Intensive Care Medicine

An Introduction

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The aim of this document is to help prepare you for your time in intensive care as part of the fourth year anaesthesia module. Walking onto an Intensive Care Unit (ICU) for the first time may feel pretty daunting. Staff in this environment care for the most critically ill and clinically challenging patients in the hospital. Not only will you experience these patients first hand, but also you will encounter the vast array of interventions utilised to support them. Hospital intensive care services have become increasingly complex. We hope that this introduction will help improve your understanding of the technology and equipment that you may come across.

Critically Ill Patients - Levels of Care

In the modern hospital environment clinical staffing and resources should be provided to meet the patient's needs e.g. patient's requiring intensive care will have a nurse to patient ratio of 1:1, whereas each nurse on a normal ward may be looking after 10 or more patients. The following describes the UK classification of critical care beds throughout a hospital. These levels of care will give you an idea of the patients you might expect to find in critical care wards.

Level 0

Patients whose needs can be met through normal ward care e.g. observations > 4 hourly

Level 1

Patients at risk of their condition deteriorating or recently discharged from a higher level of care

Patients needing additional monitoring (including minimum 4 hourly observations), clinical interventions, input or advice from the critical care outreach support team (see below)

Level 2

Patients needing pre-operative optimisation OR needing extended postoperative care (e.g. after major elective or emergency surgery in high risk patients) OR patients stepping down from Level 3 care

Patients receiving single organ support:

- Basic respiratory support e.g. >50% oxygen via face mask, non-invasive ventilation
- Basic cardiovascular support e.g. central venous pressure monitoring, **single** intravenous vasoactive drug use
- Advanced cardiovascular support e.g. **multiple** intravenous vasoactive drug use, cardiac output monitoring
- Renal support e.g. renal replacement therapy
- Neurological support e.g. intra-cranial pressure monitoring
- Dermatological support e.g. major burns care

Level 3

Patients requiring advanced respiratory support alone (e.g. invasive mechanical ventilation) OR patients requiring a minimum of 2 organs supported e.g. basic respiratory and renal support

Traditionally the levels of care provided identified critical care wards i.e. Level 2 = High Dependency Unit, Level 3 = Intensive Care Unit. Ideally, patient location should not determine their level of care. The creation of critical care outreach teams (CCOT) has permitted the provision of critical care skills to patients in normal wards ("critical care without walls"). Find out more about the CCOT: explore the literature or one of the texts in the bibliography; even better, try to spend time with the CCOT on your assigned ICU to gain some insight into their work and how they support staff on normal wards.

The Intensive Care Bed Space

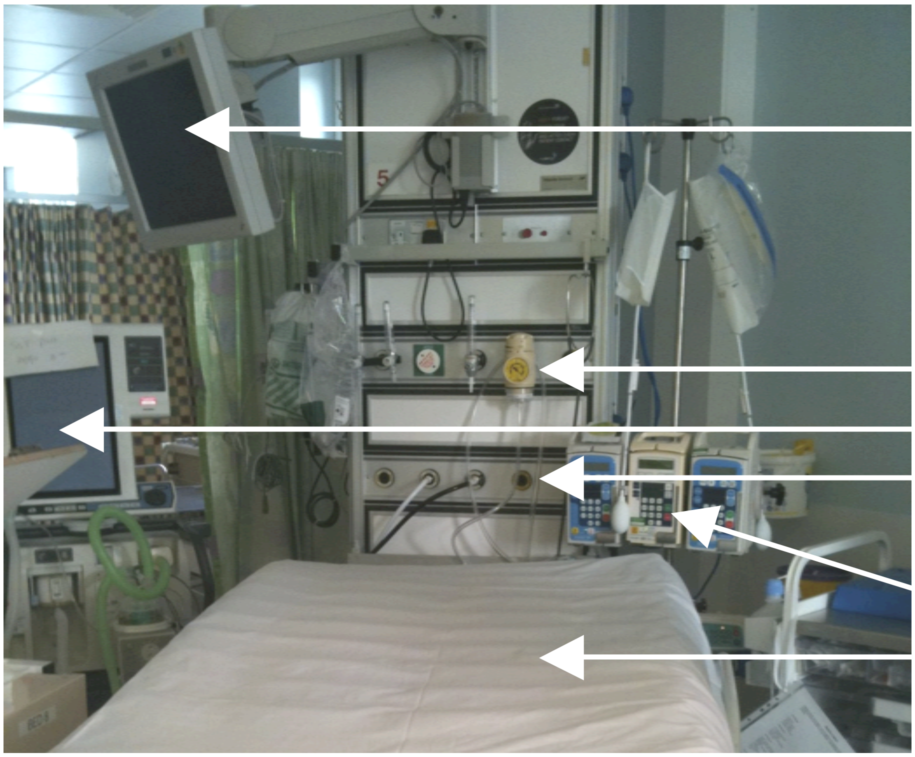


Figure 1. A 'typical' intensive care bed space

Intensive care bed spaces are designed specifically to provide the complex care that patients require.

Airway Support

Many patients on the intensive care unit require invasive ventilatory support. Invasive ventilation requires a definitive airway device to protect the airway from aspiration of gastric contents. The most commonly used devices are oral endotracheal tubes (ETTs) or tracheostomy tubes.

Endotracheal intubation

The oral ETT (Figure 2) consists of a tube that is passed down the pharynx and larynx that permits delivery of positive pressure ventilation. The tip of the ETT is positioned in the trachea above the carina. It has a cuff, inflated with air, which sits just below the vocal cords. The intubated patient is unable to speak as there is no airflow over the vocal cords. Complications associated with endotracheal intubation are shown in Figure 3. Most complications can be minimised through operator skill and experience. However, aspiration may occur in an emergency situation, as the patient is unlikely to have an empty stomach.

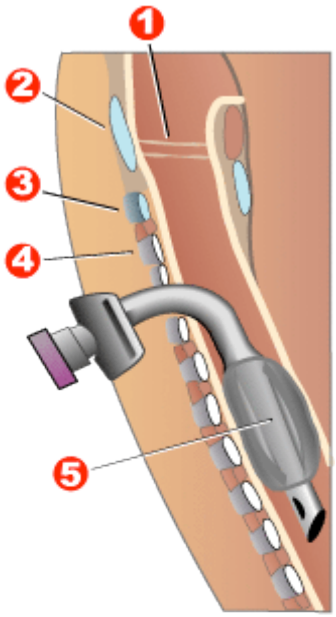
Figure 2. Cuffed oral endotracheal tube

Early Complications:	Trauma to any section of the airway including mouth, teeth, trachea
	Aspiration of stomach contents
	Tube malposition
	Airway Obstruction
	Hypoxia from prolonged attempts
Late complications:	Infection
	Mucosal damage to mouth or trachea (from cuff pressure)
	Injury to vocal cords
	Tracheal stenosis

Figure 3. Complications of endotracheal intubation

Tracheostomy

A tracheostomy tube (Figure 4) is a percutaneous airway device used for patients requiring prolonged airway or ventilatory support. Patients tolerate them better than oral ETTs as they provide a more comfortable airway: this may permit withdrawal of sedation and aid weaning from mechanical ventilation. Tracheostomies may avoid some of the complications associated with long-term oral endotracheal intubation, but they have risks of their own (Figure 5). The tracheostomy tube is inserted through an incision made in the anterior neck between the tracheal cartilaginous rings. The cuff is then inflated to form a seal against the tracheal wall providing a definitive airway. The insertion is usually observed by a second operator using a bronchoscope to ensure correct stoma and tube placement.



1. Vocal cords
2. Thyroid cartilage
3. Cricoid cartilage
4. Tracheal cartilage
5. Balloon cuff

Figure 4. A tracheostomy in situ

Early Complications:	Haemorrhage
	Pneumothorax
	Tube misplacement
	Surgical emphysema
	Blockage with secretions
	Stomal infection
	Mucosal ulceration & perforation; tracheo-oesophageal fistula
Late Complications:	Late haemorrhage (erosion into innominate artery)
	Tracheal granulomata
	Tracheal stenosis
	Scarring, persistent sinus
	Tracheal necrosis

Figure 5. Complications of tracheostomy

Breathing (Oxygenation and Ventilation)

Oxygenation is simply the provision of oxygen to the tissues. Ventilation is the delivery of oxygen to the lungs and the removal of carbon dioxide. There are various artificial means to facilitate these.

Oxygen therapy

Increasing a patient's inspired oxygen concentration allows better oxygen delivery to the tissues. It is the simplest form of respiratory support and will be discussed in depth in the respiratory physiology tutorial. In intensive care, oxygen is delivered using devices that deliver a fixed concentration of oxygen whilst warming and humidifying the oxygen to improve patient comfort and reduce complications such as mucus plugging. Oxygen therapy is not without its risks and high concentrations of inspired oxygen for a long period of time (e.g. >60% for >48 hours) may result in pulmonary injury.

Non-invasive respiratory support

Two commonly used techniques are continuous positive airway pressure (CPAP) and non-invasive ventilation (NIV). CPAP is used to support patients in acute hypoxic respiratory failure or to assist with weaning from invasive ventilation. It provides a constant pressure during inspiration and expiration. NIV incorporates CPAP in addition to an increased pressure triggered by the patient's inspiration. This assists the patient's own breathing, reducing the amount they have to 'work', and helping the patient to eliminate or 'blow off' carbon dioxide. NIV is commonly available in respiratory care units and has been demonstrated in clinical trials to prevent the need for invasive ventilation in patients with COPD. Non-invasive techniques require the patient to be alert and co-operative: they must be able to cough, make their own respiratory effort and protect their airway. They typically use a tight fitting mask over the nose and mouth, although they may be delivered via a hood that fits over the entire head (Figure 6). A high flow blower unit or a ventilator provides positive pressure.

Figure 6. CPAP/ NIV delivery via facemask and helmet

Patients often find it difficult to tolerate the tight fitting mask and the alternative helmets are disorientating, noisy and unwieldy. However both may be removed for short periods to allow eating and drinking and reapplied later.

Intermittent Positive Pressure Ventilation (IPPV)

Figure 7. Example of an intensive care invasive ventilator

During normal breathing the inspiratory muscles contract increasing the thoracic volume. This creates negative pressure within the thorax and causes inflow of air. Expiration is passive. During IPPV the ventilator creates positive pressure within the endotracheal tube driving air into the lungs. Ventilators may be set to deliver a specific concentration of oxygen, number of breaths per minute, and tidal volume which may be altered to optimise the patient's ventilation and oxygenation. More sophisticated ventilators (Figure 7), like those used in the ICU, are also capable of sensing when the patient is trying to breathe and synchronising the delivery of a "breath" to support the patient's own breathing. These modes are especially useful in assisting patients in weaning from ventilation.

The main advantage of IPPV is that oxygenation and ventilation can be achieved without the patient making any respiratory effort, however it is not without its complications.

- Ventilator-associated pneumonia (VAP)
- Ventilator-associated lung injury
- Barotrauma e.g. pneumothorax
- Haemodynamic instability

VAP is common; in addition it increases length of hospital stay and doubles hospital mortality. However, these topics will not be explored any further here. Mechanical ventilation is a postgraduate subject, but feel free to explore the literature or question the clinicians on the ICU if you are interested.

Circulation

Interventions used to support the circulation in intensive care patients are used to prevent complications relating to hypoperfusion of vital organs, especially the kidneys. Hypotension may be related to sepsis, hypovolaemia, cardiac dysfunction, anaphylaxis, or a number of other pathologies.

Fluids

The most commonly used and effective intervention to support the circulation is infusion of intravenous fluids. This topic discussed in depth in both the Cardiovascular Physiology Tutorial and the lecture on Fluid Management. Fluid resuscitation should begin on the normal wards but will continue in critical care areas along with more sophisticated interventions.

Vasoactive drugs

A patient must always be adequately fluid resuscitated before considering vasoactive drugs. Cardiovascular drugs used in intensive care include:

- Inotropes — Increase the contractile force of the cardiac muscle increasing stroke volume
- Chronotropes — Increase the heart rate
- Vasopressors — Constrict the arterial tree increasing the systemic vascular resistance

The majority of the drugs used have more than one of these effects. Most of these drugs require administration into a central vein because of the risk of tissue ischaemia secondary to extravasation if given through peripheral veins. They are given as a continuous infusion allowing careful titration of the dose. The most common agents used are shown in Figure 8.

Drug	Receptors Affected	Inotrope	Chronotrope	Vasopressor
Adrenaline	α1 β1 β2	Yes	Yes	Yes
Dobutamine	β1 β2	Yes	Yes	No
Noradrenaline	α1 β1	Yes	No	Yes
Phenylephrine	α1	No	No	Yes

Figure 8. Effects of common vasoactive drugs

Apart from dobutamine all these drugs increase vascular tone. This increases systemic vascular resistance, raising arterial blood pressure and thus improving vital organ perfusion. It must be remembered that the use of these drugs is not devoid of risk: patients should always be receiving invasive haemodynamic monitoring (via arterial and central venous catheters) and care from appropriately trained medical and nursing staff. Other drugs, which may you may see used, include anti-diuretic hormone (vasopressin) and dopamine.

Renal Replacement Therapy

Acute kidney injury is common in critical care patients. It is most commonly a secondary effect caused by problems such as shock or sepsis rather than a primary problem with the kidneys. Acute kidney injury is demonstrated by a falling urine output to less than 0.5ml/kg/hour or an acute deterioration in glomerular filtration rate, manifested by rising serum creatinine and urea. For this reason sick patients who need critical care are catheterised early to enable urine output monitoring. Untreated acute kidney injury may result in hyperkalaemia, acidosis, fluid overload and uraemia.

Figure 9. An example of a machine for continuous veno-venous haemofiltration.

The techniques available to treat a patient with failing kidneys include intermittent haemodialysis (as used in patients with end-stage renal failure) or a variety of continuous renal replacement therapies. Patients in critical care areas are less able to tolerate the large fluid changes associated with intermittent dialysis. Continuous techniques are considered more physiological as fluid and electrolyte changes occur continuously at a slower rate. The most commonly used technique in intensive care is continuous veno-venous haemofiltration (Figure 9) which is carried out via a large double lumen catheter inserted into a central vein.

5-10% of previously normal patients requiring renal replacement therapy for acute kidney injury will go on to require long term renal replacement therapy.

Sedation, Analgesia and Muscle Relaxation

Sedation is administered to aid tolerance of ETTs and to reduce patient pain and anxiety. It typically consists of an infusion of an analgesic, most often an opioid, and a sedative agent. Ideally both analgesics and sedatives should act quickly but have a short half-life allowing sedation to wear off quickly. Synthetic opioids such as alfentanil or remifentanil are commonly used analgesics. The most frequently used sedative is propofol, an intravenous anaesthetic induction agent: it can be given as a continuous intravenous infusion for sedation.

Sedation is also used to facilitate ventilation and in some circumstances may be required for medical reasons e.g. treatment of status epilepticus or reducing the metabolic demand of the brain after severe head injury. Sedatives should be used as sparingly as possible and stopped at the earliest opportunity. Insufficient sedation can lead to poor ventilation or agitation but prolonged sedation is linked with increased risk of chest infection, neuropathies and venous thromboembolism. At least once a day patients should have a “sedation hold”. During this time all sedation is stopped to prevent accumulation of sedative drugs, allowing assessment of neurological function and reducing the risk of complications. Patients who have a prolonged need for ventilation will often have their sedation stopped after a tracheostomy has been performed to allow physiotherapy, interaction with clinical staff and visitors, and ultimately to permit the resumption of activities of daily living.

Muscle relaxants are administered to aid initial intubation but continuous infusions are rarely required.

Specialist Units

Cardiac intensive care is predominantly used by patients recovering after cardiac surgery and provides specialist care such as intra-aortic balloon pumps. Neurosurgical intensive care units mainly care for patients with acute neurosurgical problems such as subarachnoid haemorrhage or major head injury. They provide specialist care such as intracranial pressure monitoring.

Conclusion

This information has been developed to supplement your time in the intensive care department and is not intended as an in depth review. Feel free to explore the topics through additional reading but the information is not core knowledge that you will be examined on. However, a basic understanding of the treatments described will help you get the most out of your placement. Please question the critical care nursing and medical staff on your placement if you wish to learn more: this is an ideal opportunity for you tap their knowledge and experience.

Bibliography and Further Reading

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www.ics.ac.uk An excellent resource for Intensivists, UK trainees and patients. Plenty for medical students to get their teeth in too. Here is the link for Levels of Critical Care.

http://www.ics.ac.uk/intensive_care_professional/standards_and_guidelines/levels_of_critical_care_for_adult_patients