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# Care of the critically ill patient

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## Abstract

The care of critically ill patient within the intensive care unit requires a multidisciplinary approach. An understanding of the main principles of intensive care medicine is essential for surgeons, both for participating in the management of their own critically ill patients and also because surgical complications of critical care are well recognized. This article describes the main principles of intensive care medicine within the context of the COVID-19 pandemic, giving an overview of a systematic approach to assessment and treatment of organ dysfunction, and highlights some of the complex ethical and organizational challenges.

**Keywords** Cardiovascular support; COVID-19; critical care; critically ill; intensive care; renal replacement therapy; respiratory support; surgery

## Principles of critical care

Critical care is the process of looking after patients who either suffer from life-threatening conditions or are at risk of developing them. The intensive care unit (ICU) is a distinct geographical entity in which high staffing ratios, advanced monitoring and organ support can be offered to improve patient morbidity and mortality. However, effective intensive care demands an integrated approach that stretches beyond the boundaries of the ICU. It requires prevention, early warning and response systems, a multidisciplinary approach before and during an ICU stay, as well as comprehensive follow-up or good quality palliative care.

The cornerstones of intensive care management are the optimization of a patient's physiology, the provision of advanced organ support, and the identification and treatment of underlying pathological processes. This is best achieved through a multidisciplinary team approach, with shared responsibility between the admitting 'parent' team and a specialized critical care team coordinated by a critical care physician.

## The surgeon on ICU

The role of the surgeon within the critical care team is crucial for advice on individual aspects of the patient care such as specific

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management of the surgical condition, wound care, nutrition and management of anticoagulation in the immediate postoperative period. Moreover, strategic decisions on the overall care of surgical patients, and a duty to communicate these to patients and relatives, rest jointly on both the surgeon and critical care physician. Difficult decisions regarding the need for treatment limitations and the recognition of failing treatments and burdensome treatments should be explored between both teams, the patient and family.

## Organization of critical care services

### Prevention and 'critical care without walls'

Early recognition of acutely ill patients in hospitals is a challenging task but can potentially improve outcomes. The use of early warning scores and 'track and trigger' systems has now been widely implemented in many countries. Rapid optimization of care on the ward and early senior involvement are essential to minimize any deterioration and reduce the need for subsequent critical care admission. Medical emergency and critical care outreach teams may play an important role in facilitating early aggressive ward care as well as helping with education and development of skilled ward staff.

### Referral and admission to the ICU

The decision to admit an acutely deteriorating patient to the ICU is complex and warrants senior involvement, both from the parent specialty and a critical care physician. The primary question is whether an ICU admission and escalation of care is in the patient's best interest. While considerable effort has been spent to predict outcomes with scoring systems – based on disease process, physiological parameters prior to admission, age and comorbidities – these do not necessarily apply to individual patients and may not be relevant in the acute setting. An increasingly referenced concept is that of patient frailty, as this may be an important determinant of outcome in ICU. The assessment of frailty may add important information to the decision making process in the perioperative period.

Frailty can be quantified quickly using tools such as the Clinical Frailty Scale (CFS), which gives a numerical score between 1 and 9 equating to the patient's pre-morbid activity and dependence levels. A higher score has been associated with increased mortality in surgical patients.<sup>1</sup> It should be noted that the CFS is not validated in patients under the age of 65 and so should be used with caution in this age group. The CFS is not designed for use in those with stable long term disability or those with a learning disability.

For each emergency referral the following issues need to be considered:

- Is there a reversible pathological process?
- Does the patient have the physiological reserve to withstand the insults of their illness and the necessary treatment?
- Is there a reasonable chance of recovery with the prospect of return to an acceptable quality of life, as viewed by the patient?
- Has the patient expressed any wishes regarding their care? Do they have an advanced directive?

For any admission, a balance must be reached between the available technical ICU interventions and the potential to cause considerable distress to the patient, with both physical and psychological impact during and beyond their ICU stay. The inherent ethical conflicts of beneficence (chance of good outcome), non-maleficence (ICU often involves distressing/painful interventions), autonomy (patients often do not have the capacity to express their wishes) and justice (responsibility with resource allocation) need to be carefully considered. These factors are complex and need individual, careful, and experienced consideration for each patient.

Broadly speaking, two types of critical care admissions are recognized:

- **Planned admissions:** patients requiring optimization and monitoring of their physiological condition before or usually after an intervention, e.g. the postoperative care of the high-risk major general surgical patient to monitor for complications of the surgical procedure, anaesthetic or exacerbation of known comorbidities.
- **Emergency admissions:** patients with potential or established organ failure needing monitoring and support of one or more vital organ functions, e.g. a patient with septic shock secondary to four quadrant peritonitis requiring invasive ventilation and haemodynamic support post operatively.

Overall, surgical patients requiring critical care appear to have lower acute hospital mortality than medical patients. Recent UK data estimated this at 2.4% for planned and 13.6% for emergency surgery, with 27% for non-surgical patients.<sup>2</sup>

### Levels of care

Modern critical care medicine offers a large variety of advanced monitoring and organ support capabilities (Table 1). These depend on the design and scope of individual units. Below, two levels of critical care are described:

**High-dependency unit (HDU) or ‘level 2’:** Admission for single-organ support (not including invasive ventilation) and should not require a dedicated critical care nurse for each patient. Provides an environment for close monitoring of patients with or at risk of developing organ failure:

- respiratory: non-invasive ventilation, arterial blood gases
- cardiovascular: low dose vasopressors, invasive arterial pressure monitoring
- renal: close fluid balance control, certain renal replacement therapies.

**Intensive care unit (ICU) or ‘level 3’:** Admission for multi-organ support or delivery of advanced monitoring techniques requiring at least one dedicated critical care nurse for each patient:

- respiratory: invasive and non-invasive ventilation, extracorporeal membrane oxygenation (ECMO) or carbon dioxide removal (ECCO<sub>2</sub>R) in selected centres
- cardiovascular: vasopressor and inotropic support, advanced cardiac output monitoring, intra-aortic balloon pump, ventricular assist devices, ECMO
- renal: renal replacement therapies
- neurological: intracranial pressure monitoring, EEG, advanced neurological monitoring.

### Post critical care

Discharge from ICU does not terminate the involvement of the critical care team and many units are developing processes to ensure high-quality in-patient follow-up with some hospitals having established RaCI (Recovery after critical illness) clinics. These may help to understand, alleviate and prevent the detrimental long-term effects of critical illness. With more patients surviving to hospital discharge it is only recently that the long-term burden and reduction in quality of life post-critical illness is being understood.<sup>3</sup>

### Sepsis

Sepsis is a major cause of morbidity and mortality around the world, and affects a large proportion of ICU patients either at the point of admission or as a complication during their ICU stay. Sepsis is defined as ‘life-threatening organ dysfunction caused by a dysregulated host response to infection’ (Table 2).<sup>3</sup> Septic shock is sepsis complicated by hypotension despite volume resuscitation and raised serum lactate >2 mmol/L. It is worth noting that sepsis is no longer defined in terms of the systemic inflammatory response syndrome (SIRS) as this may in fact represent an appropriate response to inflammation, infection or a combination of the two.<sup>4</sup>

Over the past decade there has been a significant improvement in survival from sepsis in the developed world. This has been attributed to the fact that the basic principles of sepsis have become widely accepted, in part by global initiatives such as the Surviving Sepsis Campaign.<sup>5</sup>

The main principles of progressive sepsis care are:

- early recognition of sepsis
- appropriate balanced resuscitation
- rapid identification of the source of infection
- timely source control
- early and effective antimicrobial therapy
- haemodynamic support, consideration of adjunctive therapies and high-quality supportive care.

### Critical care organ support

Comprehensive care for critically ill patients usually requires a systems-based approach and integration of complex information. To provide a consistently high standard of care, some interventions have been grouped into ‘care bundles’, which have been shown to improve outcome when implemented together.

### Airway and respiratory support

A significant proportion of critically ill patients will need some form of advanced respiratory support during their admission. The decision to commence mechanical ventilation must not be taken lightly as it may be associated with significant patient morbidity. On the other hand, it should not be delayed unnecessarily until the patient is in extremis. However, technical interventions do not replace good quality basic respiratory therapy, which often features input from a variety of specialties, most crucially the physiotherapist.

**High flow oxygen therapy:** is now widely used perioperatively, for single system ward-based support in medical and surgical patients, and in the ICU. An air–oxygen blender is used to

## Overview of some critical care organ support and monitoring options

Organ system	Common on ICU	Available in specialized units
Respiratory	High flow oxygen/high flow nasal cannula therapy CPAP (nasal, hood, mask) Non-invasive ventilation Invasive ventilation (various techniques including recruitment manoeuvres) Percutaneous tracheostomy Bronchoscopy, broncho-alveolar lavage Prone ventilation	Extra-corporeal CO <sub>2</sub> removal (ECCO <sub>2</sub> R) Extra-corporeal membrane oxygenation (ECMO) Oscillatory ventilation
Cardiovascular	IV fluids management Vasopressors and inotropes Arterial and central venous catheters Cardiac output monitoring: Pulse contour analysis (LiDCO, PiCCO and others), oesophageal doppler, pulmonary artery flotation catheter Cardiac pacing Echocardiography (trans-thoracic and trans-oesophageal)	Intra-aortic balloon counterpulsation pump ECMO Ventricular assist devices
Renal	Renal replacement therapy including continuous veno-venous haemo (dia-)filtration or intermittent haemodialysis	
CNS	Neurological observations Raw EEG (or EEG- derived) monitoring Intracranial pressure monitoring Therapeutic cooling/temperature control	Jugular venous oximetry Transcranial doppler Cerebral microdialysis Cerebral tissue oxygenation monitoring
Gastrointestinal	Enteral and parenteral nutrition, immune-enhancing nutrition	Molecular adsorption recirculating system (MARS) in liver failure
Other	Intra-abdominal pressure monitoring Epidural and intrathecal analgesia Plasma exchange Neuromuscular monitoring	

**Table 1**

deliver very high flows of warmed humidified oxygen at a set oxygen fraction to patients via a nasal or facial interface. The high flows of up to 60 litres/min are thought to reduce work of breathing and improve respiratory mechanics by providing a small amount of positive end expiratory pressure (PEEP) and washing out dead space gases. This combination with humidification acts to prevent drying of the mucous membranes, aids tolerability and promotes secretion clearance. High flow nasal cannula (HFNC) has been shown to be beneficial in the management of patients with severe acute hypoxic respiratory failure in comparison to non-invasive ventilation or face mask oxygen.<sup>6</sup>

**Non-invasive ventilation (NIV):** is a form of respiratory support that obviates the need for endotracheal intubation. It is most commonly delivered by application of positive airway pressure via a facial interface utilizing either continuous positive airway pressure (CPAP) or bi-level positive airway pressure (BiPAP).

CPAP refers to maintaining a constant positive pressure throughout the respiratory cycle. This is similar to PEEP in invasively ventilated patients. The benefits include a reduction in the work of breathing, reversal of hypoxia through alveolar recruitment and correction of pulmonary shunt as well as a reduction in cardiac afterload (via reduced left ventricular transmural pressure). CPAP is delivered either via a tight-fitting facemask or via a dedicated CPAP hood or helmet. Great care must be taken to avoid pressure damage, particularly to the nasal bridge.

Bi-level positive airway pressure (BiPAP) allows separate settings for positive airway pressure during the inspiratory (IPAP) and expiratory (EPAP) phase of the respiratory cycle. It maintains the benefits of CPAP but has the added benefits of augmenting the patient's tidal volume and overcoming respiratory muscle insufficiency. NIV BiPAP is most commonly provided through tight-fitting facemasks.

Successful delivery of NIV depends on many factors including patient co-operation and the absence of contraindications such

### Common definitions in relation to Sepsis-3<sup>3</sup>

Condition	Definition
Sepsis	'life-threatening organ dysfunction caused by a dysregulated host response to infection'
Septic shock	The following clinical components <ul style="list-style-type: none"> <li>• Hypotension (MAP &lt;65)</li> <li>• Vasopressor requirement despite fluid resuscitation</li> <li>• Raised lactate above 2 mmol/L</li> </ul>

**Table 2**

as: an unprotected airway; the inability to clear secretions; marked haemodynamic instability; or the presence of an untreated pneumothorax.

NIV is well established in the treatment of respiratory failure secondary to cardiogenic pulmonary oedema and COPD. However, it is now also being used successfully in asthma, pneumonia (particularly in the immuno-compromised patient), other forms of acute lung injury, in postoperative respiratory failure and as a tool to assist weaning from mechanical ventilation.

Surgical opinion may be requested when commencing NIV in patients who have had recent upper GI or head and neck surgery, or those who have pathology in these areas due to the risk of surgical emphysema associated with delivery of positive pressure. In these cases balancing the risks of respiratory or surgical complications must be carefully considered.

**Invasive ventilation:** mandates tracheal intubation in one form or another. Securing the airway in critically ill patients poses significant additional challenges compared with the controlled environment of an elective theatre list. This may be due to profound physiological derangement (often paired with a rapid decline), the presence of anatomical difficulties (e.g. airway burns), external factors (e.g. cervical in-line stabilization in trauma), significant time pressures, suboptimal positioning,

### Indications for tracheal intubation

Aim	Example
Ensure upper airway patency	Existing or anticipated airway obstruction: loss of oropharyngeal tissue tone, inhalational injury, infection, trauma, tumour etc
Protect lower airway (against aspiration and soiling)	Loss of airway reflexes: low GCS, bulbar dysfunction etc
Ensure adequate oxygenation and ventilation	Respiratory failure: hypoxic or hypercapnic Optimize oxygen delivery and consumption (e.g. sepsis) Control of cerebral blood flow
Facilitate secretion clearance and interventions	Tracheo-bronchial suction Bronchoscopy/lavage

**Table 3**

unfamiliar environments, and limited availability of equipment and help. Thus, thorough preparation and excellent communication of airway plans are paramount for patient safety. Some indications for tracheal intubation are outlined in Table 3.

The mechanical ventilators used in most UK intensive care units are increasingly sophisticated and allow a wide variety of different modes that can be selected based on the patients underlying physiology and acute pathology. The more advanced machines can monitor the patient's respiratory mechanics and automatically adjust to optimize ventilation.

Broadly speaking, when intubated, a patient may be fully ventilated by the machine, may trigger breaths spontaneously, or a combination of the two. The process of reducing the support given by the ventilator to allow the patient to be safely extubated is known as weaning. When reviewing a patient who is intubated it is worth noting the amount of oxygen they require (the FiO<sub>2</sub>), whether the patient is breathing spontaneously, and basic setting such as the level of PEEP they require.

Advanced techniques of respiratory support include prone ventilation (may confer mortality benefit in severe acute respiratory distress syndrome (ARDS)), extra-corporeal carbon dioxide removal (ECCO<sub>2</sub>R) and ECMO.

Mechanical ventilation can itself induce lung injury, presumably through barotrauma and volutrauma, but also through repeat inflation and deflation of collapsed lung areas (atelectrauma) and through triggering the release of inflammatory mediators (biotrauma). A lung-protective ventilation strategy has been extrapolated from ventilatory management in ARDS<sup>7</sup> and has now been widely adopted in clinical practice. It includes the following ventilator goals:

- Aim for tidal volumes of 6–8 ml/kg (of ideal body weight).
- Limit plateau pressures to ≤30 cmH<sub>2</sub>O.
- Apply PEEP ≥5 cmH<sub>2</sub>O to avoid alveolar collapse.

Complications of mechanical ventilation can be divided into those related to tracheal intubation such as damaged lips and teeth, and vocal cord injury; those resulting from equipment problems, for example ventilator malfunction or contamination; those from mechanical ventilation itself such as cardiovascular instability, ventilator-associated lung injury or pneumonia, and oxygen toxicity; and complications stemming from prolonged immobilization and sedative use in the critically ill, for example pressure sores, peripheral and respiratory muscle weakness, deep vein thrombosis, delirium, gastrointestinal tract erosions with bleeding, and so on. To reduce the likelihood and severity of these complications a 'ventilator care bundle' has been established featuring the following components:

- Elevation of the head of the bed to between 30° and 45°.
- Daily sedative interruption or reduction and assessment for readiness to extubate.
- Peptic ulcer disease prophylaxis.
- Thromboembolic disease prophylaxis.

Respiratory support is usually guided by clinical and laboratory findings, supplemented by chest radiographs and computer tomography. Lung ultrasound is now widely used as a non-invasive bedside diagnostic tool for the assessment of pleural effusions, pneumothoraces and lung pathology (consolidation, pulmonary oedema etc.), without using radiation or transferring the patient from the safety of the ICU.



### Cardiovascular support

Haemodynamic management of critically ill patients aims to optimize tissue perfusion and oxygen delivery to the various organ systems. The cornerstones of this approach are appropriate fluid management and use of vasoactive drugs based on frequent assessment of cardiovascular changes.

**Haemodynamic monitoring:** Haemodynamic derangements in critical illness are complex and their assessment is notoriously difficult. Clinicians must consider pathophysiological insults to both macrocirculation and microcirculation, and to integrate complex information from various sources. These include history, physical examination, clinical observations and various monitoring modalities. The latter often assess either pressures (such as arterial or central venous pressure monitors) or blood flow (such as cardiac output monitors). Invasive cardiac output monitoring devices such as the pulmonary artery flotation catheters have drifted out of favour (outside specialized cardiac ICUs) due to their associated significant risks in the absence of improved clinical outcomes. However, several less invasive techniques, such as arterial pulse contour analysis (i.e. LiDCO™) or oesophageal Doppler devices have been developed. As most values are derived rather than measured, they are best used in a dynamic fashion, for example to assess response to a fluid challenge. Specialized investigations such as echocardiography are finding an increasing role in the haemodynamic assessment at the bedside and many intensive care physicians are now trained to perform focussed echocardiography exams.

**Fluid management:** the goal of fluid management is restoration of an adequate circulating volume to support tissue perfusion. However, endothelial damage and capillary leakage can lead to significant tissue oedema, which can in turn adversely affect diffusion of oxygen and nutrients. The presence of a cumulative positive fluid balance during a patient's admission to ICU has been associated with worse clinical outcomes.<sup>8</sup> Fluid management is therefore a delicate balance of potentially conflicting requirements and the importance of monitoring fluid balance cannot be overstated.

There is ongoing controversy over the optimal type of intravenous fluid, crystalloid or colloid, used for resuscitation and maintenance during critical illness. Balanced crystalloid solutions are most commonly used in sepsis, blood products in severe trauma and, should a colloid be chosen, albumin is an accepted safe alternative in sepsis and liver disease.<sup>9</sup> Starch solutions are avoided due to potential nephrotoxic side effects and possible increased mortality,<sup>10</sup> and gelatins lack evidence of benefit or harm.

Blood transfusion in all patients, including the general critical care population, is not recommended until the haemoglobin is less than 70 g/L and then optimally should be administered in single unit aliquots.<sup>11</sup> A higher threshold may however be considered in the presence or anticipation of bleeding, or in patients with previous myocardial infarction or unstable angina.

**Vasoactive drugs and principles of use:** Vasopressor and inotropic agents are short-term to medium-acting drugs that are used to enhance vascular tone or cardiac output in a variety of

critical illness conditions. They are used as a temporary measure until sufficient cardiovascular function returns on resolution of the pathological process.

Vasopressors trigger smooth muscle contraction in peripheral blood vessels, leading to increased systemic vascular resistance as well as vasoconstriction in venous capacitance vessels. The observed net effect is often an increase in blood pressure. Frequently used vasopressors include norepinephrine, epinephrine, metaraminol, phenylephrine, dopamine (via  $\alpha$ -adrenoceptor effect) and vasopressin (via vasopressin  $V_1$  receptors).

Inotropes increase the contractility of the myocardium, thereby leading to a rise in cardiac output. Examples of commonly used inotropes are epinephrine, dobutamine, dopamine (via  $\beta$ -adrenoceptor effects) and milrinone (a phosphodiesterase inhibitor). Levosimendan is a newer type of inotrope which works by increasing myocardial sensitivity to calcium.

Septic patients often require escalating haemodynamic support. Aggressive fluid resuscitation is followed by increasing doses of vasopressors (e.g. norepinephrine followed by the addition of vasopressin). Hydrocortisone may be added to reduce the dose and duration of vasopressor support. If sepsis-induced myocardial dysfunction is suspected, temporary inotropic support (e.g. with dobutamine or epinephrine) may be required.

### Central nervous system

Admission to ICU may be triggered by an altered sensorium, most commonly a reduced level of consciousness and often reported using the Glasgow Coma Scale (GCS). ICU care is required as the patient may be at risk of airway compromise and need higher nursing input.

Neuroprotective management is essential for patients with intracranial or spinal pathology (e.g. traumatic brain injury, ischaemic strokes, intracranial bleeds, spinal cord ischaemia). It requires a multisystem approach with critical importance of meticulous ventilatory and haemodynamic support. Advanced imaging and monitoring techniques such as intracranial pressure or neurological function monitoring are now available to inform treatment decisions. In addition, extracranial disease processes pose a risk of causing secondary brain injury, which may be preventable. An example is targeted temperature management and prevention of hyperthermia, potentially leading to improved neurological outcome in patients surviving out of hospital cardiac arrest.<sup>12</sup>

### Renal support

Acute kidney injury (AKI) is a major complication of critical illness occurring in up to 67% in the general ICU population and represents a significant therapeutic challenge for the intensive care team as the mortality of critically ill patients with AKI remains high (40–50%). The KDIGO definition of AKI classifies severity based on serum creatinine and urine output to give a stage between 1 and 3.

Pre-renal causes (hypotension, sepsis, low cardiac output) are commonly the initial precipitant of AKI in critical illness. However, renal dysfunction often becomes multifactorial during the ICU stay, for example through parenchymal damage from nephrotoxic drugs. Post-renal causes are rare in the critically ill but need to be excluded.

Treatment of AKI relies on timely diagnosis, adequate fluid management, haemodynamic support and elimination of the underlying and contributing causes. When AKI is severe, renal replacement therapy (RRT) may be necessary to maintain homeostasis of fluid, electrolytes and metabolic waste products. Indications for RRT in critical illness include:

- oliguria/anuria
- urea >35 mmol/L or uraemic complications (pericarditis, encephalopathy)
- creatinine >400 µmol/L
- $K^+$  > 6.5 mmol/L or rapidly rising
- pulmonary oedema
- uncompensated metabolic acidosis (pH < 7.1)
- severe hyperthermia (>40°C)
- overdose with dialysable toxins

RRT relies on removal of unwanted solutes and water through a semi-permeable membrane. The techniques of intermittent haemodialysis (IHD; relying on diffusion) and continuous veno-veno haemofiltration (CVVH; based on convection; can be combined with dialysis) are widespread. CVVH modes are preferred in the UK for cardiovascular stability but there is lack of strong evidence comparing different modalities. The optimal dose of CVVH is controversial and currently 25–30 mL/kg/h are recommended unless dictated by specialized circumstances. Both IHD and CVVH require insertion of a large-bore double lumen venous catheter into a large central vein and some form of anticoagulation is required. The anticoagulant of choice is changing from a heparin-based to a citrate-based regime to further improve circuit lifespan and reduce bleeding risk.

### Gastrointestinal support and nutrition

Many patients are malnourished on admission to the ICU. This has a profound impact on their ability to withstand the physiological stresses of critical illness. Moreover, critical illness can directly affect gut function and contribute to an impaired nutritional balance. Malnutrition may lead to an increased risk of infection, poor wound healing and loss of muscle bulk. A thorough nutritional assessment on admission to identify high-risk patients and timely institution of nutritional support are therefore crucial to improve patient outcome. The surgeon has a key role in decision making regarding the initiation of feeding in the post-surgical patient. The decision of whether to start early enteral feeding, to delay feeding or to start parenteral nutrition is not straightforward.

The preferred route of nutritional support has been an area of great controversy. Enteral feeding often involves nasogastric or nasojejunal feeding tubes, frequently facilitated using prokinetics (metoclopramide and erythromycin). Parenteral nutrition is usually administered through a central vein and provides an alternative route in persistent gut failure. Both modalities are associated with a significant number of complications. At present, early enteral nutrition is the favoured approach as early parenteral nutrition does not confer clear patient benefits and has additional risks.<sup>13</sup> The role of nutritional supplements and immunonutrients such as glutamine and arginine remains controversial. Glycaemic control is now a cornerstone of good critical care practice. However, blood sugar targets have been relaxed (aim  $\leq 10$  mmol/L) due to the significant risk of

hypoglycaemia with the previously advocated intensive insulin therapy.<sup>14</sup>

### Neuromuscular considerations

A significant proportion of critically ill patients suffer from profound muscle weakness. In addition to distinct disease entities that may precipitate critical care admission (i.e. Guillain-Barré syndrome, myasthenia gravis), many patients acquire neuropathies, myopathies or a combination of both. These are often collectively described as intensive care unit-acquired weakness (ICUAW). Several factors play a contributing role, including muscle disuse atrophy, sepsis, multiple organ dysfunction syndrome, exposure to certain drugs (i.e. corticosteroids, neuromuscular blocking agents) and malnutrition. This is a common finding in patients who have survived a significant complication of surgery such as an anastomotic leak, these patients have often required multiple trips to theatre and received significant organ support. ICUAW may lead to significant delays in weaning from mechanical ventilation and discharge from ICU. Furthermore, patients are prone to developing muscle contractures. The role of early mobilization and regular and intensive physiotherapy is crucial in ameliorating the consequences of critical illness weakness.

### Sleep and delirium

Critical illness is often associated with profound disturbance in the patient's natural sleep-wake cycle. The ideal situation of daytime wakefulness and night time rest is difficult to achieve on the ICU. Contributing factors are the underlying disease process, medication side effects, frequent interventions, pain, mechanical organ support, and high noise and lighting levels. Efforts to minimize the detrimental effects of sleep disturbance therefore focus on minimizing the above risk factors and promoting sleep hygiene by re-establishing a normal circadian rhythm. Furthermore, pharmacological efforts including sedation breaks, analgesia-based sedation regimes and melatonin are being used in some units. Awareness of psychological aspects of critical illness and recovery can improve the patient and relative experience, and the return to function after discharge.

Delirium is an acute and fluctuating confusional state, with features of inattention and disorganized thinking. It affects up to 69% of ventilated patients, is frequently under-recognized (especially hypoactive delirium), and is an independent predictor of mortality. Consequently, daily delirium-screening assessments such as the CAM-ICU are now advocated.

Risk factors for postoperative delirium include age, existing cognitive impairment, depression, sensory impairment, medical co-morbidity and psychotropic drug use. Precipitating factors for postoperative delirium include surgery, critical care admission, polypharmacy (including sedatives, benzodiazepines and opiates), infection, hypoxia, dehydration, poor nutritional status, metabolic derangement, pain, constipation and sleep deprivation.<sup>15</sup> The development of delirium in the post-surgical patient requires careful assessment as this may be the first sign of a complication of surgery such as an anastomotic leak or the development of a postoperative pneumonia. A high index of suspicion is required in patients with a hypoactive delirium as the presentation is more subtle than the hyperactive delirium

patient with agitation. Management depends on the type (hyperactive, hypoactive or mixed) and comprises treatment of the underlying cause, avoidance of precipitants, reassurance for the patient as well as judicious and targeted pharmacological intervention to ensure the patient and staff remain safe.

### Further critical care considerations

Critical care is a multidisciplinary endeavour. In addition to the resident critical care staff, there is invaluable input from many specialties including physiotherapy, pharmacy, nutrition, microbiology, radiology, psychology, and speech and language teams.

### Infection control

Critically ill patients are at increased risk of acquiring infections with multi-resistant organisms. The prevalence of these ‘super bugs’ is often specific to the country, hospital or individual critical care unit. Antimicrobial stewardship is a major part of day-to-day management of the critically ill patient. In surgical patients it is important to ensure that appropriate prophylaxis is given intraoperatively but also that postoperative antibiotics are only prescribed in accordance with the principles of good antibiotic stewardship based on the best available evidence.

Effective infection control needs to focus on prevention, screening and avoidance of cross-contamination. As a visiting team to the intensive care unit, it is important to follow the local protocols such as appropriate personal protective equipment (PPE) when examining patients. Most measures are similar to other hospital wards but specific measures on critical care units include:

- selective gut decontamination in ventilated patients
- isolation of contagious patients
- frequent microbiology input to rationalize antibiotic use
- meticulous attention to asepsis on insertion and handling of invasive lines.

The Matching Michigan initiative aims to reduce central venous line infection rates and is founded on strong evidence that strict asepsis can lead to a significant reduction in mortality.<sup>16</sup>

### End-of-life care

Inevitably, a proportion of patients will die on the ICU from their underlying illness. Recent UK figures suggest a critical care unit mortality of around 13% in general ICUs but this will vary depending on case mix.<sup>2</sup> Prognostication is imperfect; therefore, the intended benefits of continued treatment need to be balanced against the potential burden for the patient. Once it becomes apparent that escalation or continuation of treatment is not in the patient’s best interest, decisions on limitation or withholding of life-sustaining therapy are required. Often, patients are not able to directly express their wishes. Therefore, this decision rests on the critical care and parent specialty team. Respectful discussions with the patient, when possible, and family are essential in this process. If withdrawal of ongoing active treatment is deemed appropriate, the main focus becomes palliative, addressing symptom relief, comfort and dignity at the end of life.

### Organ donation

An international shortage of organ donors necessitates consideration of organ donation in all dying critical care patients. Two different pathways are recognized in the UK: donation after circulatory death (DCD) and donation after brain death (DBD). The latter requires a process of formal brain-stem death testing for diagnosis. Some countries routinely supplement this with ancillary testing (imaging of cerebral blood flow or electroencephalographic response to external stimuli). Early physiological stabilization and donor optimization improves transplant outcomes after DBD. Dedicated organ donation teams can facilitate this process, help to support the donor’s family and coordinate retrieval of organs by the receiving teams.

### Critical care in 2020: COVID-19

It is hard to understate the impact of the COVID-19 pandemic on intensive care medicine.

Ventilatory support is the most common indication for critical care admission in COVID-19 with approximately 75% of admitted patients requiring advanced respiratory support which may be prolonged.<sup>17</sup> Patients receiving critical care with a diagnosis of COVID-19 in England, Wales and Northern Ireland have an approximately 39% mortality.<sup>17</sup>

Current practice is best supportive care with basic and advanced ventilatory support as required; treatment of any co-existing bacterial infection; strict fluid management to avoid lung injury; thromboprophylaxis; and adherence to infection control. To date, only dexamethasone has been shown to reduce mortality in patients with severe respiratory complications of COVID-19.<sup>18</sup>

The associated pro-coagulant state found in COVID-19 makes complications such as venous thromboembolism and ischaemic stroke more common in this patient group and may be the reason for intensive care admission.

Elective surgical patients who develop symptomatic COVID-19 are at increased mortality risk and have higher rates of pulmonary complications.<sup>19</sup> ◆

### Practice points

- Intensive care medicine is the provision of advanced organ support and monitoring to patients who are critically ill or at high risk of deterioration
- Surgeons should be aware of the principles of intensive care medicine to understand the progress of their own patients, but also as they may be asked to assist in the management of surgical complications of critical illness
- A multidisciplinary approach is essential, from admission through to rehabilitation following discharge
- Morbidity from critical illness is high, so when considering intensive care admission careful thought must be given to the best interests of the patient



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