Intensive Care: A Medical Perspective

Introduction

As a junior doctor or medical trainee the concept of intensive care (ICU) can be confusing and daunting. For those who have not worked in ICU, it can seem like an alien area of the hospital where you have very little idea of what care they offer. As a junior doctor it is easy to feel out of depth when caring for critically unwell patients, it is important that instead of feeling overwhelmed and struggling alone, that you feel happy to ask for help from intensivists appropriately. It is important to remember that as a doctor, whatever level, you are your patient's advocate. Even as a medical student you have a duty to flag up issues involving patient care if you feel they are not being addressed. If you feel your patient needs intensive care treatment you need to make this happen. The following chapter aims to address the areas listed below and should help empower you to treat your patient appropriately.

1) Help familiarise the reader with what care intensivists **can** offer
2) Help familiarise the reader with what care intensivists **cannot** offer
3) Help the reader recognise those patients that require intensive care input and recognise those where it may be inappropriate
4) Help the reader to understand the medical jargon associated with intensive care
5) Help the reader improve their understanding of ICU so the referral process is much smoother

What is Intensive Care?

Modern ICUs originated in the 1950s in the midst of the polio epidemic. At this time young patients with polio who had tracheal intubation and positive pressure ventilation had an improved survival outcome. From this point ICU evolved as a separate and specialist area of the hospital.

The Intensive Care Society defines Intensive Care Units (ICUs) as: "Areas of the hospital that look after patients whose conditions are life threatening and need constant, close monitoring and support from equipment and medication to keep normal body functions going".

ICUs have specialist equipment to assist with organ support and higher staffing levels to care for patients. These staff also have specialist training.

Patients will be admitted to ICU from all over the hospital: from the emergency department, direct from theatre, medical wards and obstetrics. Admissions may be planned i.e. after surgery, or emergency i.e. a critically unwell medical patient not responding to therapy. Unlike in the 1950s, when patients in ICUs were young and previously fit, patients now tend to be older and suffer multiple comorbidities.

Intensivists aim to identify the pathophysiological changes critical illness causes and the effect these have on the body's organ systems. By recognising and treating these patterns the aim is to improve the outcome for critically ill patients.

What can ICU offer?

ICUs manage a variety of problems. Common conditions requiring ICU care are:

- Critical illness causing failure of one or more body systems
- MI
- CVA
- Poisoning
- Pneumonia
- Sepsis of any source: Uncontrolled infection causing organ dysfunction is the commonest cause of admission to ICU.
- Trauma
- Post-operative or surgical complications
- Diabetic ketoacidosis and HHS

The role of ICU in these conditions falls into five main areas

1) Resuscitation and stabilisation
2) Physiological optimisation of patients to prevent organ failure
3) Facilitation of complex surgery
4) Support of failing organ systems
5) Recognition of futility

It is important as a doctor that you recognise critically unwell patients and the level of care that they require. You can then have a coherent conversation about this with your senior colleagues or ICU colleagues. Levels of care are 0,1,2,&3. The following definitions will assist you in classifying care needs. By using these definitions you can also ensure that nursing staff and bed managers are aware of the care that is needed and this will ensure inappropriate transfers do not occur.

Level 0: patients whose needs can be met on a normal ward

Level 1: patients at risk of their condition deteriorating, where higher care is needed but can usually be met in a monitored area of a normal ward. Critical care input may be needed e.g. with ITU outreach support

Level 2: Patients requiring a more detailed level of care, they may have single organ dysfunction, require post-operative care or require intense levels of nursing care. Level 2 care normally refers to high dependency units

Level 3: Patients requiring advanced respiratory support alone or basic respiratory support with more than one organ failing. The care needs of these patients are usually complex. Level 3 care refers to intensive care units.

Whilst ICUs can offer organ support and treatment for reversible illnesses and they can allow support whilst a diagnosis is sought and then treated, they cannot treat irreversible conditions. Even with reversible illnesses the outcome may still not be favourable. A stay in intensive care not only puts physiological stress on the body but also psychological stress. There are also risks of further complications whilst a patient is in ICU such as ventilator acquired pneumonias, line infections and sepsis from multi-resistant organisms. It is therefore imperative that as a referring doctor you assess whether your patient is appropriate for level 2 or 3 care before making a referral. Doing this will also aid your referral as it will be one of the first things an intensivists will ask.

Appropriateness for Intensive Care

Deciding whether a patient is appropriate for ICU care is a complex decision and should be made with the support of senior colleagues, nursing staff, the patients family and the patient themselves. If there is doubt about a patient's suitability for admission to ICU, seeking advice from an intensivist is also appropriate. Some patients may have clear wishes and advanced directives. These should always be respected. If no clear decisions have been made previously and the patient is able to discuss their care this should be your first port of call to clarify their wishes. If the patient is not competent to have this discussion then the next of kin should be spoken to. However, ultimately the decision for resuscitation and ICU admission is the decision of the consultant caring for the patient. In addition, just because a patient has a DNAR does not mean they are inappropriate for level 2 care. Patients may not be appropriate for ICU care if:

- They have clear wishes to receive ward based care only
- They have no clear reversible cause for their illness
- They have multiple co-morbidities, frailty or advanced age that combined make it unlikely that they will survive an ICU stay (age alone should not be a discriminating factor)
- The medical team feel that the physiological and psychological stress of ICU is unlikely to be in the patient's best interest

Setting ceilings of care can be complex and an ethical minefield, it is important that the multidisciplinary team (MDT) and next of kin are kept updated and all decisions are thoroughly discussed.

There are scoring systems available to try and predict the outcome of an ICU stay which can be implemented when making a decision as to whether a patient is suitable for higher level care. However there are flaws in these systems. Though they are based on large data sets and may accurately predict population outcomes, they are unreliable in predicting outcomes on an individual basis. In addition, the scoring systems do not necessarily encompass the outcome after ICU discharge; even if a patient is discharged to a ward there is still significant mortality risk.

Intensive care scoring systems

One of the commonest scoring tools used is the APACHE II score (acute physiological and chronic health evaluation). The score is based on the worst physiological derangement in the first 24 hours

(A), age (B) and chronic health. A score of greater than 35 indicates that the patient is unlikely to survive. There are some caveats to this e.g. a patient with severe DKA may score very highly but with appropriate therapy they do tend to reverse very quickly. This score is also based on population data and may not be accurate on an individual basis.

The following link will take you to the apache score: www.mdcalc.com/apache-ii-score-for-icu-mortality/

There are other scoring systems available, these are APACHE 3 score, SAPS (Simplified Acute Physiology Score), TISS (Therapeutic Intervention Scoring System) and SOFA score (The Sequential Organ Failure Assessment Score).

Assessment of the deteriorating patient and the NEWS score

It is important that patients who are clinically deteriorating are identified, so that interventions can be put in place to avoid unnecessary escalation of care, peri-arrest or arrest situations.

In 2012 the Royal College of Physicians (RCP) worked in conjunction with the Royal College of Nurses (RCN) and now advocates that the National Early Warning Score (NEWS) is used across the NHS. This scoring system is based on six physiological parameters: respiratory rate, oxygen saturations, temperature, systolic blood pressure, pulse rate and level of consciousness. The patient is scored depending on their parameters and this can trigger a low, medium or high response. The RCP advocates that NEWS is used in all acute care areas to assess and monitor patients but it should not replace clinical judgement. Doctors are expected to respond in a timely way and conduct an appropriate assessment if they are called to a patient with a high NEWS score. This assessment should follow a structured ABCDE approach as advised by the Resuscitation Council in ALS guidelines. The Resuscitation Council have identified that many hospital peri-arrests or arrests may be preventable if the deterioration is detected.

ICU outreach

In addition to the NEWS triggering nursing staff to call a doctor for assistance, in many trusts a high NEWS score will also prompt the intensive care outreach team to be called. The ICU outreach team are usually senior ICU nursing staff or physiotherapists who provide several invaluable roles. They can provide a liaison with ICU, they can help support the care of patients requiring level 1 care on the wards, they can assess and instigate interventions of at risk patients with high NEWS and they can promote education on the wards. As a junior doctor, working with the outreach team is incredibly valuable as not only can they offer their expertise but they can also help facilitate and expedite ICU admission if necessary. The outreach team will also support the intensivists if they need to commence level 2 or 3 care on the ward, in order to stabilise a patient prior to transfer to ICU. In addition with outreach assistance and intervention you may also be able to prevent some ICU admissions.

An important **key point** to remember is that if you are caring for a deteriorating patient, do not leave calling ICU until the last minute. If they are called early they may be able to offer some help and advice which may delay or prevent ICU admission. The outreach team will also be able to assist with this. As a junior doctor if you are struggling with a critically unwell patient you should always seek help early from the medical SpR, the ICU SpR and outreach.

Another **key point** is to have a baseline knowledge of what ICU can offer in terms of care, this will mean that when you call for help you will know what you are asking for. The following sections should aid you with this point.

What Respiratory Support can ICU Offer?

Respiratory support is needed when a patient has respiratory failure. Respiratory failure can be defined as type 1 or type 2 failure.

Type 1: Hypoxic respiratory failure, when the PaO2 is less than 8Kpa with a normal or low PaCO2. Type 1 failure is caused by diseases that impair alveolar function. e.g. pneumonia, pulmonary oedema and lung fibrosis.

Type 2: Hypoxic and hypercapnic respiratory failure, when the PaO2 is less than 8Kpa and the PaCO2 is greater than 6. Type 2 failure is common in chronic obstructive pulmonary disease but is also caused by neuromuscular diseases and conditions where there is a decreased respiratory drive.

If a patient requires respiratory support, this can be delivered on ICU as either non-invasive or invasive ventilation. Non-invasive ventilation can also be delivered on certain medical wards e.g. a respiratory ward or an acute medical unit.

Non-Invasive Ventilation (NIV)

This is broadly divided into hi-flow nasal oxygen, Continuous Positive Airway Pressure (CPAP) or Bi-level Intermittent Positive Airway Pressure (BiPAP). These methods of ventilation are used in spontaneously breathing patients.

Hi-flow oxygen (also known as optiflow)

Hi-flow oxygen can be delivered via specialist nasal cannulae. The principle behind hi-flow oxygen delivery is that a high percentage of inspired oxygen can be delivered e.g. FiO2 of 60% but in addition the flow of oxygen e.g. 70L can deliver some positive end expiratory pressure (PEEP). The exact amount of PEEP delivered is not 100% predictable due to leakage but between 3-6 cmH_20 can be delivered. Hi-Flow nasal cannulae can be used as a step up from conventional oxygen delivery methods to help treat Type 1 respiratory failure. Depending on the trust in which you work, the patient may need to be admitted to HDU for this treatment to enable closer monitoring.

Continuous positive airway pressure (CPAP)

CPAP is delivered by means of a tight fitting mask over the nose or nose and mouth or it can be delivered via a whole head hood. It can also be delivered via a tracheostomy tube. The mask/hood is attached to a ventilator and delivers expiratory support which is analogous to PEEP in ventilated patients. Usual settings are 5, 7.5 or 10 cmH_2O. An escalating pressure requirement may be an indication that invasive ventilation is needed. The aim of CPAP is to splint open airways, reducing alveolar collapse, enable alveolar recruitment and to increase the functional residual capacity to help reduce the work of breathing. These three mechanisms help to increase oxygenation and support respiration to prevent the patient from tiring.

A CPAP hood and CPAP face mask

Bi-level intermittent positive airway pressure (BiPAP)

BiPAP is also delivered by means of a tight fitting face mask but the ventilator delivers two different airway pressures. These are an inspiratory pressure and an expiratory pressure. The expiratory pressure (EPAP) is analagous to PEEP on CPAP and is usually set between 4-6 cmH_20. The inspiratory pressure (IPAP) is a higher pressure which aims to augment the patient's inspiratory effort. Common settings for this are 12 cmH_20 which can then be escalated depending on the patient response. BiPAP is used to treat type 2 respiratory failure and is commonly used in exacerbations of COPD. BiPAP may be delivered on some medical wards but it is also used in ICU. BiPAP should not be used as a treatment in COPD until the patient has received optimal medical management. If following medical management the ABG results and patients clinical condition fail to improve then this BiPAP can be considered. The aim is to commence BiPAP at settings of 12 cmH_2O/4cmH_2O and escalate the IPAP. Some patients with COPD may need an IPAP over 20cmH2O. Setting changes should be guided by serial ABGs and the respiratory or ICU teams should be involved to help guide this.

With both CPAP and BiPAP the inspired oxygen (FiO2) can be titrated to achieve a target PaO2 or saturations. Close monitoring and serial blood gases are imperative for any patient being treated with non-invasive ventilation so any improvements or deteriorations in the clinical state can quickly be identified.

Prior to commencing non-invasive ventilation it is important that any contraindications to treatment are considered and that there is a clear escalation or de-escalation plan documented in the patients notes should the treatment fail. These plans should always be discussed with the patient (if able) and relatives. As a patient or relative the CPAP or BiPAP machine can be very frightening, so it is important that the rationale behind the treatment and a plan of what the treatment involves is clearly explained.

Possible Treatment Plans

Prior to starting NIV the BTS recommend that treatment and escalation plans are clearly documented and discussed. They suggest that there are five categories in which a patient can fall. These are:

1) In the event of failure of NIV in the first 4 hours of treatment, escalate to intubation and invasive ventilation if appropriate

2) In the event of late failure of NIV treatment (between 4-48hours), escalate to intubation and invasive ventilation if appropriate.

3) In the event of failure of NIV consider palliation if it is not appropriate to proceed to invasive ventilation

4) Continue NIV if there is a response to therapy and seek specialist respiratory input with regards to duration of therapy and weaning.

5) Inappropriate to commence NIV and palliate from the outset

In addition DNAR status should be considered prior to commencing NIV: having a DNAR does not exclude NIV as a treatment.

Contraindications to NIV

- Facial burns/facial trauma
- Recent upper GI surgery
- Vomiting
- Fixed airway obstruction
- Undrained pneumothorax
- Patient is unable to protect their own airway
    - e.g. moribund with low GCS or copious secretions
- Life threatening hypoxaemia
- Multiple comorbidities
- Confusion and agitation
- Patient refusal
- Bowel obstruction
- Haemodynamic instability

Ideally a patient should be conscious and able to consent to treatment; patient's wishes should be of the upmost importance and the potential for recovery and expected quality of life need to be considered. However, on medical wards NIV may be used in the presence of the contraindications if this decision is made by a senior doctor. It may be that NIV may be the only hope for survival. However these patients should not be sent to ICU, should have a DNAR in place and the decision to commence NIV in the presence of contraindications should be clearly documented.

Both CPAP and BiPAP can reduce cardiac output and cause haemodynamic instability so it is important to monitor pulse and blood pressure closely. It is also important to consider that whilst

wearing an NIV mask the patient will have less oral intake and insensible losses will be higher. It is therefore imperative to monitor fluid balance and supplement this with IV fluids if necessary. If NIV is to be worn for more than 24-48 hours (which is usually the case) and the patient is struggling with oral intake then NG feeding should also be considered.

If the patient does not tolerate NIV it is important that every attempt is made to optimise their tolerance. Common problems are ill fitting masks, so other masks should be tried, skin necrosis can cause pain and so pressure dressings can be placed under the mask, bloating can be treated with pro-kinetics and an NG tube may help. Modification of the setting may also be required. However if the patient remains intolerant and wants to stop treatment it is important that they can be facilitated to make this decision. As a physician you need to counsel them on the risks and ensure they are competent to make this decision.

NIV and ICU

Patients who should be transferred to ICU to commence NIV should be those where escalation to intubation is appropriate and those who are more severely unwell (either sever hypoxia or respiratory acidosis). The rationale for taking these patients to ICU for NIV is that if treatment fails they are in the correct place for prompt intubation and ventilation. NIV may also be used on ICU following extubation as part of a respiratory weaning programme.

CPAP is often only delivered on ICU and so if this is required ICU should be involved early in the management.

Hi flow oxygen in some trusts is also only delivered on ICU/HDU and therefore ICU should also be involved early in these patients care.

Invasive ventilation

Invasive ventilation is used to treat severe respiratory failure either immediately or after a trial of NIV has failed. It requires endotracheal intubation or a tracheostomy. Other indications for invasive ventilation are:

- Apnoea
    - E.g. secondary to cardiac arrest or severe respiratory muscle weakness
- Airway protection if the GCS is less than 8
- Airway obstruction secondary to trauma, laryngeal oedema, tumour or burns
- Haemodynamic instability e.g. in shock

Clinical indications for ventilation (in the context of appropriate conditions) are:

- Raised respiratory rate (>30)
- PaO2 <11 on FiO2 of >0.4
- High PaCO2 with a respiratory acidosis (PH< 7.2)
- Exhaustion
- Confusion
- Severe shock
- Severe left ventricular failure.

Invasive ventilation is a highly complex subject and will not be covered in detail here. However invasive ventilation allows the intensivist to manipulate the patient's respiratory physiology controlling the respiratory rate, tidal volume, inspiratory flow, inspiration-expiration ratio, the FiO2 and the airway pressure.

Although ventilation can be imperative and lifesaving, it is important to carefully consider patients who are appropriate as it is also associated with haemodynamic instability, barotrauma, problems associated with sedation, damage to the trachea, volume trauma, impaired cough and secretion retention, ARDS and ventilator acquired pneumonias. Patients who are ventilated may also take a long time to wean and during this time they will become physically deconditioned and rely on nasogastric feeding. Patients who are ventilated are managed very carefully and need stress ulcer prophylaxis, DVT prophylaxis, daily chest physiotherapy, oxygen humidification and intensive monitoring of gaseous exchange.

What Cardiovascular support can ICU offer?

The most common reason a patient may require cardiovascular support on ICU is for the treatment of shock. The primary function of the cardiovascular system is to maintain perfusion of tissues and organs with oxygenated blood. If the cardiovascular system fails, blood pressure and cardiac output can drop leading to organ failure. Although it is important to treat the underlying cause of the shock (cardiovascular, septic, hypovolaemic or obstructive e.g. PE) patients may need cardiovascular monitoring and support on ICU while this is happening.

Invasive monitoring

ICU offers the ability to monitor patients more invasively and intensively than on the wards. Not only are the nurse to patient ratios much less but ICU has the facility to implement invasive monitoring. Although a lot of clinical data can be gained from basic observations such as pulse, capillary refill time, blood pressure, respiratory rate, temperature, GCS and urine output, it is easier to assess clinical state and subtle responses to therapy with invasive monitoring in the critically ill patient.

Common types of invasive monitoring are central venous pressure monitoring and invasive arterial pressure monitoring. However, oesophageal doppler can be used to assess fluid status and specialist haemodynamic monitoring such as PICCO and LIDCO can also be used. In some cases pulmonary artery catheterisation is still used, but the use of this has decreased in frequency. Fluid filling and the use of inotropes and vasopressors can be far more accurately delivered with sophisticated invasive monitoring.

When invasive monitoring is used it is important that it is interpreted correctly. It is important to assess trends rather than absolute figures and to be aware of what outcome you are seeking from your therapy. It is also important not to lose sight of how helpful basic observations can also be e.g. urine output, pulse and blood pressure.

In order to treat shock the following principles should be followed:

- Treat the underlying cause
- Optimize circulating blood volume
- Optimize cardiac output
- Optimize blood pressure
- Optimize oxygen delivery
- Support any organ systems that may be failing

Invasive monitoring can help detect more accurately when therapy may need to be modified to target any of these areas.

Drugs and goal directed therapy

Goal directed therapy uses the results from invasive and non-invasive monitoring to attempt to optimise the outcome in critically unwell patients. You can use goal directed therapy on the wards e.g. if the urine output is failing in a patient you can deliver fluid boluses with the goal of improving urine output to a normal volume (0.5ml/kg). Goal directed therapy on ICU just uses more variables to guide treatment and if fluid filling is not achieving results there is the option to use drugs. The aim is to optimise the cardiovascular performance of individual patients with titration of fluids and drugs to achieve an optimal response for each patient.

Steps in therapy:

1) Is fluid status optimal? (Use arterial line, CVP and ***mixed venous saturations*** as a guide) If yes proceed to step 2) if no consider a fluid bolus and reassess. Optimise fluid status prior to proceeding.

2) Is cardiac output optimal? If yes proceed to step 3) if no add in ***inotropic support*** and reassess. Optimise cardiac output prior to proceeding.

3) Is blood pressure optimal? If yes continue to monitor and reassess and ensure oxygen delivery and tissue perfusion is adequate. If no add in a ***vasopressor***.

Mixed venous saturations

These can be gained by obtaining a blood gas from a central line sample. A normal value is 55-75%. Mixed venous saturations are an indicator of oxygen delivery and consumption and will be substandard in an under-filled patient. Resuscitation guided by mixed venous saturations has been shown to improve outcome by reducing the severity of organ failure and duration of intensive care stay.

Inotropes

Inotropic drugs are used to optimise cardiac output. Examples are dobutamine, dopexamine, adrenaline and dopamine. Each drug has slightly different mechanisms of action but the aim of them all is to increase the heart rate +/- stroke volume. This is because Cardiac Output (CO) = Stroke Volume (SV) x Heart Rate (HR). Dobutamine and dopexamine increase heart rate and stroke volume but cause peripheral vasodilation, whereas adrenaline causes an increase in heart rate and stroke volume but causes vasoconstriction. When considering the use of an inotropic drug it is important to be aware of the mechanism of action so the effect of the drug can be effectively monitored. If the cardiac output is low but blood pressure well maintained, dobutamine or dopexamine may be logical choices whereas if cardiac output and blood pressure are both low adrenaline may be the inoptrope of choice. Dopamine has a variable action depending on its dosage and it is commonly used in Europe as a first choice inotrope.

Vasopressors

Vasopressors are vasoconstrictors. The commonly used agents are phenylephrine and noradrenaline. Both agents act on alpha-1 receptors and increase blood pressure by vasoconstriction. In appropriate doses the aim of vasopressors is to increase blood pressure and improve blood flow to vital organs. However if used in excessive doses they can cause reduced splanchnic blood flow, reduced renal blood flow, impaired peripheral perfusion and reduced cardiac output by increasing afterload. It is important that invasive monitoring and careful clinical judgement is used to titrate vasopressors to the lowest possible dose to achieve an appropriate response in the individual patient.

Inotropes and vasopressors should not be used until there has been adequate fluid filling, they should be given via central access and the intended goal of therapy should be clearly documented. Clinical judgement remains imperative despite invasive monitoring as the aim is to treat the patient not numbers. It may be acceptable to tolerate lower values of blood pressure if the patient is conscious and passing urine. Prior to the use of drugs to support the circulation it is also important to ensure that cardiac output and blood pressure have been optimised by treating any dysrhythmias, treating any mechanical causes of low blood pressure (e.g. massive PE) checking electrolytes and correcting severe acidosis (inotropic drugs do not work well at a PH < 7.2).

Hypertension

Hypotension is a much more common complaint on ICU but hypertension can also occur. This hypertension can either be due to physiological stresses from ICU treatment (e.g. ventilator weaning) or it may be the reason admission is required to ICU (e.g. malignant hypertension).

If hypertension is thought to be transient and as a result of ICU care it is important not to over treat this. Ensure the blood pressure reading is correct by checking the arterial line and performing non-invasive measurements. Ensure adequate analgesia and sedation, stop vasopressors and inotropes and reassess fluid status and consider diuretics if necessary.

If the patient is persistently hypertensive despite simple interventions or they have been admitted to ICU for the specific intent of treating hypertension then pharmacological therapy may be required. Malignant hypertension is when there is a sustained diastolic blood pressure over 110mmHg or a systolic blood pressure greater than 200mmHg. This is also associated with end organ damage e.g. myocardial ischaemia, renal failure and retinal signs. In this situation blood pressure needs to be lowered cautiously. Nifedipine can be used but this can drop blood pressure too quickly, hydralazine intravenously can be used as can GTN or labetalol infusions. It is important to involve the cardiology team or clinical pharmacology team in the management of these patients and ensure that they are closely monitored.

Arrhythmias

Disruptions to usual cardiac rhythm are common in ICU. Patients may have pre-existing arrhythmias that are exacerbated by critical illness or disturbances of physiology in the critically ill patient may precipitate an arrhythmia. It is important to treat bradycardia or tachycardia as per ALS guidelines and specialist cardiology input may be needed for pacing or cardioversion. However, it is also important to be alert to factors on ICU that may precipitate dysrhythmias.

Tachycardias

Tachycardias may be caused by pain and anxiety, increased catecholamines (either endogenous or from administered drugs), hypoxia, hypercarbia, electrolyte disturbance, hypovolaemia, pyrexia a cardiac event or endocrine abnormalities. It is imperative that any of these causes are identified and treated if present as this may treat the tachycardia and prevent further drug administration or cardioversion. However, if a patient is decompensated by a tachycardia ALS guidelines should be followed.

Bradycardias:

Bradycardia is a heart rate less than 60, often caused by 1st, 2nd and 3rd degree heart block. Bradycardia on ICU can also be caused by hypoxia, increased vagal tone secondary to suctioning, myocardial depressant drugs, brain injury or cervical spine injury. Drugs can be given to treat bradycardia e.g. atropine or glycopyrronium but these are usually short acting and if the patient is decompensated they may require external temporary pacing or cardiology input for a pacing wire +/- permanent pacemaker.

Gastroenterology and Intensive Care

Gastrointestinal (GI) illnesses can either be the cause for admission to ICU or they can occur as a result of critical illness. The gastrointestinal tract may "fail" whilst on ICU.

GI Failure

Gastrointestinal failure can manifest in several ways:

- Delayed gastric emptying
- Failure to absorb feed
- Ileus and pseudo-obstruction
- Diarrhoea
- Stress Ulcerartion
- Haemorrhage
- GI ischaemia
- Liver dysfunction

It is important to try and protect against as many of the features of GI failure as possible and to monitor patients for it as closely as possible. Stress ulceration should be avoided with PPI prophylaxis and NG feeding should be instigated early under dietician advice. Prokinetics such as metoclopramide or eryththromycin can be used to aid with gastric emptying and electrolytes should be reviewed and corrected daily to prevent ileus.

Patients with diarrhoea should be assessed fully to exclude infection and stool cultures should be sent. Diarrhoea may be a result of overfeeding or feeding with an electrolyte composition not suitable for that patient. However the ICU physician must be alert to more sinister causes of diarrhoea such as ischaemic colitis and clostridium difficile colitis. Those with diarrhoea need to be resuscitated with electrolytes and fluids and treated with antibiotics if appropriate. It is important to ensure nursing staff are equipped to cope with turning and cleaning the patient with diarrhoea as severe diarrhoea can exacerbate existing pressure ulceration and cause local infections.

Ischaemic colitis

This may present with diarrhoea, rising lactate and abdominal pain (if conscious). A CT scan may be helpful in the diagnosis. Patients may have a previous history of vascular disease or have a history of atrial fibrillation. Surgical advice should be sought urgently as treatment is resection of the ischaemic bowel.

GI illnesses that require ICU admission

Gastrointerstinal (GI) haemorrhage

One of the commonest GI reasons for ICU admission is upper gastrointestinal haemorrhage. Patients with upper GI bleeds can haemorrhage profusely and often need level 2 or even level 3 care to manage this. Those with alcoholic liver disease and upper GI haemorrhage are even more likely to require admission to ICU as the haemorrhage may cause encephalopathy.

Causes of GI haemorrhage include:

- Duodenal ulceration
- Gastric erosions and ulcers
- Oesophageal varices
- Portal hypertension and gastric varices
- Aortoenteric fistulae
- AV malformations

Patients with GI bleeds should be resuscitated with IV fluids and blood through large bore access. FFP and platelets should also be considered in major haemorrhage and you may need to activate your trust's major haemorrhage protocol. Ensure clotting, full blood count, group and save and electrolyte samples have all been sent to the lab urgently.

On ICU, resuscitation can be guided by invasive CVP and arterial line monitoring. Definitive treatment will always be required and when the patient is stable enough an OGD should be performed. It is always important to inform the gastroenterology team early that there is a patient with an upper GI bleed so they can prioritise the OGD. Patients who are actively having haematemesis are likely to need intubation for airway protection during the procedure. Other options for definitive treatment of upper GI bleeds include embolisation under radiological guidance or surgical removal of the actively bleeding area. However endoscopy is usually the first step.

Variceal bleeding

Variceal bleeding can be profuse and is associated with a high mortality. If bleeding cannot be controlled insertion of a Sengstaken-Blakemore tube can be attempted to compress the varices at the gastric fundus. Vasopressin should be administered if there are no contraindications. OGD is needed once bleeding is controlled so banding of the varices can occur. If all of these procedures fail a Trans-hepatic Intravenous Porto-systemic Shunt (TIPSS) can be considered.

Decompensated chronic liver disease

Patients with chronic liver disease may decompensate for a variety of reasons e.g. alcohol binge, sepsis, progression of disease, high protein diet and constipation etc. These patients require level 2 or level 3 support for several reasons:

- Encephalopathy may result in a low GCS and they may require airway protection
- Encephalopathy may result in combative and aggressive behaviour that requires sedation and higher level nursing
- Hypotension and 3rd space fluid loss may result in the need for inotropes and higher level monitoring
- Ascites can lead to severe sepsis requiring higher level monitoring and inotropic support
- Ascites can cause an intra-abdominal compartment syndrome which can lead to renal hypo-perfusion and patients may require treatment for renal failure.
- Hepatic failure can lead to hypoglycaemia which needs prompt detection and treatment

It is important that prior to referring a patient with decompensated chronic liver disease to ICU, that you carefully consider whether the patient is appropriate for higher level care. This often depends on the patient's underlying cause for decompensation and whether this is reversible. It also depends on the severity of their liver disease and if they are a candidate for transplant. These decisions are complex and should be made with the consultant who knows the patient.

Post-operative management

Many patients are admitted "electively" to ICU following major surgery. Undergoing a laparotomy can greatly alter a patient's physiology and sometimes despite optimal resuscitation during theatre by an anaesthetist patients may still need admission to ICU for 24-48 hours. This is especially the in emergency laparotomy. A short stay on ICU can optimise fluid management, treatment of sepsis and allow restoration of normothermia. In patients undergoing elective laparotomies they are often pre-assessed as to whether they will need ICU post operatively. These patients often have multiple co-morbidities and a stay on ICU is part of the enhanced recovery pathway.

Other GI conditions that require ICU admission are **biliary sepsis, acute pancreatitis, intra-abdominal sepsis and acute fulminant liver failure (e.g. secondary to drugs).** These conditions may all require higher level monitoring, inotropic support and in the case of fulminant liver failure patients need incredibly close monitoring of LFTs, clotting and prompt ICU transfer to a liver unit as mortality is so high and transplant may be the only option.

Renal and Intensive Care

This section is aimed at covering renal replacement therapy that can be offered on ICU. It will not go into depth about renal conditions and physiology or patients on long term renal replacement therapy as this is covered elsewhere on the website.

Acute kidney injury (AKI) is common in critical illness and is seen regularly on the medical take. Patients suffer from acute kidney injury for many reasons. One of the commonest reasons is due to renal hypoperfusion which can be secondary to shock. It is a common occurrence to see a patient with acute kidney injury secondary to sepsis or diarrhoea and vomiting. It is especially common in the elderly, isolated population who may have been unwell for several days yet continued to take their medications including antihypertensives. To compound matters these patients may have also fallen and had a long lie on the floor releasing creatine kinase which is also toxic to the kidneys.

When assessing a patient with AKI it is important to undertake some basic investigations. All patients should have a full set of U&Es sent, a venous or arterial blood sample is also important and can give a quicker assessment of potassium and acid-base status. Patients should ideally be catheterised and a fluid balance assessment is imperative. Patients should be treated with appropriate IV fluid resuscitation and urine output measured hourly. If potassium is high this should be treated with insulin and dextrose infusions. The underlying cause of the hypoperfusion should be identified and treated. Even if the cause of the AKI is thought to be pre-renal an USS of the renal tract is also advised. Reno-toxic drugs should be stopped.

Patients will need reassessment at least twice a day, if not more frequently. Blood tests will need to be repeated at least 12 hourly. If a patient with AKI fails to improve with therapy then they may need to be considered for filtration. Do not be tricked by high output renal failure, where the urea and creatinine continue to rise despite good urine output.

Renally excreted medications need to be reviewed in AKI and during renal replacement therapy. With a fall in eGFR many renally excreted drugs will not be metabolised as quickly and so accumulate. It is important to seek advice from a pharmacist as the prescription of opiates, antibiotics and many more drugs can be affected by renal failure. In addition nephrotoxic drugs need to be stopped e.g. ACE inhibitors. NSAIDs, Aminoglycosides and caution is needed with contrast media and the use of chemotherapy agents.

Indications for renal replacement therapy

- Acute
    - Persistently raised potassium >6.5 despite medical management
    - Persistent acidosis: PH <7.2
    - Fluid Overload and pulmonary oedema
    - Oligo/Anuria
- Within 24 hours:
    - Urea >40-50mmol/l and rising
    - Creatinine > 400 and rising
    - Severe sepsis not improving despite treatment

Types of renal replacement therapy

Continuous Venovenous Haemofiltration (CVVHF):

Blood from the patient is passed through a filter which allows plasma water, electrolytes and small molecular weight molecules to pass through a filter down a pressure gradient.

Continuous Venovenous Haemodialysis (CVVHD):

In CVVHF the clearance of small molecules and solutes is inefficient. In CVVHD, dialysis fluid is passed over the filter in a countercurent manner. Fluids, electrolytes and small molecules can move in both directions depending on hydrostatic pressure, ionic binding and osmotic pressure. Creatinine clearance is much better than in filtration alone. Fluid balance can also be manipulated by altering the quantity of diasylate passed into the patient at the end. By allowing more diasylate to pass out, fluid can be effectively removed from the patient up to 200ml/hour.

In order for renal replacement therapy to occur, a large bore double lumen, vascular access is required. This is known as a “vascath” and is inserted using Seldinger technique. Most commonly the femoral vein is used, but the internal jugular can also be used (the right is better than the left as the right internal jugular vein is straighter). In addition to requiring large bore access, anticoagulation is needed as passing blood into an extracorporeal circuit can lead to clotting. Unless the patient has a severe coagulopathy, they tend to be loaded on heparin and then have a heparin infusion run into the dialysis circuit. The APTT and activated clotting time must be monitored.

Complications of renal replacement therapy:

- Hypotension
- Dysrhythmias
- Haemorrhage
- Platelet consumption
- Disturbances in fluid balance
- Infection
- Air embolism

Most cases of AKI caused by acute tubular necrosis tend to recover, however there are a proportion of patients who fail to regain adequate renal function or are left with severe renal impairment. These patients should be referred to the renal team whilst they are on ICU so they can be further assessed and further management can be planned. Patients may need to be transferred to a renal unit for permanent dialysis.

Plasma Exchange

Plasma exchange is used as a therapy in some acute immune mediated conditions. The aim is to exchange a patient's plasma, thus removing the immunologically active proteins.

Indications for plasma exchange (PEX):

- Guillain-Barre syndrome
- Myasthenia Gravis
- Systemic Lupus erythematosus
- Vasculitis e.g. Wegner's and good pastures
- Thrombotic thrombocytopenic purpura (TTP)

Plasma exchange requires large bore vascular access and is associated with coagulopathy and hypotension secondary to fluid shifts. There are many other conditions where PEX can be considered but is not currently standardised therapy.

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