone takes responsibility for secure patient identification, and ensures that results are conveyed to a member of the team who can act upon the information to alter the patients' management appropriately.

If a blood test is ordered on a patient it becomes the responsibility of all members of the team to follow this process to its conclusion. It is not intended that any member of staff should work outside of their job specification, but it is expected that all healthcare professionals are able to offer the best of care to their patients. This is not an easy feat with national staff shortages across all specialities.

Top Tips to help you help your patient!

1) Good communication. If a blood test has been ordered, inform the rest of the team. Ensuring that all members know that a blood test is required increases the chance that it will be done on time and by an appropriate person.

2) Know your patient. As many as 1 in every 2000 samples are labelled as someone other than the patient from whom the sample was taken. Always check that you are dealing with the right patient and that all labelling is correct. One of the most common causes is the presence of someone else's stickers in a set of notes (or out of date ones for the correct patient). This is why all blood transfusion related samples must be written by hand and countersigned by whoever bleeds the patient.

3) Correct sample, taken at the right time, delivered to the laboratory appropriately. Ensure that you know everything about the blood test before starting to take samples as some require pre-prepared sample tubes or transport on ice. If in doubt consult the laboratory handbook, intranet or telephone the laboratory for help.

4) Follow it up. If a blood test has been ordered there is a reason for it, therefore follow it up. Make it a point to review the results ASAP, most routine haematology and chemistry results will be available within 3 hours. It is a common occurrence that patients who deteriorate have had markers in their blood results (often for several days) that have not been identified, because blood has been drawn as requested but no-one has looked at the results. Never assume that someone else has done it.

5) Familiarise yourself with the results for frequent tests in your clinical area. Nurses are in a prime position to intercept abnormal blood test results and inform the Doctor ASAP. Nurses and Physiotherapists are not expected to know about every blood test on offer, but to be able to identify common tests and their implications for the health of their patients is good practice.

6) Try to erase the concepts of "it's a Doctors job" or "it's the nurses job" from your minds. Consider yourselves as a team working towards the best interest of your patient. Ordering blood tests, obtaining samples, receiving the results and acting upon them requires a multi-disciplinary approach if the patient is to benefit.

NHS staff may work in a variety of hospitals where slight differences in practice will inevitably occur. It is important to check the normal reference ranges for the hospital that you currently work in, as individual laboratories may have slight variations due to differing assay techniques. In addition, many ranges depend on the gender and age of the patient.

For those who are on a rotational programme, remember that different hospitals may have different coloured bottles!

- Do you know which tests go to which laboratory?

- Do you know which bottles the tests go in?

Ensure that as much as possible patients have given consent for the procedure (this includes a patient who holds their arm out giving implied consent).

Ensure that forms are correctly completed and that the samples are properly labelled, as wrongly labelled samples will be rejected and you will have to repeat the tests. Labelling policies will again differ from hospital to hospital but at least 3 items of identification will typically be required e.g. Name, unit number and Date of Birth, similarly data on the request must match that on every sample tube.

Some laboratory tests (e.g. Troponin and Drugs) require samples at a particular time relative to the onset of symptoms or last drug dose. Samples taken at the wrong time are at best a waste of time, at worst they can cause mis-diagnosis and inappropriate treatment.

Ensure that the sample gets to where it's meant to go and on time.

Remember documentation… if it's not written down then you didn't do it!

Identify which blood tests are commonly used in your clinical setting. Discover why these tests are performed, and what interventions are likely should the test be abnormal. This will help your understanding and will assist you in your communication with the patient/relatives when discussing their condition.

Common Blood Test Top Tips

If Hb is low, this is classed as anaemia either acute or chronic – remember that in an acutely bleeding patient, Hb might not have had time to drop as the patient is losing both cells and plasma.

Abnormal U+E results indicate a problem with fluid regulation either due to inappropriate intake, imbalance between circulation and tissues or change in renal or GI function. Urea can also indicate excessive breakdown of proteins (high) and prolonged low protein intake (low).

Abnormal LFT results can indicate the nature of liver disease but are often affected by other problems such as haemolytic anaemia (elevated Bilirubin), MI (elevated AST), increased bone turnover (elevated ALP) and renal disease (elevated ALP). Similarly the 'Bone' group is affected by liver problems (ALP), endocrine problems (Calcium), renal disease (ALP and Calcium) and a variety of other conditions.

Troponin is very specific to the heart (unlike CK which is also in skeletal muscle) and is used to rule out MI in patients with chest pain. The sample should be taken at least 12 hours after the onset of symptoms, when an undetectable result indicates a high probability that a patient has not had an MI. Taking the sample too soon will risk missing the diagnosis of MI and inappropriately sending the patient home.

A significantly raised Amylase (at least 3 times the upper limit of normal) is consistent with acute pancreatitis. In some patients who may be in an early stage of developing pancreatitis, a repeat sample may be required to rule out a rising level. Especially in the absence of abdominal pain, small increases may be due to benign causes (e.g. Salivary gland problems).

When a patient is admitted to hospital they are reliant on the multi-disciplinary team to care for them, to take shared responsibility in reducing symptoms and ideally cure them of all ills!

Blood tests have been highlighted as a useful tool in assisting healthcare professionals to appropriately treat or not treat their patients. This chapter has indicated some important points to consider in relation to blood tests, their uses and their limitations, and should be used in conjunction with other available texts and resources to ensure best practice.

Appendix – add local blood test chart/guidelines

LINES AND IV ACCESS

Assessment of IV Access

Common to all patients with a deteriorating clinical condition is the need for adequate venous access. Hence while assessing circulation you should investigate if the patient has venous access and if the access is appropriate to clinical need.

Venous access can be achieved by different methods

- Peripheral cannulation.

- Central venous catheter (CVP) – can be multi lumen enhancing ability to administer multi drug therapy and monitor central venous pressure.

- Peripheral inserted central catheter (PICC) – used for short term central venous access with lower potential for complications than CVP lines but are single lumen only.

- Hickman line – subcutaneous tunnelled line mainly used for long term drug therapy as can be left in place for up to six months.

When checking IV access consider these points

- Is the line useable and will it flush easily.

- Condition – Signs of infection
                 Irritation
                 Tissued
                 Speed of flow

- Is the dressing intact and secure. If not secure it. May be your only access and other access may be unachievable.

- Is the access appropriate for need?

- Is there a possibility of gaining more access?

Colour	Size	Time to infuse 1litre crystalloid	Common applications
Orange/ Brown	14G	3.7 minutes	Rapid blood/ fluid transfusion
Grey	16G	5.8 minutes	Rapid blood/ fluid transfusion
Green	18G	11 minutes	Surgery or receiving large fluid volumes
Pink	20G	18 minutes	Fluid therapy
Blue	22G	40 minutes	Long term medication or fluid therapy

Guidelines for MAXIMUM infusion rates based on recent company data. (Rarely achieved in clinical practice!)

Care of IV access

In general IV access should be secured with a transparent semi permeable membrane dressing and checked for signs of infection and or irritation at least once a day. Always refer to your organisational policy and procedures.

If a patient is spiking a temperature and/or raised white cell count for no apparent reason, who also has indwelling central access, always consider line sepsis and removal of the line sending tip for culture and blood cultures.

For further guidance and information refer to **Standards for Infusion Therapy produced by Royal College of Nursing October 2003** available on their web site.

Top Tips

If patient peripherally shut down and IV access urgently needed try immersing hand in warm water to encourage identification of veins.

If using multiple IV drugs always consider compatibilities. A very useful book for reference is *UCL Hospitals Injectable Drug Administration Guide Shulman et al ISBN 0-632-05027-6*

Always use dedicated line for total parenteral nutrition (TPN).

Always aspirate blood and flush with saline any line/lumen which has had a drug infusion discontinued to prevent accidental drug bolus administration or unexpected incompatibility.

Never run drug infusions with fluid boluses especially inotropes to prevent sudden bolus administration, as this will give fluctuating drug dose administration and cardiovascular instability.

Central Venous Catheters

Four lumen CVP line with needle, blade, dilator, syringe and wire

A central venous catheter is designed to be inserted into one of the central veins i.e. the superior or inferior vena cava. These veins have the largest blood flow of any veins in the body and return blood to the right atrium.

Single lumen and multiple lumen catheters are available – the type to be chosen should depend on the intended use e.g. fluid administration and/or multiple drug administration. The different positioned openings along the length of multiple lumen catheter reduce the risk of harmful drug or fluid interactions.

Distal – furthest away from patient's external surface
– CVP measurements

Proximal – nearest to patient's external surface
– fluids

Medial – in the middle
– Total Parenteral Nutrition

Measuring the central venous pressure

An isolated CVP reading is of little value, response to a fluid bolus and several readings to identify a trend are necessary to indicate a patient's response to therapy and/or disease progression.

In critically ill patients treatment often aims to maintain a slightly higher than normal CVP measurement to ensure sufficient blood return to the heart.

Normal values

Mid axilla point   5-10cm H_2O

Sternal angle   0-5cm H_2O

Measurement of CVP can be taken at either of these points and the site chosen should be documented and the patient's skin marked to ensure continuity of the readings. The reading can then be taken with the patient positioned:

- At a 45 degree angle
- Lying flat

The position chosen should be recorded and all subsequent measurements taken in the same position to ensure continuity.

Causes of low CVP measurement

- Hypovolaemia – fluid losses – trauma or surgery, diabetes or diuretic therapy
- Poor venous return – cardiogenic shock
- Peripheral vasodilatation – septicaemia or vasodilatory therapy

Causes of high CVP measurements

- Hypervolaemia – excessive fluid infusion or fluid retention
- Cardiac failure – right ventricular failure, pulmonary embolism, cardiac tamponade, mitral valve disease
- User error – wet filter
- Lumen occlusion – kinked cannula, cannula resting against vessel wall, thrombus

Care of the patient with a central line

- Awareness that any patient who requires a CVP line is acutely ill and that their susceptibility to infection is increased – aseptic technique during any procedure including insertion, administering bolus drugs, connecting infusions, blood sampling, measurements, dressing the site and removal of the line.

- Minimal handling of the central line

- Regular flushing of the line

Central lines dressings

Using an aseptic technique the dressing should be changed when it becomes soiled, damp, loosened or a closer inspection of the site is required. The dressing used should be as per local protocol.

Central venous site inspection

The site should be inspected at least once per shift to assess for signs of infection and possible complications. The site should be assessed for swelling, redness, warmth, tenderness or discharge – if present the medical staff should be notified and the line removed. All lines, connections and hubs should be inspected for leakage and replaced as necessary. The catheter length should be assessed – note the cm mark at the skin exit and compare this with the previous documented catheter length – if this has changed the medical staff should be notified.

Flushing central lines

Occlusion of the lumens usually occurs as a result of insufficient or incorrect flushing when not in use. Precipitate formation and kinking may also affect the patency. Sodium chloride 0.9% is most commonly used to clean the internal diameter of the lumen of blood and drugs, the lumen should always be flushed after blood withdrawal or drug administration, and then at least 8 hourly with 3-5mls sodium chloride via each lumen not in use. It is important to use a pulsatile – push-pause method to create a turbulent flow injecting 1ml at a time and completing the procedure using a positive pressure technique i.e. clamping the lumen while flushing before the syringe completely empties. Excessive force should never be used while flushing, if resistance is felt due to partial occlusion and force then applied to the plunge – a high pressure within the lumen could result in catheter rupture.

Unblocking central line lumens

Gentle aspiration may dislodge a clot followed by a 0.9% saline flush to restore patency. Only 10ml syringes should be used when attempting to unblock a catheter as smaller syringes appear to create a greater pressure which may result in rupture of the catheter and/or clots being forced in to the circulation.

Removal of the central line

The patient should be given an explanation of the procedure and reassured throughout. The patient should be positioned lying flat and head down if this can be tolerated so that if an air embolus should occur it will rise to the highest point. If patients cannot tolerate this position they should be asked to perform the valsalva manoeuvre during catheter removal i.e. the patient should breathe in, close their mouth and bear down to raise the intrathroracic pressure. The catheter should be removed rapidly and a sterile swab placed over the site, pressure applied until bleeding ceases. Caution should be taken in coagulopathy. A sterile dressing should cover the site. The catheter tip should be sent for culture and sensitivity.

Central venous catheter complications

Signs and symptoms may include

Action

Pneumothorax/Haemothorax
Chest pain
Hypoxia
Dyspnoea
Tachycardia
Cyanosis
Restlessness
Shock

Notify Medical Staff immediately
Administer oxygen
Record vital signs observations
Order chest x-ray
Set up for chest drain insertion or needle cannulation

Air/Pulmonary/Catheter Embolus
A clot, catheter segment or air bubbles become free
floating in the circulation and are propelled by the
venous circulation through the right heart and into the
pulmonary artery. In air embolus – tenacious air
bubbles then block the pulmonary capillaries
Dyspnoea
Tachycardia, weak rapid pulse
Chest pain – sudden onset
Hypotension
Syncope
Productive cough with reddish pink sputum
Tachypnoea
Cyanosis
Loss of consciousness
Cardiac arrest

Emergency situation
Obtain immediate Medical Assistance
Clamp catheter
Place patient head down on left side and give high
flow 100% oxygen
Take pulse, blood pressure, respiratory rate and
saturation levels continuously
Record ECG

Cardiac Arrhythmia
Change in pulse rate, rhythm
Change in ECG rhythm

Medical staff to reposition or remove catheter
Confirm position on chest x-ray

Catheter rupture
Shortness of breath
Alteration in vital signs observations
Arrhythmias
Fluid leakage

Inform Medical Staff immediately

Laceration of major vessels
Respiratory distress
Pain in shoulder and arm
Tachycardia
Pallor
Elevated blood pressure
Rigors
Haematoma

Inform Medical Staff immediately
Monitor vital signs observations
Apply direct pressure for 5-10 minutes

Damage to brachial or phrenic nerves
Altered motor or sensory impairment
Numbing or tingling
Respiratory difficulties
Hoarse voice
Painful shoulder or arm
Painful paresthesia

Inform Medical Staff immediately

Hydrothorax and vessel erosion
Increasing hypoxia
Cardiac compromise
Respiratory compromise
Chest pain
Mediastinal widening
Failure to aspirate blood from catheter

Inform Medical Staff
Administer high flow oxygen
Chest x-ray
Evacuation of fluid

Sepsis
Pyrogens introduced into the circulation producing a
febrile reaction, elevated temperature
Tachycardia
Respiratory distress
Pallor
Confusion
Headache
Backache
Pain, swelling or inflammation at insertion site
Rigors
Nausea and vomiting

Inform Medical Staff
Remove line as instructed
Swab from site/tip of catheter for C&S
Send Blood Cultures
    MSU
     sputum specimen
Use measures to cool patient

Occluded Lumen
Prevention
Causes: Incorrect or insufficient flushing of the lumen
when not in use
An administration set or infusion device being turned
off for long periods

Maintain patency
• Continuous infusion to keep vein open (KVO)
• Intermittent flushing
Gentle aspiration may dislodge the clot and 0.9%
saline flush may be all that is needed
If not use of negative pressure technique

Deep Vein Thrombosis
Can occur as a result of fibrin sheath breaking away
from indwelling device, thrombus from intimal damage
during insertion, infusion.
Thrombus blocks flow through a vessel causing
pressure to rise distal to the blockage
Redness
Pain
Swelling
Oedema
Difference in colour and temperature of extremities
Vein engorgement on affected side

Inform Medical Staff immediately

DISABILITY

This chapter covers the assessment and monitoring of the neurological system and care of the unconscious patient.

Primary Survey

Assess conscious level – AVPU/GCS – low level may indicate need for intubation. Recovery position if necessary and not contraindicated

Pupils size, reactivity, symmetry
Any abnormal movements or weakness – treat seizures
Blood Glucose – treat hypoglycaemia
Rash/fever suggesting meningoencephilitis – antibiotics

Secondary Survey

Detailed neurological assessment and full GCS
CT scan
Lumbar puncture
Further investigations
Refer if necessary.

Introduction

Impairment of neurological function and conscious level is a potential medical emergency and may have many causes. The important issue is recognising the problem, providing appropriate resuscitation/ stabilisation and identification of correctable and treatable pathology.

Causes of impaired consciousness

Altered level of consciousness may be caused by processes affecting the brain stem, reticular formation or cerebral cortex. The cortex is in generally responsible for performance of higher functions and the interpretation of and interaction with the environment. The brainstem is the location of structures responsible for vegetative and autonomic functions. The Reticular Activating System is a diffuse poorly defined area of the central nervous system ascending from the brainstem to the Thalami. It is responsible for maintaining the capacity for consciousness amongst other functions.

In general acute dysfunction is caused by trauma, hypoxia, ischaemia, metabolic disturbance, toxicology or infection.

Diffuse cortical dysfunction

- Trauma – diffuse axonal injury (DAI), shearing or tearing of cortex, cerebral contusion.

- Infection – meningitis, encephalitis or abscess, bacterial, viral and parasitic.

- Intoxication/poisoning – deliberate or accidental effect of drugs especially opiates and other sedatives.

- Metabolic – hepatic failure, renal failure, inborn errors of metabolism.

- Endocrine – diabetes, hyper and hypoglycaemia.

- Hypertensive encephalopathy.

- Epilepsy – post ictal phase.

- Post cardiac arrhythmia – anoxia or hypo-perfusion.

- Intracranial haemorrhage.

- Ischaemic stroke.

- Hypoxia.

- Hypercarbia in respiratory failure – raised $PaCO_2$ has a direct anaesthetic effect as well as increasing cerebral blood volume and potentially increasing intracranial pressure.

- Hypothermia or hyperthermia.

Direct effect on brain stem

- Brain stem haemorrhage, infarction, neoplasm.

- Brain stem demyelination.

- Wernicke-Korsakoff syndrome – acute thiamine deficiency associated with alcohol excess.

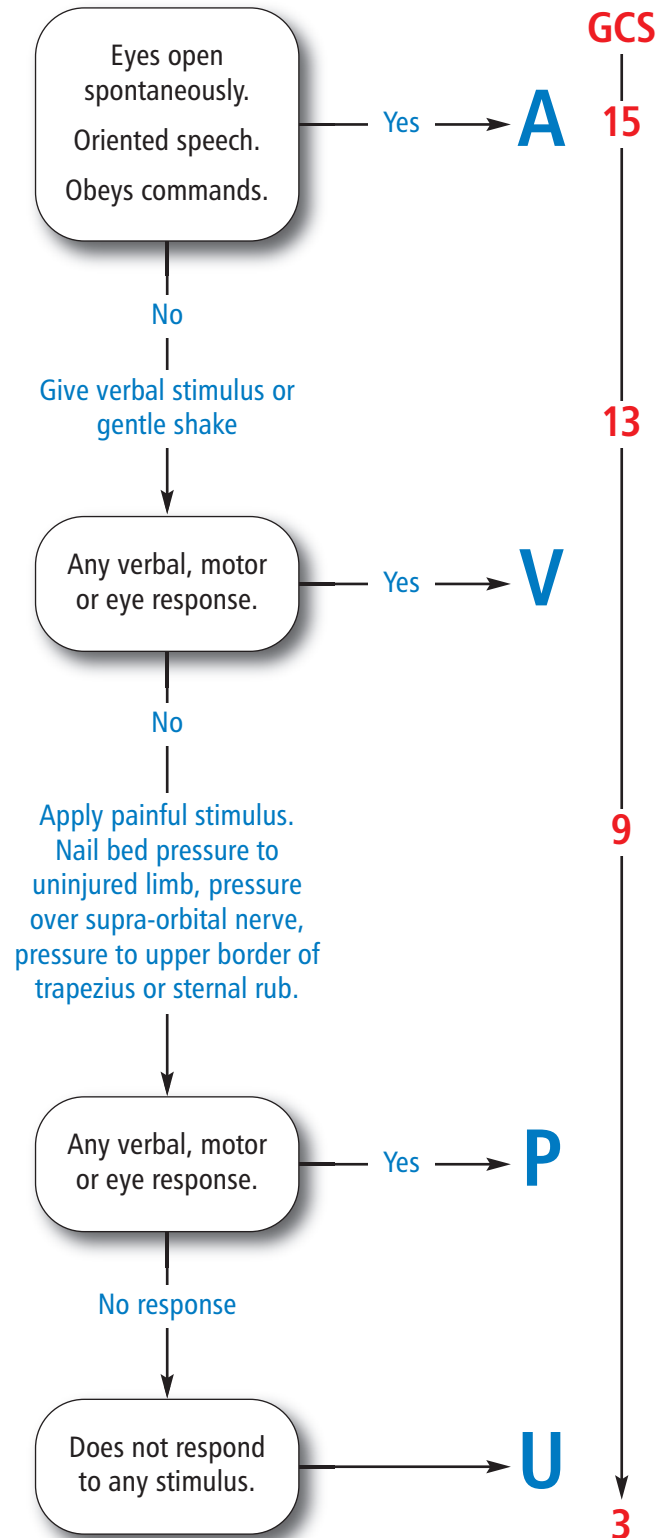- Trauma.

Indirect effect on brain stem

Supra-tentorial pathology causing brainstem compression from above such as hemisphere tumour, infarction, abscess, haematoma, encephalitis or trauma.

Infra-tentorial pathology such as cerebellar lesions.

Clinical Application

Primary Survey

As a part of the primary survey an assessment should be made of conscious level and neurological disability. Initially a rapid assessment can be made using the AVPU[1] system, documenting whether the patient is **A**lert, responding to **V**oice, responding to **P**ainful stimulus, or **U**nresponsive. This is a simple easily reproducible method that is ideally suited to rapid assessment and is easier than, but not as sensitive as the Glasgow Coma Scale and Score.

GCS

Eyes open spontaneously.
Oriented speech.
Obeys commands. — Yes → **A** **15**

No

Give verbal stimulus or gentle shake

13

Any verbal, motor or eye response. — Yes → **V**

No

Apply painful stimulus.
Nail bed pressure to uninjured limb, pressure over supra-orbital nerve, pressure to upper border of trapezius or sternal rub.

9

Any verbal, motor or eye response. — Yes → **P**

No response

Does not respond to any stimulus. — → **U**

3

The airway and breathing should have been assessed and managed accordingly at the beginning of the primary survey but even if the airway is clear and spontaneous breathing is maintained the airway may be at risk due to decrease airway reflexes in the face of decreased conscious level. Oxygen should be given by facemask to keep $SpO_2 > 90\%$. If there is absence or impairment of the gag reflex simple measures to protect the airway and reduce the risk of airway soiling due to vomiting or passive regurgitation should be considered. Unless contraindicated the patient should be placed in the recovery position with their head and limbs positioned appropriately to avoid further damage. An AVPU level of **P** or **U** should lead to urgent consideration of formal airway and ventilatory control by intubation of the trachea with a cuffed endotracheal tube.

Spontaneous limb movement should be documented and any unilateral paralysis or weakness noted.

The pupils should be examined and pupillary size; symmetry and reactivity to light should be noted.

Any seizure activity should be noted and managed accordingly in line with local policy and close attention paid to the ABCs.

The blood glucose should be measured to exclude hypo or hyperglycaemia.

Immediate intervention is required for:

- Hypoglycaemia, which should be corrected with intravenous (IV) 50% glucose or Glucagon IM.

- Seizure activity should be stopped with IV anticonvulsants according to local policy.

- Suspicion of meningoencephalitis should be treated urgently with IV antibiotics and antivirals after blood cultures have been taken.

- Wernicke's encephalopathy due to acute thiamine deficiency in alcoholism should be treated with IV thiamine.

- Evidence of raised ICP causing lateralising signs, i.e. 3rd Cranial Nerve palsy (blown pupil) should be managed with IV mannitol (10%) or hypertonic saline and urgent CT scanning considered.

[1]*American College of Surgeons.*
Advanced Trauma Life Support manual 1983.

Differential Diagnosis

The arrival at a diagnosis will depend on detailed assessment during the secondary survey. However, a list of differential diagnoses can usually be arrived at if one takes note of the context of the patient's deterioration. In the context of morphine administration for postoperative analgesia the composition of the differential diagnosis of reduced consciousness will have a different order to that associated with pyrexia and symptoms of menningism. It is worth remembering that the underlying cause of a drop in the level of consciousness may not be the obvious one and full examination and investigation should not be limited by first impressions.

Secondary Survey

The secondary survey is more leisurely and can be carried out once any immediately life-threatening problems have been dealt with. Formal assessment of conscious level using the Glasgow Coma Scale can be carried out and a full neurological examination performed. The art of the Neurological exam is beyond the scope of this text but is dealt with in most books on Clinical Medicine.

Detailed physiological and clinical assessment is essential. Frequent routine observations should be carried out including BP, HR, RR, SpO$_2$ and temperature as the patient's condition dictates and in addition neurological observations ('Neuro Obs') should be documented. These include GCS and pupillary size and reactivity. Neuro Obs should be documented on an appropriate observation chart with the frequency as dictated by the patient's condition and clinical management plan.

Respiratory pattern should be noted with reference to rate, depth and pattern.

Eye signs – abnormalities are common in pathology of the Reticular Activating System or Brain stem.

Fundoscopy

The fundi should be examined with an ophthalmoscope. Signs including papilloedema, subhyaloid haemorrhage, hypertensive retinopathy and diabetic retinopathy are of importance in the formulation of a diagnosis but the details of these are beyond the scope of this text.

Motor Assessment

Symmetry of CNS: full assessment of tone, power, movement and reflexes. This is more a part of a formal neurological assessment and will not be covered here.

[2]*Dolls eye movements are tested by rotating the head from side to side or irrigating the outer ear with cold fluid. With movement of the head the normal response is for the eyes to attempt to remain fixed on one point. Abnormal is when the eyes remain fixed in their orbits and do not move relative to the head as the head is moved. If using iced water irrigated into the outer ear a normal response is nystagmus towards the irrigated ear. An abnormal response is no movement with cold irrigation.*

Pupillary & eye movement signs:	Interpretation:
Normal direct and consensual reflex.	Intact Brain Stem.
Midposition (3-5mm) non-reactive +/− irregular.	Midbrain lesion.
Unilateral dilated and unreactive.	3rd nerve compression.
Small reactive (pinpoint or pontine pupils).	Pontine lesion or drugs (opiates).
Horner's syndrome – unilateral constricted pupil with conjunctival injection.	Ipsilateral lateral medulla or hypothalamic lesion.
VOR (Vestibulo-Occular Reflex)[2] tested by dolls eye movements or ice water caloric testing.	Normal indicates mostly intact brain stem between 7th nerve nucleus in the medulla to the 3rd nerve nucleus in the medulla.

The Glasgow Coma Scale

The Beginnings.

The Glasgow Coma Scale was introduced by Teasdale and Jennett in 1974 in their paper in the Lancet[3]. There was at the time the need for a clinical scale that could be used to reliably assess impaired consciousness. It needed to be simple, consistent and allow accurate communication between clinicians.

To be generally accepted it needed to be…

- Practical to use in a wide range of hospitals.
- Suitable for use by a wide range of staff without specialist training.
- Not reliant on only one type of response.
- Involves identifying clearly defined responses that can be accurately graded according to a rank order that indicates the degree of dysfunction.

The Scale assesses response to stimuli in three parameters – EMV:

- Eye opening scores 1-4
- Motor Responses score 1-6 (5 initially in the original paper)
- Verbal Responses score 1-5
- The Score calculated from these responses can therefore range from 3-15 and be constructed from a variety of response combinations.

Eye opening 1-4.

1. No eye response
2. Eye opening in response to pain
3. Eye opening in response to speech
4. Spontaneous eye opening

Record if eyes are swollen and cannot open. Record 'C' on chart.

The patient may move their head to attempt to locate the examiner even if their eyes cannot open but the GCS does not allow for recording such responses numerically.

Motor Responses 1-6(5).

1. No response
2. Extensor posturing, decerebrate
3. Flexion – abnormal, decorticate[4]
4. Flexion – withdrawal response
5. Localising response
6. Obeying commands

Motor responses to painful stimuli

Painful stimulus can be applied in a variety of ways but should be assessed consistently. Pressure can be applied to the upper border of the trapezius muscle or to the supraorbital ridges – take care with the eyes. Alternatively firm pressure to the sternum can provide adequate stimulus. However, a positive localisation to painful stimuli requires movement of the hands to above the level of the clavicle so pressure to the nail beds with a pencil may not provide an accurate assessment. Spinal cord injury may mean that painful stimulus below the level of the lesion may not be detected and therefore confound the assessment.

Note that repeated assessment can leave bruises.

Record the best response if there is a true difference between left and right.

Supraorbital ridge
Upper border of Trapezius
Sternal pressure
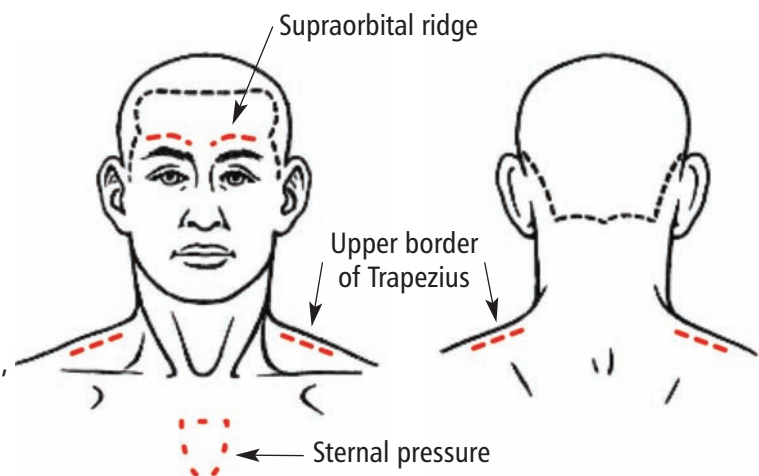
[3] Assessment of coma and impaired consciousness.
A practical scale.
Teasdale G, Jennett B.
Lancet. 1974 Jul 13;2 (7872):81-4

[4] Decorticate posturing not originally included in the GCS but included later.

Verbal Responses 1-5.

1. No response even to painful stimuli

2. Incomprehensible speech/groaning

3. Inappropriate speech/monosyllabic

4. Disoriented, confused conversation

5. Oriented and converses

Why do we use the Glasgow Coma Scale?

Before it's introduction there were various scoring systems around the world assessing neurological dysfunction with differing numerical and descriptive systems. This could potentially lead to confusion between those assessing patients and in the communication of those assessments to the people making clinical management decisions. The GCS was introduced as a reliable, reproducible system based on multiple parameters identifying clearly defined responses that could be accurately graded according to a rank order that indicated the degree of neurological dysfunction. It was also simple enough to be used by a wide range of staff.

The GCS is useful in the initial assessment of patients and as a monitor of progression, improvement or deterioration in their condition.

As it has been widely adopted across the world it acts as a reliable communication tool in the referral of brain injured/impaired patients to specialist teams. For added clarity it is useful to communicate the individual components of the scale as well as the summated score recognising that the same score may be achieved by a variety of EMV combinations.

A score of 8 could therefore be communicated as GCS=8/15 (E2M4V2) with the breakdown according to individual responses.

Prediction of outcome?

The use of the score as a predictor of outcome is useful in traumatic brain injury with the best GCS obtained in the first 24hrs after injury after adequate resuscitation being predictive of overall outcome at 6 months post injury. Its predictive usefulness in other causes of neurological impairment is less clear. Other scoring systems have been suggested with greater application to medical causes of coma but none have yet gained the level of usage that the GCS enjoys[5,6].

The GCS is also an integral component of other predictive and clinical scoring systems such as RTS, TRTS, TRISS and Apache II amongst others[7].

Note

The GCS is a good assessment of current state of brain dysfunction.

If used in the assessment of traumatic injury the result may be affected by intoxication with alcohol, drugs etc.

A score of 8 or less is defined as coma and consideration should be made of formal airway protection by intubation and ventilation. In addition a drop of 2 points or more points in the score should also prompt consideration of intubation.

GCS and AVPU:
As discussed above the AVPU score is a simpler but less sensitive assessment tool of level of consciousness. A lack of response to verbal stimulation implies a GCS of 9 or less[8].

Summary

The Glasgow Coma Scale is a method of monitoring conscious level and indirectly an assessment of brain dysfunction. It is useful as an initial assessment tool and an ongoing screen for changes in neurological status.

[5] *Validation of a new coma scale: The FOUR score. Eelco F. M. Wijdicks, MD, William R. Bamlet, MS, Boby V. Maramattom, MD, Edward M. Manno, MD, Robyn L. McClelland, PhD. Annals of Neurology Volume 58, Issue 4 , Pages 585 – 593.*

[6] *Simple bedside assessment of level of consciousness: comparison of two simple assessment scales with the Glasgow Coma Scale. A. F. McNarry and D. R. Goldhill, Anaesthesia, 2004, 59, pages 34–37.*

[7] *RTS (Revised Trauma Score), TRTS (Triage Revised Trauma Score), TRISS (Trauma Injury Severity Score), Apache (Acute Physiological and Chronic Health Evaluation).*

[8] *Association between the assessment of conscious level using the AVPU system and the Glasgow Coma Scale. Mackay C., Burke D., Burke J., Porter K., Bowden D., Gorman D. Pre-Hospital Immediate Care 2000; 4: 17-19.*

Planning care and decision making

After initial assessment, management of life threatening abnormalities and specific investigations, discussion should be with appropriate specialists.

- ICU
- Neurosurgery
- Neurologists
- Radiologists

Acute airway control and protection is best provided on ICU while structural brain injury, intracranial haemorrhage, abscess or tumour needs urgent discussion with Neurosurgeons.

Specific care should be planned in the context of pathology identified or suspected.

Escalation of care to an HDU or ITU environment in patients whose neurological deterioration carries a hopeless prognosis is inappropriate and the temptation to escalate should be resisted. However, if deterioration can be halted and deficit potentially reversed then intensive monitoring and support should be considered without delay. Senior assessment and input is essential.

A patient with a decreased level of consciousness who is to be managed conservatively on the ward should be nursed in the recovery position to minimise the chances of airway obstruction. Basic nursing care appropriate to an unconscious patient should be continued.

EXPOSURE

The aim of this chapter is to highlight the importance of a head to toe examination of the critically ill patient and to discuss the important information that may be gathered at this time.

Primary Survey

Brief tip to toe examination including back
Look, listen and feel
Beware heat loss

Secondary Survey

Full detailed top to toe examination

Introduction

Once ABCD have been addressed the system comes to Exposure. This is the point in time when the covers are pulled back and you take a quick look but it still follows the key principals of **Look, Listen and Feel**.

Often it is at this point in the resuscitation and assessment of the patient that all the information fits together and a diagnosis and treatment plan is formed.

Primary Survey

Always remember to start with a revisit to **A, B, C and D** to check that no deterioration has occurred before moving forward to **E**xposure.

Then while preserving the patient's privacy and dignity pull back the covers and take a head to toe examination using the look, listen and feel approach. It is impossible for this section to include everything that could be found while examining a patient but the most common aspects will be discussed.

In the primary survey a swift examination should take place from head to toe of the patient looking for obvious causes for the patient's deterioration such as haemorrhage. Any such discoveries should be treated immediately.

At all times remember to communicate your findings to all the members of the team and ensure each finding if relevant is acted upon. No matter how trivial you feel something may be voice your thoughts as it may become very important to someone else.

Again before moving on to secondary survey quickly revisit **A,B,C and D** to check no deterioration has occurred and take action as necessary.

Primary Survey

Skin – colour
hot/cold
wet/dry
rash
bruising

Infection –
redness or inflammation
of line or wound sites
Colour of sputum/urine
Offensive diarrhoea
Swollen red/hot areas
Pyrexia

Fluid losses –
vomiting
diarrhoea
stoma
naso-gastric
wound losses
burns
pyrexia
drains
ascites
urine
fluid balance?
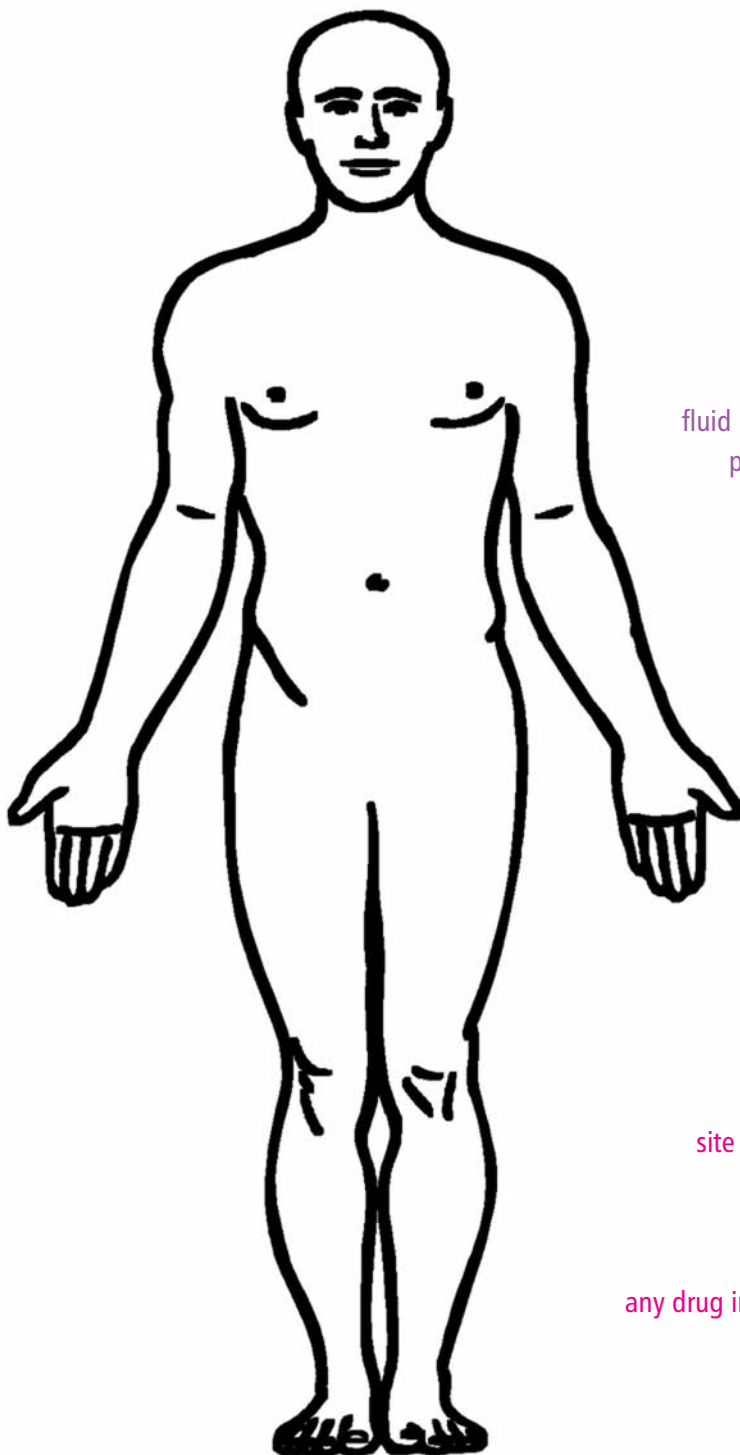
Bleeding – wound sites
puncture sites
drain sites
stoma
PR or PV
vomiting/faeces

Oedema present or not
areas affected
fluid losses from puncture sites
pressure limiting perfusion

Abnormal distension –
abdomen
limbs
diaphragm splinting

IV access –
present or not
adequate for need
secured in position
tissued or useable
site clean or signs of infection
fluids attached or not
IV fluids what type
delivered on time?
any drug infusions eg. Insulin or KCl

Secondary Survey

During the secondary survey the knowledge gained in the primary survey is built upon with the additional information gained from the notes, care plan and charts together with the blood results and other investigations.

The success of the secondary survey is dependant on the quality of the history gained from the notes and the detail documented on the charts.

If fluid balance charts have been poorly completed

dehydration or fluid overload are not as apparent. Equally poor history taking at the time when the patient was well enough to answer questions makes differentiating newly developed symptoms from the patient's norm difficult.

Once all the information has been collated a plan of care needs to be formulated including organising appropriate investigations and referral to relevant practitioners. Where will the patient receive appropriate care? What is the resuscitation status of the patient?

PAIN

The purpose of this chapter is to gain an understanding and raise awareness of the safe and effective management of acute pain.

> **Primary Survey**
> Your first priority
>
> **Secondary Survey**
> Includes the assessment, treatment and monitoring of pain

Introduction

The aim of this section is to ensure that pain is assessed and managed effectively with the appropriate analgesic treatment for individual patients.

Pain is multi-dimensional which can make it difficult to measure objectively, unlike a blood pressure or a pulse. Managing pain effectively is an important aspect of high quality patient care. The key to effective pain management is regular assessment and monitoring of individualised treatment. When assessing pain in the acutely ill patient the drug card should be reviewed as part of the management plan.

Definitions

- **Nocioceptive** pain occurs when tissue has been damaged e.g. inflammation, post-operative pain, chest trauma. This type of pain is best treated with regular paracetamol, $+/-$ NSAID and opiates for incident pain e.g. pain on movement.

- **Neuropathic** pain, which occurs as result of damage to nerve tissue e.g. ischaemic limb pain. This type of pain is best treated with regular paracetamol, $+/-$ NSAID adjuvants e.g. Amitriptyline, Gabapentin or Pregablin and opiates.

Whether pain is nociceptive, neuropathic or a combination of both will determine the appropriate pain relief required and the frequency of pain assessment and observations.

Acute pain has a protective function with a rapid onset, usually of short duration. This resolves after removal of stimulus or tissue healing and measured in days rather than months. The incidence of patients experiencing chronic pain following inadequate management of trauma/post surgery is 28%.

Chronic pain has no protective function and is present long after the immediate effects of an injury have subsided and persists beyond the healing time. Pain can be described as chronic when it exists longer than 3 months. In the context of acutely ill patient a history of previous chronic pain may impact upon their treatment.

Why Treat Pain?

Inadequate treatment of pain is distressing for patients and can affect them physically, psychologically and emotionally. The perception of pain can be influenced by the following factors:-

- Gender

- Age

- Culture

- Individuality

- Meaning

Physiological consequences of inadequate pain control

Pulmonary

- Reduced pulmonary function

- Reduced ability to deep breath and cough

- Hypoxaemia (reduced O_2 in arterial blood)

- Sputum retention

- Chest infection/pneumonia – leading to possible admission to either High Dependency Unit or Intensive Care Unit

Cardiovascular

- Sympathetic nervous activity

- Tachycardia

- Hypertension

- Vasoconstriction

- Increased myocardial O_2 consumption leading to myocardial ischaemia/infarction

Gastrointestinal

- Reduced gut motility

- Nausea and vomiting

- Reduced nutrition – resulting in poor wound healing

Mobility

- Deep vein thrombosis
- Pulmonary embolism
- Pressure sores

Psychological effects

- Anxiety
- Insomnia
- Low mood
- Altered behaviour
- Demoralised

Initial assessment of pain

- All pain needs to be assessed, by the nurse/doctor looking after the patient, 4-6 hourly or more frequently if necessary and documented on TPR chart or pain chart.

- Following the administration of analgesia, pain should be re-assessed to evaluate the efficacy of analgesia given.

- Dynamic pain assessment, i.e. at rest and on movement and monitoring the presence of side effects.

Use of the Pain Assessment Tool

3   SEVERE PAIN
- Free movement not possible
- Pain continues at rest
- Normal sleep impossible
- Clinical care not tolerated

2   MODERATE PAIN
- Mostly comfortable at rest
- Interrupted sleep
- Movement/clinical care restricted

1   MILD PAIN
- Comfortable at rest
- Comfortable on movement
- Able to sleep/perform normal activities

0   NONE
- No pain at rest or on movement
- Able to perform activities of daily living

If the patient is asleep when you go to assess their pain and they are not sedated due to opiates, then document 'A' (asleep) on the TPR chart

Analgesic Ladder

To be used alongside the pain assessment tool

3   SEVERE PAIN
- Regular Paracetamol +
- Regular Codeine +
- Regular NSAID (where not contra-indicated) +
- Morphine protocol
- Refer to the Acute Pain Team if pain is still not controlled

2   MODERATE PAIN
- Codeine 30-60mg PRN (use Morphine Protocol if ineffective or post-op)
- Regular Paracetamol +
- Regular NSAID (Codeine 30-60mg PRN if NSAID contra-indicated)

1   MILD PAIN
- Regular Paracetamol
- Regular NSAID (where not contra-indicated)

Baseline Analgesia

By using the concept of the analgesic ladder, if patients are regularly given simple analgesia, e.g. Paracetamol +/− non-steroidal anti-inflammatory (Ibuprofen) if not contraindicated, plasma levels achieved can have an opiate sparing effect therefore requiring fewer opiates hence reducing the risk of opioid side-effect (sedation, nausea, respiratory depression).

Hydration is an important factor whilst managing pain effectively. Elderly patients are often dehydrated. In addition they may have a degree of renal impairment resulting in reduced blood flow, clearance and filtration. Also consider cardiac disease in relation to the analgesics being given and the bodies ability to metabolise and excrete the drug or in the case of opiates the excretion of active metabolites. Dehydration is a common cause of adverse drug reactions.

- Ensuring that patients are well hydrated is essential.

Analgesic Routes

- Oral
- Subcutaneous
- Intravenous
- Intra-muscular
- Rectal
- Epidural
- Intrapleural

If patients can take oral medication, this is preferred over other routes.

Naloxone	Reversal of postoperative opiate induced respiratory depression, overdose of opiates. Well tolerated if given slowly. Short duration of action.
Indications	Opioid induced respiratory depression (<8 per minute).
Dose	By Intravenous injection, 0.4-2mg repeated at intervals of 2-3 minutes to a maximum of 10mg. If respiratory function does not improve question the diagnosis.
Risks	Caution in cardiovascular disease, physical dependence.

CHEST TRAUMA

Patients with fractured ribs, sternum or other chest trauma are at risk of significant pulmonary complications. This is often related to inadequate analgesia.

- Individual assessment of patients pain will highlight their respiratory support and analgesic requirements
- Baseline analgesia should be prescribed regularly
- Intrapleural blocks/epidurals can be helpful but need to be identified early
- Contact relevant expertise

Did you know?

Bilateral thoracic injury is associated with a 13 fold higher probability of prolonged ventilation than unilateral injury.

The probability of development of a pneumothorax and/or haemothorax is 25% with one or two rib fractures and over 80% in patients with more than two fractured ribs.

Elderly patients with rib fractures have twice the morbidity and mortality of younger patients. For each additional rib fracture in the elderly, mortality increases by 19% and the risk of pneumonia by 27%.

Mortality rates as high as 36% have been reported with first rib fractures, which are associated with injury to the lung, ascending aorta, subclavian artery, and brachial plexus.

Average blood loss per fractured rib is reportedly 100-150ml.

Appendix – analgesic drugs and pain protocols

MICROBIOLOGY

This chapter aims to describe the principles of microbiological practice in the critically ill.

Introduction

Whilst patients may become critically ill as a result of an infection it must also be noted that they are all extremely vulnerable to infections. Critically ill patients should be regarded as being relatively immunocompromised and close attention to infection control is imperative.

The principles of microbiological practice in the critically ill can be divided into infection control, microbiological diagnosis and antimicrobial prescribing.

Infection Control

Infection control measures for critically ill patients include the general measures that should be applied to all patients as well as specific measures relating to the insertion and handling of invasive lines.

General measures

Despite many clinicians still being in strong psychological denial transmission of infections by staff is a major source of cross infection. Hand washing campaigns alone are well documented to have substantially reduced infection rates on intensive care units.

Universal Minimum Standard

- Bare below the elbows is the current national best practice guidance i.e. Short sleeves (or at least rolled up), no wristwatches, bracelets or rings.

- Wash your hands with soap and water before and after any patient contact. At the very least use alcohol hand gel. It is important to remember, however, that alcohol hand gel is ineffective against *Clostridium difficile*, and is no good on visibly soiled hands.

- If you expect to come into contact with body fluids then wear gloves. Remember to take your gloves off before handling the notes, and to wash your hands before and after using gloves.

- Clean equipment that touches the patient between patients (stethoscopes, patella hammers, otoscopes, pulse oximeter probes, sphygmomanometer cuffs to name a few). Alcohol wipes suffice on most occasions.

Barrier Nursed is also advisable in any patient who is critically ill. As above plus:

- Wear gloves for any patient contact

- Wear a disposable plastic apron, it will help to keep your clothes clean as well as reducing microbiological cross contamination between patients.

- Remove the gloves and apron and wash your hands before leaving the patients room.

- Leave unnecessary equipment (notes, charts etc.) outside. If possible, each patient should have their own stethoscope as opposed to each clinician.

- Minimise the number of staff entering the room. e.g. don't take the entire team into the room during the ward-round.

- A side room with the door open is a bay not a room! Keep doors closed whenever possible.

Invasive procedures

Invasive procedures, by definition, breach a patient's natural defences and provide a route of entry for infection. Critically ill patients often undergo a number of invasive procedures, such as insertion of venous and arterial catheters, as well as insertion of urinary catheters The risk of introduced infection rises with each procedure performed, and those patients with invasive devices in situ for longer periods of time are also at increased risk of infection. Line sepsis is not uncommon and can be fatal. Many line infections are initiated/caused by 'dirty' insertion, however scrupulous attention must be paid to every invasive device to ensure there are no signs of infection, and that devices are not left in situ for longer than is absolutely necessary.

Basic principles for placement of central venous catheters, etc

- Wear sterile gown, gloves, mask and hat and use an appropriately sized sterile area to work from, e.g. dressings trolley with a dressing pack opened on top.

- The most effective skin prep is 2% Chlorhexidine in alcohol (check expiry date, apply two coats allowing the skin to dry between coats).

- Once the skin is prepped then drape an adequately large area to ensure sterility. Most dressing packs contain an inadequate sterile drape but additional dressing towels are often available, remember that

the Seldinger wires provided in some Invasive line kits can be up to 45cm long and therefore the sterile field must extend to more than this length in all directions from the site of puncture.

- After the procedure has finished clean the area well before applying a dressing. Remember blood is the perfect culture medium. If there is ooze from the site, a gauze dressing can be used, but aim to replace it with a clear dressing as soon as oozing has completely stopped. Note Kaltostat is a useful tool in this situation as it will promote clot formation – it should be removed after 24 hours and the area cleaned before a standard dressing is applied.

- Ensure that all sharps are disposed of appropriately. It is best to take a sharps bin with you when inserting a line, rather than taking your used sharps to the nearest sharps bin.

Central Line Specific Infection Control Notes

Venous and arterial catheters are a very common cause of blood stream infection, it is essential that good infection control practices are followed by everyone handling the line.

1. Surveillance

a. Daily inspection of line sites (all of them) for erythema, discharge etc. is part of the daily review and it is important to be aware of the length of time the line has been in, especially if it is ≥ five days. Ask yourself every day whether a line is still required – a line left in 'just in case' is not acceptable. Lines that had to be inserted in non-ideal conditions (A&E, patients deteriorating on table in theatre, etc.) should be considered for early change.

b. Daily review of markers of possible infection, e.g. pyrexia, raised white cell count, elevated C Reactive Peptide, raised ESR or elevated procalcitonin. If any of these factors occur then a paired set of blood culture (one set from the line and one set from a venous stab).

c. At Doncaster we do not change lines routinely, but if a line infection is suspected a change to a fresh site is probably necessary. Avoid 'railroading' a line in an existing site if possible.

2. Care

a. If you use a line (to withdraw blood or inject) then wear gloves, clean the hub of the three-way tab with a Chlorhexidine 2% in alcohol wipe before and after use and keep the cap in a clean place (not the palm of your hand, not on the bed) or, better still, replace it with a sterile one.

b. Central lines should not be used for routine venous blood sampling other than in exceptional circumstances (i.e. IVDU), as residual blood increases infection risk. Keep the use of a line to a minimum – every time the cap is removed from the line there is a potential for organisms to enter the system.

Blood Cultures

Peripheral blood cultures have to be done in a sterile fashion, otherwise the false positive rate due to contamination will be unacceptably high. Contaminants may swamp true pathogens in culture bottles leading to infections being missed, and also act as potentially confusing 'false alarms', which may result in unnecessary antibiotic therapy or premature removal of a line. Blood cultures do not need to be taken on every patient regardless – only obtain blood cultures if it is thought there is a possibility of bacteraemia.

Many Trusts ensure that all sets of blood culture bottles are supplied with the relevant equipment and instructions to ensure that contaminants are kept to a minimum, but the basic procedure is as follows:

1. Ensure all required equipment is at hand and check expiry dates.

2. Wash hands.

3. Before venepuncture, remove caps from bottles and clean with 2% Chlorhexidine in 70% isopropyl alcohol wipes.

4. Apply disposable tourniquet, and select vein for puncture, clean puncture site with Chlorhexidine and alcohol swab for 30 seconds, allow to dry.

5. Wash hands again, and apply gloves.

6. If using a Vacutainer-style system, attach a butterfly needle to the adaptor cap.

7. Enter vein without palpating site again.

8. Obtain aerobic sample first, then anaerobic. If you are unable to obtain sufficient blood for both bottles, just the aerobic bottle will suffice.

9. Discard sharps appropriately, remove gloves, and wash hands.

10. Fill in the patient details on the blood culture bottles and request forms, and record procedure in patient's notes.

Guidance for Antibiotic Use

Basic Principles

Normally the initial prescription for an infective problem is made on the basis of an educated guess. This prescription should be reviewed and refined when the infecting organism and its antimicrobial resistance pattern is identified. The only way the second part of the process can be completed is if adequate and appropriate samples have been taken and sent to the laboratory **before** the administration of the initial anti-microbial and so adequate sampling prior to the first dose of antibiotic is imperative.
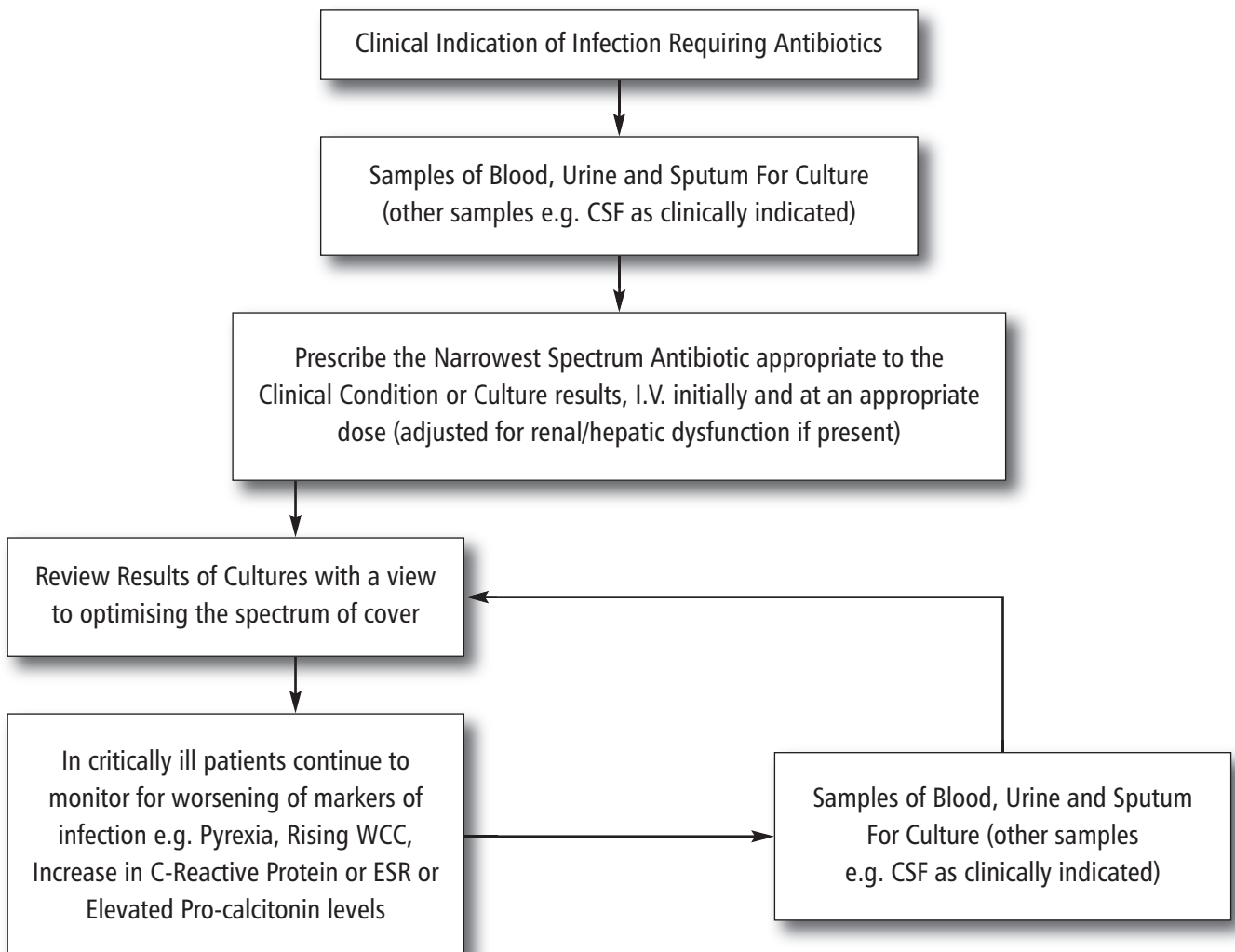
Early delivery of the right/best empirical antibiotic regime can reduce mortality of seriously ill patients by up to 50%. See table 1 for examples of commonly used antibiotics and their uses.

Remember:

- Use the narrowest spectrum antibiotic
- Give an appropriate/adequate dose
- Conversion of I.V. to oral at 48hrs if the patient condition allows.
- Limit the duration of therapy to 5 days if possible.
- For longer course of antibiotics continue to screen and take samples to identify secondary infection with resistant bugs.
- When causative infection has been identified, and antibiotic sensitivities obtained, it is important to narrow the antibiotic choice down as much as possible.

The resistance patterns of micro-organisms tend to be location specific and local antibiotic prescribing guidelines/policies should always be followed. Microbiology consultants are an excellent source of advice and their guidance should be sought and followed.

Good Practice for Antibiotic Prescribing

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┌─────────────────────────────────────────────────────┐
│  Clinical Indication of Infection Requiring Antibiotics │
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                        │
                        ▼
┌─────────────────────────────────────────────────────┐
│  Samples of Blood, Urine and Sputum For Culture       │
│  (other samples e.g. CSF as clinically indicated)     │
└─────────────────────────────────────────────────────┘
                        │
                        ▼
┌─────────────────────────────────────────────────────┐
│  Prescribe the Narrowest Spectrum Antibiotic appropriate to the │
│  Clinical Condition or Culture results, I.V. initially and at an appropriate │
│  dose (adjusted for renal/hepatic dysfunction if present) │
└─────────────────────────────────────────────────────┘
                        │
                        ▼
┌──────────────────────────────────┐
│  Review Results of Cultures with a view │◄─────────────┐
│  to optimising the spectrum of cover │               │
└──────────────────────────────────┘               │
                        │                           │
                        ▼                           │
┌──────────────────────────────────┐    ┌──────────────────────────┐
│  In critically ill patients continue to │    │  Samples of Blood, Urine and Sputum │
│  monitor for worsening of markers of │───►│  For Culture (other samples │
│  infection e.g. Pyrexia, Rising WCC, │    │  e.g. CSF as clinically indicated) │
│  Increase in C-Reactive Protein or ESR or │    └──────────────────────────┘
│  Elevated Pro-calcitonin levels  │
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Table 1: Characteristics of commonly used antibiotics and their spectrum of activity

Antibiotic	Type	Spectrum covered	Not covered	Comments
Benzyl penicillin	Penicillin	*Streptococcus pneumoniae* Group A,B,C beta-haemolytic streptococci *Neisseria meningitidis* Anthrax Diphtheria Clostridium	Some *Streptococcus pneumoniae* (especially those acquired abroad) 90% *staph aureus* Gram-negative organisms Enterococci	Narrow spectrum. Useful for splenectomy chemoprophylaxis. Susceptible to - ß-lactamase.
Amoxicilllin (and ampicillin)	Broad-spectrum Penicillin	Wider spectrum than Ben-Pen, including gram negatives such as coliforms. Most enterococci. Some *Haemophilus influenzae*.	As above, also: 50% coliforms. *Pseudomonas aeruginosa*.	Susceptible to - ß-lactamase.
Co-amoxiclav (Amoxicillin and clavulanic acid, aka Augmentin)	Penicillin derivative plus ß-lactamase inhibitor	Wider spectrum than amoxicillin, including *Staph aureus* (not MRSA), some more resistant coliforms, and many anaerobes. Covers most amox-resistant *Haemophilus influenzae*.	*Pseudomonas aeruginosa*.	Antibiotic of choice when dealing with animal bites.
Flucloxacillin	ß-lactamase - resistant penicillin	*Staphylococcus aureus*	Gram-negative organisms. Streptococci (in low doses). Enterococci. MRSA.	High dose in staph endocarditis, can cause hepatitis and cholestatic jaundice.
Piperacillin-tazobactam (Tazocin)	Antipseudomonal penicillin with - ß-lactamase inhibitor Tazobactam	As for co-amoxiclav, plus *Pseudomonas aeruginosa*	MRSA	Not first line antibiotic, beware penicillin-allergy when giving Tazocin.
Clarithromycin	Macrolide	Similar to benzylpenicillin. Staphylococci. Chlamydia. Mycoplasma.	Poor activity against haemophilus, some staph now also resistant (especially MRSA)	Less GI disturbance than erythromycin. A good 2nd line agent to use in penicillin allergy when treating Gram-positive infections.
Clindamycin	Lincosamide	Gram positive organisms, especially staphylococci and streptococci. Anaerobes.	Gram-negative organisms. If an organism is macrolide resistant, it is clindamycin resistant.	Excellent tissue and bone penetration. Risk of *Clostridum difficile* infection.

Antibiotic	Type	Spectrum covered	Not covered	Comments
Cefuroxime	Second generation cephalosporin	Less susceptible to - ß-lactamase. Haemophilus influenzae. Staphylococci. Streptococci.	Only moderate gram-negative cover. Pseudomonas aeruginosa. Enterococci.	15% of penicillin-allergic patients show cross-reactivity with cephalosporins.
Cefotaxime	Third generation cephalosporin	Better gram-negative cover than cefuroxime	Poorer gram-positive cover than cefuroxime, esp staph. Enterococci.	First line in meningitis/meningococcal sepsis. Risk of Clostridium difficile infection.
Ceftazidime	Third generation cephalosporin	Very good activity against pseudomonas, especially if structural lung disease present.	Enterococci.	Risk of Clostridium difficile infection.
Metronidazole		Anaerobes, including Clostridium difficile. Protozoa. Tetanus.	All aerobic bacteria.	Standard in oral/GI infections, good for antibiotic-associated colitis, give orally for C. diff.
Ciprofloxacin	Quinolone	Broad gram-negative cover	Poorer gram-positive cover, esp Streptococcus pneumoniae and enterococci.	If used without staph cover quickly selects out MRSA. May reduce seizure threshold.
Gentamicin Once-daily dosing (see below or local guidelines)	Aminoglycoside	Broad gram-negative cover. Some gram-positive cover (including staphylococci, but not a first choice to treat)	Anaerobes, haemolytic strep + Streptococcus pneumoniae	Is nephro- and ototoxic. Rapidly accumulates in renal impairment. Poor activity in collections and in pus.
Meropenem	ß-lactamase resistant Abx (Carbapenem)	Similar to Domestos, broad gram positive and negative cover including anaerobes	MRSA. VRE.	Third line antibiotic, often after tazocin. Useful in multiresistant gram-negative infections.
Teicoplanin and Vancomycin	Glycopeptide	Most gram-positives including MRSA	No gram negatives at all. VRE.	Empirical for septic shock or exclusively for MRSA. Vancomycin requires therapeutic drug level monitoring.
Fluconazole 400mg, then 200-400mg per day	Antifungal	Candida albicans	Some non-albicans candida species, aspergillus, Cryptococcus.	

Infections by system

Respiratory

Community-acquired pneumonia (CAP) is defined as a pneumonia that patients bring into the hospital with them or develop within 48 hours of admission.

Overall, the commonest organism causing community-acquired pneumonia is *Streptococcus pneumoniae*, followed by *Haemophilus influenzae*. Other organisms implicated include *Moraxella catarrhalis*, atypicals (such as *Legionella pneumophila*, *Mycoplasma pneumoniae*, *Chlamydia psittaci* and *Chlamydia pneumoniae*), and sometimes gram-negatives such as *Klebsiella*. People with underlying lung disease such as COPD are at increased risk of infection with organisms such as *Pseudomonas aeruginosa*. *Staphylococcus aureus*, and MRSA in particular, can be associated with pneumonia in people who are admitted from a nursing or residential home.

Severe haemorrhagic pneumonia due to Panton-Valentine Leucocidin (PVL) producing *Staphylococcus aureus* is a rare phenomenon seen mainly in the young, but the increase in the incidence of PVL-producing community-acquired MRSA suggests we will see more cases in the future. All cases where this is suspected should be discussed with a microbiologist.

Local guidelines will dictate empirical treatment. Current Doncaster Royal Iinfirmary recommendations for empirical therapy to treat CAP are Benzylpenicillin 1.2g QDS and Clarithromycin 500mg BD, sometimes upgraded to Co-amoxiclav 1.2g TDS (or Cefuroxime 1.5g TDS) and Clarithromycin. All patients with pneumonia severe enough to warrant admission to Critical Care should have a urine sample sent for Legionella antigen detection, along with a blood sample for atypical serology.

However, if the patient has already received antibiotics recently (i.e. from GP) or has only been discharged from hospital a few days ago with the same problem, this makes the issue more complex and the above combination may not be sufficient. Selection of more resistant organisms or gram negatives such as coliforms or Pseudomonas (see below) may have taken place already, and these cases may need to be treated as though they were a hospital-acquired pneumonia, as below.

Hospital-acquired pneumonia (HAP) is defined as a pneumonia developing 48 hours after hospital admission. The picture here is dominated by gram-negative bacteria such as coliforms and Pseudomonas colonising the oropharynx from the upper GI tract, with subsequent silent aspiration. In addition, gram-positive organisms such as *Staphylococcus aureus* can be a cause of HAP.

Due to the different spectrum of organisms, more extensive gram-negative cover is necessary. Other co-morbidity may give clues as to the likelihood of the infective organisms (table 2). Piperacillin/Tazobactam (Tazocin) or Meropenem are often used. Ciprofloxacin is an option against pseudomonas, however it lowers the seizure threshold and is discouraged in head injuries and it is hardly used as a single agent, as it quickly selects out MRSA, and is associated with an increased risk of *Clostridium difficile* infection. Ceftazidime may be considered where there is a strong possibility of Pseudomonas infection.

In both CAP and HAP, once the causative organism has been identified, it is important to select the narrowest-spectrum antibiotic available to reduce the incidence of secondary infection with more resistant organisms (including MRSA and *Clostridium difficile*).

Table 2: Host factors associated with specific organisms

Host factors	Likely/more common organism
Epidemiological Factors	
Diabetes/DKA	Strep. pneum., Staph. aur.
Alcoholism	Strep. pneum., Staph. aur., Klebsiella, Anaerobes
COPD	Strep. pneum., Haemophilus., Chlamydia pneum., Legionella
Structural lung disease (i.e. bronchi-ectasis, cystic fibrosis)	Pseudomonas, Staph. aur.
Intravenous drug use	Staph. aur., Anaerobes, Strep. pneum, Tuberculosis
Nursing home residency	Gram neg. bacilli, Strep. pneum., Haemophilus, Staph. aur., Anaerobes, Chlamydia pneum.

GI tract

The GI tract starts at the teeth and therefore oral infections are included here. Flora changes as you pass along the GI tract:

The mouth is heavily colonised with streptococci, anaerobes, mixed gram-negative organisms and occasionally candida species. The stomach and small bowel are relatively sterile environments, with bacterial load increasing as the jejunum and ileum are reached. Infections related to oesophageal, gastric and small-bowel pathology (including anastomotic leaks after surgery) may involve coliforms, streptococci, anaerobes and yeasts. An antifungal is often considered when giving empirical therapy in these situations.

The distal small bowel and the large bowel are very heavily colonised with faecal bugs such as coliforms, enterococci and anaerobes. Infections related to large bowel pathology (usually perforation of a viscus or an anastomotic leak) tend to require broad-spectrum cover to ensure the mixed faecal flora is covered. A 2nd generation cephalosporin such as cefuroxime, plus metronidazole is a commonly used empirical regimen.

Hepatobiliary infection such as cholangitis or cholecystitis is usually due to faecal gut flora, and the use of an antibiotic which achieves high concentrations in the bile is often advocated. Piperacillin-tazobactam is one such empirical choice. Severe pancreatitis is a difficult issue, as the disease itself can mimic sepsis, even if the necrotic pancreas is actually sterile. Empiric use of antibiotics and antifungals rapidly selects out difficult to treat gram-negative organisms, however a partially avascular organ is obviously at risk of being infected. Discuss at senior level!

Patients with fistulating disease or complex abdominal pathology (e.g. after multiple laparotomies) may have difficult to predict infective problems, and should be discussed at senior level on a case-by-case basis.

GU tract:

Remember UTI can be a significant cause of sepsis, especially in the elderly. Urosepsis needs urgent attention. The underlying treatment principle includes not only treatment of suspected infection, but also ensuring or establishing free flow of urine. If there is obstruction in a potentially infected kidney, a nephrostomy may be necessary. Pathogens are usually gram-negative organisms such as coliforms and so cefuroxime and gentamicin have a place. Enterococci

are sometimes implicated, and often may be treated with amoxicillin. Use gentamicin with care in those with renal impairment, and always obtain levels to ensure the plasma concentratration is within the therapeutic window.

Remember abnormal findings on urine dipstick in catheterised patients are very common (i.e. leukocytes, traces of blood, candida) but this may be of very little clinical significance. In fact, bacterial colonization of a urinary catheter becomes inevitable after just a few days.

Skin/soft tissues/bones

Postoperative wound infections are not uncommon (20% of nosocomial infections). Risk factors include diabetes, renal failure and use of steroids.

Most wound infections are due to *Staphylococcus aureus*, including MRSA, though other organisms such as streptococci and anaerobes may be implicated. Gram negative organisms such as coliforms and *Pseudomonas aeruginosa* tend not to cause overt soft tissue infection, but can colonise a wound preventing effective healing. On occasion (especially after abdominal or groin surgery) mixed bacterial wound infections can lead to a rapidly necrosing picture requiring broad-spectrum antibiotics and prompt surgical intervention.

Burns patients are nearly always colonised (and sometimes infected) by pseudomonas and other gram-negative organisms.

Cellulitis/erysipelas is often due to Staphylococcus aureus or Group A/C/G beta-haemolytic streptococci. Empirical treatment in cases severe enough to warrant admission to a High Dependency Area is iv flucloxacillin (2g QDS) plus benzylpenicillin (1.2g QDS); if the cellulitic area is near/over operated bone discuss with the microbiologists (may need additional fusidic acid/rifampicin or other agents, to treat potential osteomyelitis). Please also refer to local guidance on use of antibiotics in orthopaedics, and discuss with the microbiologists if the patient is allergic to penicillin.

Necrotising fasciitis is a deep, fast spreading infection commonly caused by Group A beta-haemolytic streptococcus. It can lead to extensive tissue damage and severe illness with a high risk of mortality. Antibiotics alone (meropenem 1g TDS plus clindamycin 600-1200mg QDS) are insufficient and prompt surgical assessment at senior level and extensive debridement

is an integral part of the management. Survival is possibly better when surgery is undertaken early, amputations may be unavoidable. Some patients benefit from intravenous human normal immunoglobulin, but this should always be discussed with a microbiologist before use.

Central Nervous System

Adult meningitis is most commonly caused by *Streptococcus pneumoniae* and *Neisseria meningitidi*s. Due to widespread vaccination, *Haemophilus influenzae* is now a rarer cause. The interval to administration of the first dose of antibiotic (empirical cefotaxime 2g) has been shown to influence outcome, so DO NOT DELAY IT. Lumbar puncture does not take precedent over antibiotic administration, particularly if there are concerns about its safety (raised intracranial pressure).

Adults over 55 years of age are also at risk of *Listeria monocytogenes* meningitis, so amoxicillin 2g iv QDS should also be given in this age group.

Corticosteroids have been shown to reduce neurological sequelae in pneumococcal meningitis if given WITH the first dose of antibiotics (Dexamethasone 0.15mg/kg qds for 4 days).

The Meningitis Research Foundation publishes excellent guidelines and algorithms for the management of bacterial meningitis, which can be found on their website at: **www.meningitis.org**.

Children below 2 years of age may present with meningitis due to Group B beta-haemolytic streptococcus, *E coli, Klebsiella pneumoniae* or *Listeria monocytogenes*, in addition to those pathogens that can affect adults, and therapy should be discussed with a paediatrician or microbiologist at the earliest opportunity.

Viral meningitis is usually associated with a lymphocytic picture on lumbar puncture, and is most commonly due to enteroviruses (many of which cause minor gastrointestinal upsets), but Herpes simplex virus and Varicella zoster virus may also be implicated. Treatment is usually supportive.

Encephalitis is inflammation of the brain, commonly caused by viral infection. The most significant pathogens are the Herpes simplex viruses type I and II, which tends to affect mostly the temporal and frontal lobes. Clinical signs are focal, including seizures, altered cognition and speech alteration. Early in the disease process CT may not be diagnostic (hypodense lesion in temporal lobe) and aciclovir (30mg/kg/d) may have to be started empirically.

NB: Aciclovir is not a risk-free drug, and shouldn't be started unless encephalitis is suspected. MRI is more sensitive than CT early on and PCR on CSF samples may confirm the diagnosis.

Neutropenic patients

Patients with haematological malignancies or those undergoing chemotherapy often have bone marrow suppression leading to neutropenia (White Cell Count <1). This leaves them at risk from sepsis, usually due to gram-negative bacteria such as coliforms and *Pseudomonas aeruginosa*. Many have tunneled venous lines (e.g. Hickman, Broviac) in situ, which can act as a portal of infection for many bugs such as coagulase negative staphylococci (e.g. *Staphylococcus epidermidis*), *Staphylococcus aureus*, enterococci, environmental gram-negative organisms (e.g. *Stenotrophomonas maltophilia* and *Acinetobacter baumanii*), and fungi (e.g. Candida species).

Infections in these patients can be rapid and fulminant, so require prompt intervention. Blood cultures should be taken peripherally and from all lumens of any venous lines in situ, and then empirical broad-spectrum antibiotics commenced – DRI currently advises Piperacillin-tazobactam 4.5g TDS along with gentamicin 7mg/kg OD (this should be reviewed after the 1st dose, and appropriate levels should be taken to ensure the plasma concentration is within the therapeutic window). Empirical therapy will often be amended after discussion between microbiology, haematology and the parent team consultants.

Often infections are line-related, and in some cases the ideal treatment may be to remove the infected line, but this should only be done after discussion with the consultant intensivist/haematologist.

MANAGEMENT PLAN

1. **Primary survey complete? ABCDE/monitoring/ immediate management undertaken**

2. **Secondary survey complete? History/full exam/ investigations sent**

3. **Definitive diagnosis? Senior help needed/further investigations/other specialists**

4. **Definitive treatment? Surgical/medical/ radiological/location of treatment**

5. **Documentation? Clear, time and date of entry, full details include future care**

6. **Review? Who, when, what circumstances hasten this**

7. **Reassess? Patient condition may deteriorate, ABCDE again, be ready to change working diagnosis**

8. **Communicate clearly your plan**

1. Primary survey complete? ABCDE/monitoring/ immediate management undertaken

Treatment must be prompt and appropriate. These should follow the guidelines in the manual. Remember treat simultaneously with ABCDE, not after. *Despite an acceptable history and examination, initial treatment was often delayed, inappropriate or both.* (NCEPOD 2005). During treatment remember to reassess and reassess and reassess. If primary survey only undertaken then the lack of secondary survey must be documented.

2. Secondary survey complete? History/full exam/ investigations sent

The secondary survey should be as thorough as time allows. They may not occur till hours after admission. A patient with a ruptured spleen may go straight to theatre from casualty having only had ABC done.

3. Definitive diagnosis? Senior help needed/further investigations/other specialists

Is there a definitive diagnosis? If not a working differential diagnosis should be outlined. Has the appropriate seniority of professional seen the patient? Should another speciality see the patient? The national confidential enquiries into perioperative death and

maternal deaths always comment about the lack of senior clinician involved in suboptimal management of patients. *Junior doctors must seek advice more readily. This may be from specialised teams e.g. outreach services or from the supervising consultant. (NCEPOD 2005 report).* IF IN DOUBT, REFER UP. This must be done clearly, concisely with a clear indication of the urgency. This must be documented in the notes. Further more specialised investigations may be needed after the secondary survey.

4. Definitive treatment? Surgical/medical/ radiological/location of treatment

The primary and secondary survey will treat life threatening conditions as they are found. In some cases this will involve definitive treatment but in the majority of cases the definitive treatment will occur after this initial plan. The definitive treatment needs to be clearly outlined. Be careful not to be blinkered by the specialty area you work in. Abdominal pain admitted to a surgical ward may have a medical reason. Remember definitive treatment may be medical, surgical, radiological etc. Is the patient in the right place for definitive treatment? This not only covers equipment levels, but also staffing expertise and staffing levels. Should this patient be in a high dependency area?

5. Documentation? Clear, time and date of entry, full details include future care

The team should produce a clear management plan. This must include current assessment (history, examination, and investigation), results, possible diagnosis and management plan at that time. This should be agreed with all those involved and clearly documented in the notes. This must be clear, concise and legible. Timely and appropriate. Avoid abbreviations, shorthand etc. Written notes may be all the communication the next carer sees. Thus it should include everything, including outstanding questions, concerns and what has been done. Any communication should also be documented. Remember what you write in the notes may be all you have to go by in court in three to six years time! Lawyers assume if you have not written it you have not done it!

6. Review? Who, when, what circumstances hasten this

It must be clear when the patient should be reviewed. This should include reviewing of tests not yet completed and a review of the effectiveness of treatment. How often should the nursing team be taking observations? When should the physiotherapist see the patient? When should the doctor review the patient? What happens if things are not improving? *Part of the treatment plan should be an explicit statement of parameters that should prompt a request for review by medical staff or expert multidisciplinary team. (NCEPOD 2005 report).*

7. Reassess? Patient condition may deteriorate, ABCDE again, be ready to change working diagnosis

Patients may have evolving conditions. Certain conditions e.g. haemorrhage may not reveal itself for hours. Physiology may deteriorate to reveal a problem not in the original diagnosis. Be prepared to think again and even go back to ABCDE if needed.

8. Communicate clearly your plan

As you will have gathered this is a major part of the management of sick patients. This is important in the initial acute management but often fails after this stage which may cause significant problems. Beware of handovers. With most health professionals now working on shift patterns handovers are part of normal practice. Multidisciplinary handovers are rare and doctors are poor at handing over patients. There must be a clear ongoing management plan for the patient including who out of the new team should review the patient and when.

Do not forget communication with the patient. They will want to know what is happening and what you are doing to care for them. The relatives will also want to know when the appropriate time comes but this may be best done by someone more senior if complex.

Case study – poor management of a patient

See if you can identify five problems with the management of this case (taken from NCEPOD 2005). The first has been identified for you.

A patient in their mid-seventies was admitted as an emergency with diarrhoea and general malaise. The only significant past medical history was hypertension, treated with an ACE inhibitor. On admission they were noted to be dehydrated, with a blood pressure of 110/60mmHg and a pulse rate of 100 beats per minute. Their respiratory rate was measured at 36 breaths per minute. Serum creatinine was 154 μmol/l. They were admitted by the medical SHO who prescribed intravenous fluid (1000ml over 8 hours) and antibiotics. The impression noted in the admission clerking was '? infection'. Four hours after admission the BP was noted to be 85/50mmHg. Maintenance intravenous fluids (3000ml) were prescribed and given over the next 24 hours despite the low blood pressure that persisted. In the first 24 hours after admission the nursing staff requested medical staff review on five occasions. Four of these reviews were by the PRHO and one by the SHO. Despite continuing hypotension no additional therapy was instituted. One entry (24 hours after admission) by the PRHO states that the blood pressure is 70/30mmHg but that the patient appears stable. Analysis of blood gases at that time revealed the following; pH 7.31, $PaCO_2$ 3.7 kPa, PaO_2 13.5 kPa, base excess –11.1mmol/l, lactate 4.3mmol/l. At that time urine output was noted to be negligible. SHO review confirmed these findings and the differential diagnosis of septic shock was made. An additional 500ml of colloid were infused over the next two hours. No other treatment was initiated nor advice sought. The patient remained hypotensive, tachypnoeic and confused overnight. The patient was reviewed by the SHO on several occasions, with no changes to treatment. Indeed one nursing entry states 'Dr. not unduly worried at present – continue with present regime'. A deterioration in consciousness at 48 hours after initial hospital admission prompted referral of the patient to the outreach service. At this point the patient was more acidotic, tachypnoeic and shocked. Admission to the ICU was expedited but despite initiation of organ support the patient continued to deteriorate and died 12 hours after ICU admission.

Problems:

1. Did the medical SHO recognise how ill the patient was?

2

3

4

5

ERRORS – WHERE DO WE GO WRONG?

Let me let you into a secret – doctors are not perfect. Nurses are not perfect. Physiotherapists are not perfect. We are human and thus will make mistakes. If you count the mistakes you make in one day (e.g. picking up the wrong keys, making coffee when you meant to make tea, etc) you will be surprised how often this occurs. Clearly making mistakes in the clinical environment have greater consequences. *'An organisation with a memory'* estimates that 10% of admissions have adverse incidents causing harm costing the NHS approximately £2 billion per year in additional hospitals stays alone. Some adverse events will be inevitable complications of treatment but around half may be avoidable. The aim of this short section is to make you more aware of medical errors, the situations they more commonly occur in and hopefully how to avoid them. References at the end lead to more in depth reading of this important area.

Medical errors occur due to patient factors, carer factors, factors concerning what we do to patients and the organisation we do them within.

Patients

Patients may answer our questions incorrectly for many reasons, forget important information etc. The way we ask questions can increase or reduce the likelihood of errors. Remember this possible source of error!

Carer factors

There are many situations where errors are more common amongst clinical staff. Unfamiliar surroundings (e.g. rotations, new jobs), unfamiliarity with drugs/procedures/equipment are some of the reasons. What other reasons can you think of? One pneumonic includes many aspects and is worth remembering as a self-check before we carry out clinical work.

I'M SAFE

I – Illness. Am I well enough to work?

M – Medication. Have I taken/forgotten to take medication which will adversely effect performance?

S – Stress (home or work) Am I too stressed to work safely?

A – Alcohol. Am I still intoxicated or too hungover?

F – Fatigue. Am I too tired?

E – Eating.

What we do to patients

Patients undergo investigations, treatments, surgery and other procedures all of which are error prone. Wrong diagnosis or incorrect management can be one possibility. Poor infection control (e.g. doctors not washing hands between patients) increases hospital acquired infection. Fifteen percent of these may be preventable at a cost to the NHS of £1 billion.

Medication errors are consistently reported to account for between 10 and 20% of all adverse events. Drug errors are one of the most common especially amongst acutely ill patients where treatment can be complex. One common problem is giving the medication by the wrong route. Oral medications and nebuliser solutions may be inadvertently given by the intravenous route etc. Key measures to reduce the risk include:

• Using devices for the administration of infusions and feeds only for the purpose for which they are designed.

• Preventing oral and intravenous drugs being taken to the patient's bedside at the same time.

• Labelling the distal ends of all lines to allow positive identification of the site of access.

• Confirming the route of administration during the checking process.

Clear prescriptions, appropriate checking of drugs and pharmacists questioning drug doses and pointing out possible interactions are there to provide a safe system.

Many medication errors occur at 'handover points' within the health care system. It is easy to understand the critical importance of effective communications when patients move from one care setting to another.

Four hundred people die or are seriously injured in adverse events involving medical devices in the NHS. Unfamiliarity with equipment, poor training and technical failure are the cause of most of these.

The organisation we work in

In such a large and complex organisation there are plenty of opportunities for errors to occur. Communication and teamwork are key to managing sick patients. Indeed communication, teamwork and situational awareness can be the cause of up to 80% of errors.

When a significant adverse event occurs it is rarely due to one single event but rather a cascade of events. This is illustrated by James Reasons 'Swiss cheese model'. This shows the barriers to errors as slices of cheese. No barrier is perfect so they have holes in. When these holes line up an 'error trajectory' occurs.
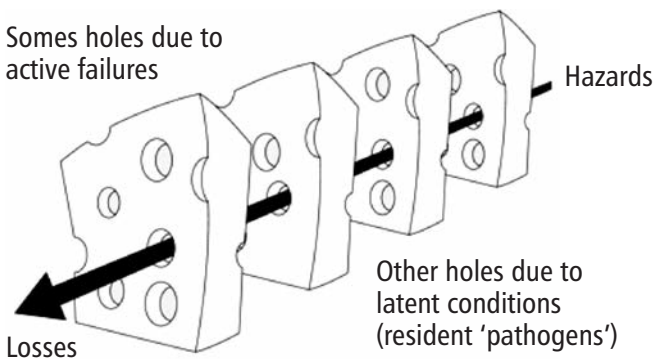
Successive layers of defences, barriers and safeguards. Perneger BMC Health Services Research 2005 5:71

The barriers may have holes in due to human (active) errors. The other holes may be due to latent errors. These are errors in the system waiting to catch someone out. There are many examples around us in hospitals. One example is the ease of which an epidural infusion bag of bupivicaine can be attached to an intravenous cannula. This is waiting to catch out a tired distracted clinician. If you add in unfamiliar equipment it would be easy to see how a patient could receive inadvertent intravenous bupivicaine. And it has happened more than once!

You are part of this system. Checking a patients name badge before giving blood, checking the consent before undertaking a procedure, asking about allergies before giving antibiotics, washing hands between patients can not only save the NHS money but also save lives.

Further Reading

An organisation with a memory. Report of an expert group on learning from adverse events in the NHS. A government white paper worth reading. Contains many illustrations of errors which have occurred and the financial cost to the NHS. (www.dh.gov.uk/en/ Publicationsandstatistics/Publications/PublicationsPolicy AndGuidance/DH_4065083)

Building a safer NHS for patients. Improving medication safety. A report by the Chief Pharmaceutical Officer 2004. Another government paper worth reading parts of to understand the impact of medication errors. (www.dh.gov.uk/en/Publicationsandstatistics/Publications/ PublicationsPolicyAndGuidance/DH_4071443)

British Medical Journal 18th March 2000. An entire issue dedicated to medical error and patient safety written by experts.

APPENDIX 1 PULSE OXIMETRY

Principles

Pulse oximetry is based on the differences in the absorption of light between oxy-haemoglobin and deoxy-haemoglobin. Two wavelengths of light are shone through the tissue. The relative absorption of each wavelength is used to calculate the relative proportions of oxygenated and deoxygenated haemoglobin expressed as a percentage saturation.
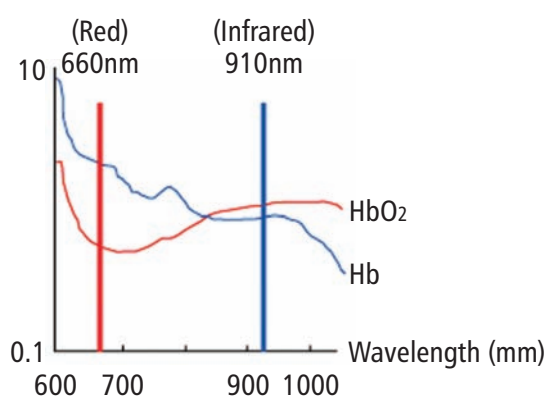

Figure 3. Absorption of light by oxy-and deoxy-haemoglobin

In order for the value to reflect the arterial component it is essential to identify the arteriolar component of the total absorption.

Clearly light will be absorbed by tissues especially those containing Myoglobin and by blood within the capillaries and veins which can affect the calculations and so the software specifically analyses only the pulsatile component of the total absorption. (This is why the abbreviation for Pulse oximeter saturations is SpO_2 and for directly measured arterial samples are SaO_2).

Factors Affecting Accuracy

No effect

Foetal haemoglobin (HbF), SulphHb, Bilirubin (absorption peaks are 460, 560 and 600nm), dark skin.

Falsely low reading

A reduction in peripheral pulsatile blood flow produced by peripheral vasoconstriction results in an inadequate signal for analysis.

Venous congestion of the limb may affect readings, as can a badly positioned probe.

Methaemoglobin (MetHb). The presence of MetHb will prevent the oximeter from working accurately and the readings will tend towards 85%, regardless of the true saturation.

Use of dye (indocyine green in cardiac studies, methylene blue in surgery).

Venous congestion, which may be caused by tricuspid regurgitation, high airway pressures and the Valsalva manoeuvre, may produce venous pulsations which can produce low readings.

External fluorescent light in the operating theatre may cause the oximeter to be inaccurate, and the signal may be interrupted by surgical diathermy. Shivering may cause difficulties in picking up an adequate signal.

Nail varnish may cause falsely low readings.

Falsely high reading

Carboxyhaemoglobin (CoHb). CoHb (haemoglobin combined with carbon monoxide) is registered as 90% oxygenated haemoglobin and 10% desaturated haemoglobin – therefore the oximeter will overestimate the saturation.

Calibration

Oximeters are calibrated during manufacture and automatically check their internal circuits when they are turned on. They are accurate in the range of oxygen saturations of 70% to 100% ($+/–2\%$), but are less accurate under 70%. Below the saturation of 70%, readings are extrapolated. Due to the shape of the oxyhaemoglobin curve, the saturation starts to fall rapidly at 90%.

Limitations

The oximeter averages its readings every 10-20 seconds. Hence, they cannot detect acute desaturation. The finger probe has a response time of approximately 60 seconds, whereas the ear probe has a response time of 10-15 seconds.

The site of application should be checked at regular intervals, as pressure sores and burns have been reported.

The pulse oximeter only provides information about oxygenation. It does not give any indication of the patient's carbon dioxide elimination.

APPENDIX 2 – BLOOD GAS ANALYSIS

Blood gases enable you to assess the ventilation status of a patient i.e. their Gases pCO_2 and pO_2 as well as their acid base status.

Ventilation

The pCO_2 is the only indicator of the effectiveness of ventilation. Oxygenation as indicated by the pulse oximetry saturation. The pO_2 can be preserved for a surprisingly long time in a patient with inadequate ventilation.

Acid Base Made Easy

Changes in the concentration of Hydrogen ions $[H+]$ affects the charge on the active moieties of enzymes and can thus have profound effects on the rate of metabolic reactions. As a result the body attempts to maintain the $[H+]$ ion concentration within very narrow limits.

There are three values required to define an individuals acid base status.

1. pH or H+ ion concentration as a measure of acidity or alkalinity.

2. $PaCO_2$ to identify the respiratory component.

3. HCO_3- ion concentration as a measure of the metabolic component.

HCO_3- is not measurable directly and so it is usually a calculated variable. A range of attempts to separate the respiratory and metabolic components have been tried resulting in the derived indices: Standard Bicarbonate, Base Excess and Buffer Base.

1. Standard Bicarbonate

Is an estimate of the bicarbonate concentration of the sample after the removal of any respiratory component. It is calculated using the standardising $PaCO_2$ of 5.3kPa. At first glance it would seem to be an easy way of estimating the metabolic component of any disorder, however it makes no allowance for chronic respiratory disease associated with hypercapnia as in these disorders some metabolic compensation will have already taken place affecting the normal values. Theoretically the calculation could be done against the individuals known normal $PaCO_2$ to estimate new metabolic components.

2. Base Excess

The Base Excess (in alkalosis) or Base Deficit (in acidosis) is defined as the amount of acid or base required to return the pH of 1 Litre of blood to normal defined as pH 7.4 at a $PaCO_2$ of 5.3kPa.
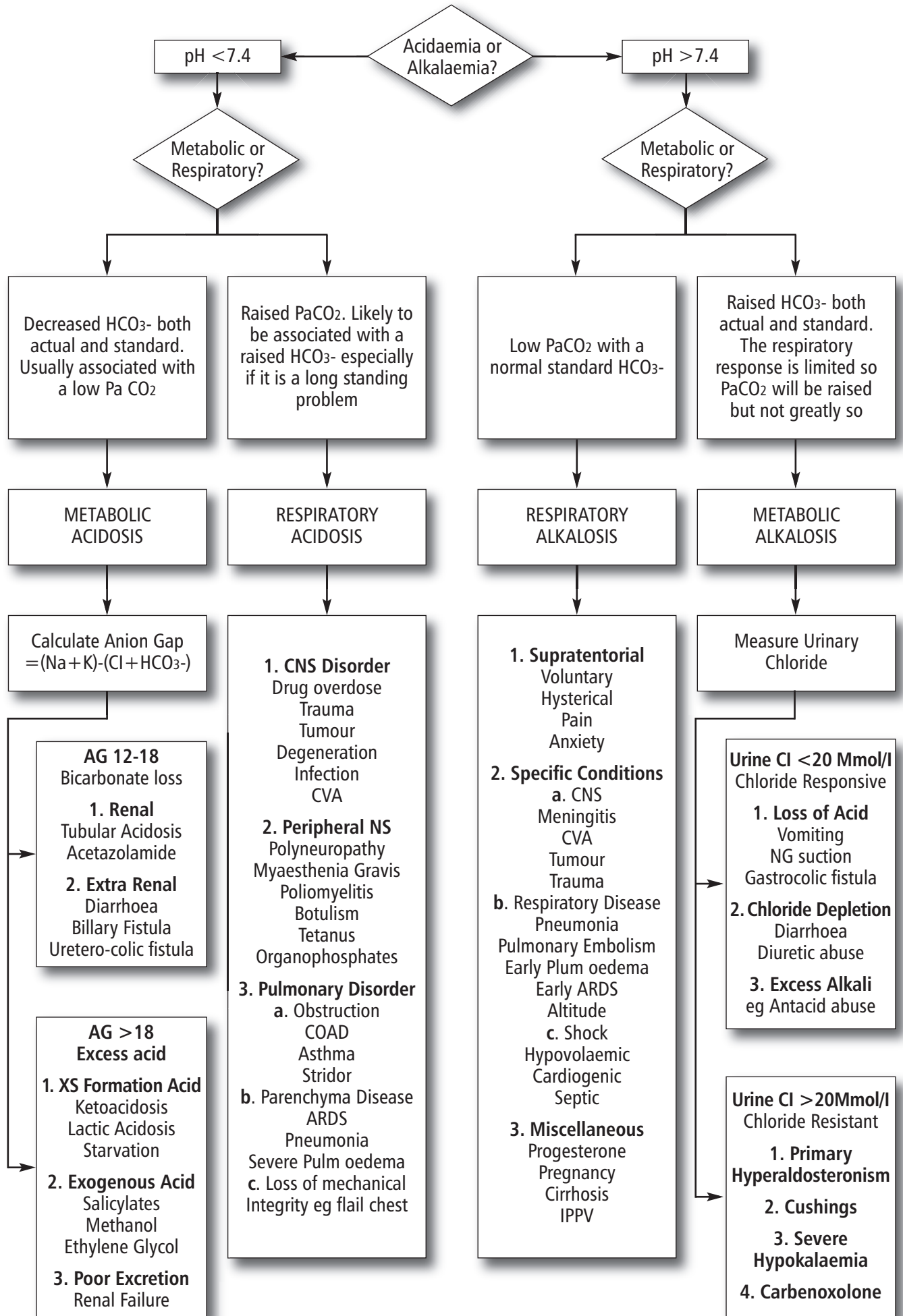
It is often used to calculate the dose of bicarbonate required to correct severe, life threatening, acidaemia.

Base Deficit x (Weight/3) = The Number of Millimoles of Sodium Bicarbonate

1 ml of 8.4% Bicarbonate = 1 millimole

3. Buffer Base

Fell out of fashion a long time ago.

Practical Acid Base Assessment

Acidaemia or Alkalaemia?

→ **pH <7.4**

← **pH >7.4**

pH <7.4 branch

Metabolic or Respiratory?

Decreased HCO3- both actual and standard. Usually associated with a low Pa CO2

→ **METABOLIC ACIDOSIS**

Raised PaCO2. Likely to be associated with a raised HCO3- especially if it is a long standing problem

→ **RESPIRATORY ACIDOSIS**

METABOLIC ACIDOSIS

Calculate Anion Gap $=(Na+K)-(Cl+HCO_3-)$

AG 12-18
Bicarbonate loss

1. Renal
Tubular Acidosis
Acetazolamide

2. Extra Renal
Diarrhoea
Billary Fistula
Uretero-colic fistula

AG >18
Excess acid

1. XS Formation Acid
Ketoacidosis
Lactic Acidosis
Starvation

2. Exogenous Acid
Salicylates
Methanol
Ethylene Glycol

3. Poor Excretion
Renal Failure

RESPIRATORY ACIDOSIS

1. CNS Disorder
Drug overdose
Trauma
Tumour
Degeneration
Infection
CVA

2. Peripheral NS
Polyneuropathy
Myaesthenia Gravis
Poliomyelitis
Botulism
Tetanus
Organophosphates

3. Pulmonary Disorder
a. Obstruction
COAD
Asthma
Stridor
b. Parenchyma Disease
ARDS
Pneumonia
Severe Pulm oedema
c. Loss of mechanical Integrity eg flail chest

pH >7.4 branch

Metabolic or Respiratory?

Low PaCO2 with a normal standard HCO3-

→ **RESPIRATORY ALKALOSIS**

Raised HCO3- both actual and standard. The respiratory response is limited so PaCO2 will be raised but not greatly so

→ **METABOLIC ALKALOSIS**

RESPIRATORY ALKALOSIS

1. Supratentorial
Voluntary
Hysterical
Pain
Anxiety

2. Specific Conditions
a. CNS
Meningitis
CVA
Tumour
Trauma
b. Respiratory Disease
Pneumonia
Pulmonary Embolism
Early Plum oedema
Early ARDS
Altitude
c. Shock
Hypovolaemic
Cardiogenic
Septic

3. Miscellaneous
Progesterone
Pregnancy
Cirrhosis
IPPV

METABOLIC ALKALOSIS

Measure Urinary Chloride

Urine Cl <20 Mmol/l
Chloride Responsive

1. Loss of Acid
Vomiting
NG suction
Gastrocolic fistula

2. Chloride Depletion
Diarrhoea
Diuretic abuse

3. Excess Alkali
eg Antacid abuse

Urine Cl >20Mmol/l
Chloride Resistant

1. Primary Hyperaldosteronism

2. Cushings

3. Severe Hypokalaemia

4. Carbenoxolone

APPENDIX 3 – ANALGESIC DRUGS

Paracetamol

Well tolerated. Can reduce need for stronger analgesia if given regularly. Various routes of delivery e.g. PO, PR, IV.

Indications	Mild-moderate pain/antipyretic.
Action	Acts centrally and peripherally by inhibition of chemical mediators.
Dose	Adults' 1g 4-6 hourly, maximum dose 4g (8 tablets) in 24 hrs.
Risks	Liver impairment, toxicity

Non-steroidal anti-inflammatory drugs (NSAIDs)

Indications	Moderate-severe pain.
Action	Anti-inflammatory analgesic Inhibits the synthesis of prostaglandins – this modifies the inflammatory process which produces pain Can have an opioid sparing effect if given regularly
Dose	Diclofenac 50 mg TDS (oral/pr) Ibuprofen 400 mg TDS (oral) Ketorolac 10-30 mg 4-6 hourly (IV)
Risks	Gastro-intestinal (GI) disturbances e.g. bleeding, ulceration Renal – reduction in blood flow to the kidneys, fluid retention (low urine output) leading to toxic effects and renal damage Cardiac Platelet/bleed – coagulation defects Hepatic impairment

Tramadol

Indications	Moderate-severe pain
Action	Weak opiate which binds to opiate receptors
Dose	50–100mg QDS
Risks	As with other opiates

Opiates

Morphine

Indications	Severe pain
Action	Binds to opioid receptors (Mu) in the brain, spinal cord and GI tract. Long acting opioid
Dose	IV/subcut/PO/PCA (as per local protocol)
Risks	**The following risks apply to all opiates**

Side effects induced by opiates particularly sedation and respiratory depression must be monitored as the drug can accumulate and may lead to a respiratory arrest. Urine output must be monitored to ensure the patient is excreting the drug.

Fentanyl

Indications	Severe pain
Action	Binds to opioid receptors, like Morphine, but short acting.
Dose	Combined with a local anaesthetic for post-operative epidural pain management
Risks	Sedation, respiratory depression

Oxycodone

Indications	Moderate – severe pain
Action	Full opioid agonist with affinity for Kappa and mu opioids receptors
Dose	Refer to BNF
Risks	See Morphine

Breakthrough Doses

If patients are on regular opioid analgesia for breakthrough pain should be calculated as 1/6th of their total regular daily dose.

e.g. MST 60mg bd = 120mg in 24 hours
Breakthrough dose = 120 divided by 6 = 20mg (as Oramorph)

Fentanyl 25mcg patch = Morphine 180mg daily
Breakthrough dose = 180 divided by 6 = 30mg (as Oramorph)

Fentanyl patch equivalences to oral morphine

Fentanyl 25mcg patch = Morphine 90mg daily
(i.e. MST 45mg BD)

Fentanyl 50mcg patch = Morphine 180mg daily
(i.e. MST 90 BD)

Fentanyl 75mcg patch = Morphine 270mg daily
(i.e. MST 135mg BD)

Fentanyl 100mcg patch = Morphine 360mg daily
(i.e. MST 180mg BD)

Oxycodone equivalences

Oxycodone (Oxynorm) 10mg   = Morphine
(Oramorph) 20mg

Oxycodone MR (Oxycontin) 10mg = Morphine MR
20mg (MST 10mg
BD)

APPENDIX 4 – LOCAL PROTOCOLS

(suggested to add)

Oxygen Therapy

Tracheostomy care

Pain Protocols

Antibiotic policies

Outreach/EWS