Chapter 27

Musculoskeletal considerations in Critical Care

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Aim

This aim of this chapter is to provide an evidenced-based understanding of both primary and secondary musculoskeletal complications experienced by patients in critical care.

Learning outcomes

1. Understand the varying nature, mechanism, presentation, and management of traumatic injury.
2. Describe how to carry out a comprehensive assessment of musculoskeletal injury or impairment.
3. Recognise the complex nature of intensive care unit-acquired weakness (ICUAW), its management, and persistent functional impact.
4. Describe the physiological assessment necessary to determine appropriateness for early mobilisation, understanding precautions and relative contraindications.

Test your knowledge

1. How is major trauma defined and how is severity of injury determined?
2. What is damage-control surgery and why is it commonly used in the management of major trauma?
3. Why is physical and functional impairment after critical illness often associated with poor quality of life?

4. Can you describe some of the pathophysiological processes that lead to ICUAW?
5. What are some of the key physiogical considerations when determining safety and appropriateness to mobilise?

Introduction

Chapter 27 explores musculoskeletal considerations for patients in critical care. Musculoskeletal injury can either be primary in nature, and the reason for admission (i.e., in the event of traumatic injury), or a secondary effect of critical illness and its management. All healthcare practitioners in critical care should have an understanding of musculoskeletal anatomy and physiology, and be able to assess for and recognise impairment. Musculoskeletal impairment can prolong rehabilitation and recovery, and potentially lead to longer term functional disability. This chapter will explore the mechanisms and management of traumatic injury, the pathophysiology and assessment of ICUAW, and provide an evidence-based overview of assessment for early mobilisation.

Trauma

Major trauma is defined as an injury or combination of injuries that is life-threatening and has the potential to cause long-term disability (National Institute for Health and Care Excellence [NICE], 2016). The majority of people suffering major trauma will require critical care for advanced monitoring and management, the primary principles of which are to restore homeostasis, continue resuscitation and monitor closely for potential complications (Tisherman and Stein, 2018). Severity of traumatic injury is graded using the Abbreviated Injury Scale (AIS); a severity scoring system which uses an ordinal scale to classify each injury in every body region according to relative importance (Table 27.1).

1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximum (Currently untreatable)

Table 27.1 – The Abbreviated Injury Scale (AACM, 2020)

The majority of patients suffering major trauma will be cared for in a specialist trauma critical are unit within a Major Trauma Centre (MTC), patients with less severe injuries may be managed in a non-specialist critical care unit.

6 Cs - Courage is essential when discussing life-changing trauma with patients. Honesty is key.

Mechanism of injury

Major trauma is the largest cause of mortality in adults under 45 years. In these cases, the overwhelming mechanism of injury is high impact, such as in the case of road traffic collisions. Although major trauma was previously associated with the younger population, Kehoe *et al.* (2015) recently demonstrated that the majority of patients suffering major trauma in the UK are over the age of 50. Adults aged 60 years and over account for more than 50% of severely injured patients admitted to critical care. Currently, the most predominant mechanism of injury resulting in major trauma in the UK is a low-energy fall (TARN, 2017). Regardless of the type or severity of injury, older patients suffer more complications and have higher mortality risk than their younger counterparts (Gillies, 1999; TARN, 2017). Trauma in the over 75 age group is often referred to as ‘Silver Trauma’.

Musculoskeletal injury

Musculoskeletal injuries are the most common reason for surgery in severely injured patients following trauma, with more than 70% of patients requiring at least one orthopaedic operative procedure (Balogh *et al.*, 2012). Injury to limbs may result in nerve injuries, vascular injuries or muscle damage (Singer & Webb, 2013). Fractures are often defined by the amount of damage to the soft tissue around the bone. When a fracture is associated with an open wound, it is termed an ‘open’ or ‘compound‘ fracture. An open fracture associated with significant soft tissue damage, wound contamination and a high risk of infection and further complications. With a closed fracture, there is no penetration of protrusion of the bone through the skin. It is important to recognise that a closed fracture may be still be complex in nature, with associated damage to the surrounding soft and connective tissue. Musculoskeletal injury is commonly associated reduced functional outcome and reduced quality of life and persistent pain (Gabbe *et al.*, 2012).

A crush injury to skeletal muscle can cause the direct release of intracellular muscle components, such as myoglobin, creatine kinase, lactate dehydrogenase and electrolytes in the bloodstream (Torres *et al.*, 2015). This destruction of skeletal muscle tissue and release of enzymatic content is known as rhabdomyolysis. It can lead to systemic complications, most notable acute kidney injury (AKI) (Chavez *et al.*, 2016). Refer to chapter 24 for further discussion about the renal complications associated with rhabdomyolysis.

Pelvic injury

High impact injury often results in complex pelvic trauma, which has one of the highest associated mortality rates of skeletal injury (Coccolini *et al.*, 2017). The pelvis is rich in blood supply, so traumatic injury can lead to haemorrhage, caused by damage to internal organs and blood vessels. In severe pelvic injury, the application of a non-invasive external pelvic compression, in the form of a pelvic binder or a circumferential sheet, is required to temporarily stabilise the pelvis and reduce bleeding (Weaver and Heng, 2015; Coccolini *et al.*, 2017). This should not be removed without the documented consent of the appropriate specialist team. External-fixation may be used to stabilise the pelvis in the presence of haemodynamic instability.

The severity of the pelvic injury and the respective operative or non-operative management will often dictate the approach to mobilisation. In some cases, a period of bed rest may be required, in others, weight-bearing and mobilisation within pain limitations may be advocated (Van Aswegen, 2016).

Chest trauma

Chest trauma is highly associated with mortality and morbidity. Injuries to the chest wall can result in complications including pneumonia, haemothorax, pulmonary contusion and chronic pain. The main objective of chest trauma care in critical care is to reduce pain and promote pulmonary hygiene, limit secondary respiratory complications, and monitor closely for signs of deterioration.

Recent studies have focused on the implementation of multi-disciplinary integrated ‘bundles or pathways of care in order to prevent complications, and recognise and treat deteriorations quickly (Curtis, 2016; Kelley, 2019; Todd, 2006). Pathways include early and optimal analgesia, often employing the use of regional anaesthetic techniques; respiratory adjuncts such as CPAP, NIV or HFNC; early recognition of deterioration using screening for patients at risk and/or target inspiratory capacity measurements; and complication prevention including surgical fixation, early mobilisation and intensive physiotherapy (Battle, Hutchings and Evans, 2013).

6Cs - If people remember not what you say to them, but how you made them feel, then **compassion** is essential for all healthcare professionals.

Management of traumatic injury

The management of a patient who has suffered major trauma will differ depending on the mechanism of injury, injuries sustained, and the teams involved in the operative/non-operative management. The concept of damage-control orthopaedics uses little operative intervention until the patient is physiologically stable enough to undergo definitive fixation (Balogh *et al.*, 2012; Van Aswegen, 2016).

Red flag – Spinal injury/instability

It is unsafe to mobilise a patient with spinal injury prior to confirmation of stability, or surgical fixation. Depending on the mechanism of injury and individual's symptoms, it may be necessary to carry out full in-line spine immobilisation (NICE 2016).

External fixation

External fixation is commonly used in the management of traumatic limb injuries or pelvic injuries to provide rapid, stable fixation when a patient is not physiologically stable enough to tolerate a more invasive surgical procedure (Pacheco and Saleh, 2004; Balogh *et al.*, 2012). This can be particularly common in the presence of polytrauma, or in the case of severe intra-articular or open fractures. Metal pins or wires are placed into the bone and are then attached to an external frame of bar outside of the skin, allowing for the segments of the fracture to be held in a desirable position. The sites where the pins or wires enter the skin are called pin sites. Pin sites should be cleaned regularly, and closely monitored for signs of infection (Timms and Pugh, 2012; Walker, 2018).

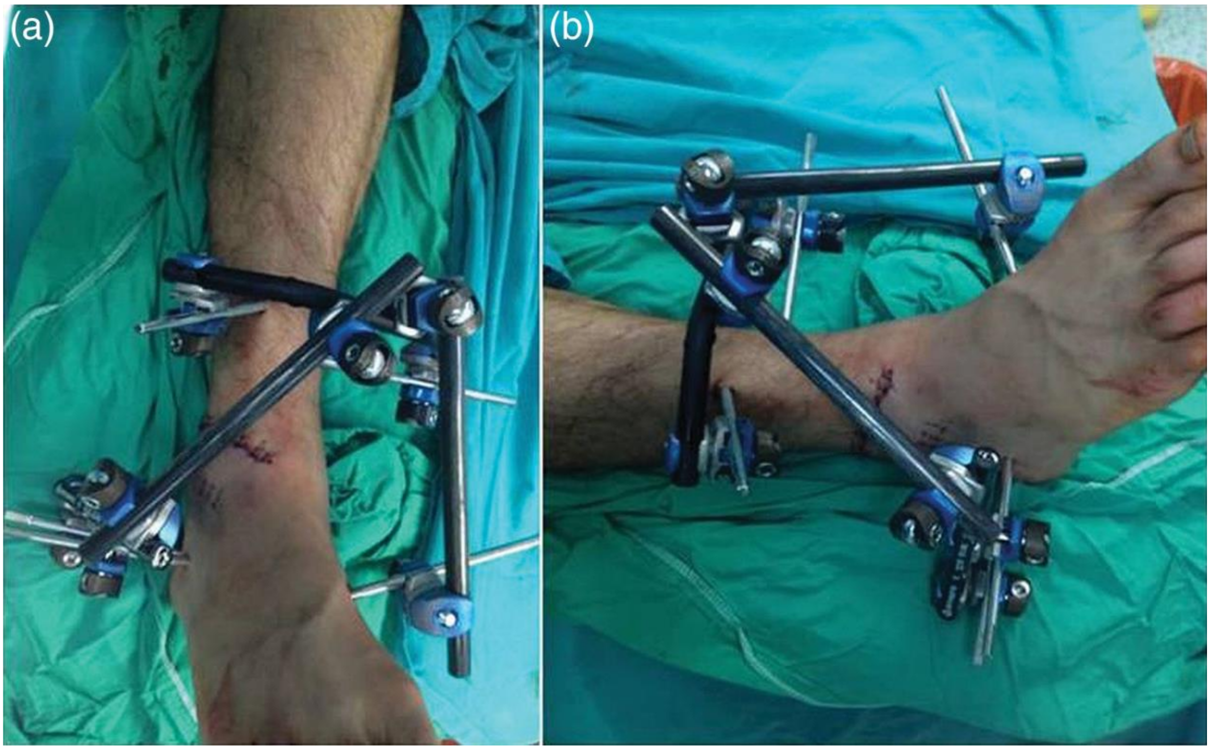


Figure 27.1 – Wiley Source - https://onlinelibrary.wiley.com/doi/10.1111/os.12292

Surgical fixation

Once a patient is physiologically stable, definitive care may involve surgical fixation of fractures and/or soft tissue injuries. This will often consist of open reduction and internal fixation (ORIF), to realign the bone and insert hardware, like plates, screws, or an intra-medullar (IM) rod to hold the realigned bone together. Post-operative complications may include infection, pain, and limb compartment syndrome.

Conservative management

In some cases, fractures may be managed conservatively (or ‘non-operatively’). This can often be the case in non-displaced upper limb fractures such as clavicle or humeral fractures), foot or ankle fractures, or stable pelvic fractures. In these cases, it is important for all members of the multi-disciplinary team have a clear understanding of the management plan as set out by the responsible orthopaedic team. This may include a period of joint or limb immobilisation in a cast, splint or sling; physiotherapy and progressive rehabilitation; or mobilisation and provision of walking aid to facilitate preferred load-bearing status. It is important to recognise that any form of reduced weight-bearing can increase energy expenditure during ambulation when compared to the non-injured, healthy population (Hoyt *et al.*, 2015). This should be taken into consideration when considering appropriateness to mobilise (Table 27.2)

FWB	Full weight-bearing	100% of body weight as pain allows
PWB	Partial weight-bearing	30-50% of body weight
TTWB	Toe-touch weight-bearing	20% of body weight
NWB	Non-weight bearing	No weight

Table 27.2 – Load-bearing equivalent of common weight-bearing terms (Thompson, Phillip and Roberts, 2018)

Trauma Competencies

T6a – Musculoskeletal Injuries and Compartment Syndrome (National Major Trauma Nursing Group (NMTNG), 2017)

Undertake in a safe and professional manner:

- Care and management of the patient with skin and/or skeletal traction
- Care and management of the patient with external fixation including pin site care and documentation
- Care, management and removal of a pelvic binder (application and skin care)
- Care and management of the patient with plaster of Paris
- Care and management of the patient with splints

6 Cs – Assess your own **competence** against the competencies in this chapter. If you are unsure, discuss them with your mentor.

Snapshot - Polytrauma

Alice is a 45-year-old woman, admitted to hospital 2 days ago, following an RTC. She has fractures to her left acetabulum, patella, shaft of tibia, and sternum. She also sustained abdominal bruising under her seatbelt, and splenic laceration. The orthopaedic trauma surgeons performed an ORIF of her acetabulum and stabilised the tibial shaft fracture with intramedullary (IM) nail. Her sternal and patella fractures, and splenic laceration are being managed conservatively.

Airway (A): Patent.
Breathing (B): SpO_2 95% (NEWS2 = 0), on 40% oxygen, with 40L flow, via HFNC (NEWS2 = 2), respiratory rate (RR) 29 breaths per minute (NEWS2 = 3).
Cardiovascular System (C): Blood Pressure (BP) is 115/85 (NEWS2 = 0), Heart Rate (HR) is 102 beats per minute (NEWS2 = 1), warm peripheries.
Disability (D) Patient is Alert (NEWS2 = 0). Temperature is 37.6^{O}C
Exposure (E) Sitting up in bed, pain at rest is documented as 6/10.

Total NEWS2 Score: 6

Actions:

- Clarify location and type of pain with Alice.
- Check prescribed analgesia, offer PRN analgesia if able.
- Check orthopaedic post-operative instructions for pelvic ORIF and tibial IM nail
- Check management instructions for splenic laceration – has bed rest been recommended?
- Perform neurovascular observations, with particular focus on left foot.

Diagnosis:

- Alice’s main source of pain is around her pelvis, and the site of her acetabular ORIF.

- She has PRN opiate analgesia prescribed, and her pain at rest reduces to 2/10 on a numerical pain rating scale, 20 minutes after liquid morphine (oramorph).
- The orthopaedic post-operative instructions for the tibial nail are to ‘weight bear as tolerated’, but for the pelvic ORIF to ‘toe-touch weight bear on left’.
- The general surgeons have not requested any limitation in mobility in their non-operative management of Alice’s splenic injury.

Snapshot – Silver Trauma

Mohammed is a 78-year-old retired GP. He tripped whilst out walking, and admitted to hospital via A+E. His medical history includes hypertension. His CT scan showed undisplaced fractures to his 6^{th}, 7^{th}, 8^{th} and 9^{th} ribs on the left side. After initial admission to the trauma ward, the nursing staff on this ward requested an urgent medical review due to his NEWS2 score of 9. He has been transferred to the HDU for observation, pain management, and respiratory support as required.

A (airway): Own
B (breathing): Self ventilating on 4L nasal cannula (NEWS2 =2). SpO2 93% (NEWS2 = 2), RR35 (NEWS2 = 3), able to talk in short sentences only.
C (cardiovascular): Unsupported. HR 110 (NEWS2 = 2), BP 150/85
D (disability – neurological status): Alert and orientated. Temperature 37.
E (exposure – everything else): Sitting slumped in bed, reports 9/10 pain on inspiration.

NEWS2 = 9

Actions required:

- Urgent review by the medical team and/or pain team. Assessment for possible regional anaesthesia.
- Escalation of respiratory support to achieve target SpO_2 of 94-98%
- Complete any blunt chest trauma assessments used in your hospital. Some hospitals measure inspiratory capacity.
- Monitor vital signs closely. Tachycardia, tachypnoea, and low oxygen saturations may further deteriorate whilst pain remains severe.
- Discuss Mohammed's care with him – does he understand why he has been admitted to HDU, what the current plan of treatment is, and why? Remember to use language and detail appropriate to his level of understanding.
- Report and document findings

Intensive Care Unit Acquired Weakness

Muscle weakness remains one of most commonly reported complications of critical illness. Acquired muscle weakness can lead to delayed recovery, increased post-critical care dependency and disability, increased morbidity and decreased quality of life for critical illness survivors (Herridge *et al.*, 2011; Hermans and Van den Berghe, 2015). Although there are primary neuromuscular disorders that can trigger profound muscle weakness, leading to the need for critical care intervention, the overwhelming majority of muscle weakness suffered by those in critical care develops as a secondary disorder while they are being treated for their critical illness (Vanhorebeek, Latronico and Van den Berghe, 2020). Studies have shown an average of 45% (range 25-70%) of critically unwell patients can develop muscle weakness of a result of their critical illness (Puthucheary *et al.*, 2013).

Differential conditions that can be the cause weakness in critical care patients	
Rhabdomyolysis	
ICUAW	
Guillain-Barré	
Myasthenia Gravis	
Spinal Cord Injury	

The pathophysiology by which this muscle weakness occurs is still not fully understood, but there are processes that are known to contribute. Severe muscle atrophy and weakness can occur due to critical illness myopathy (CIM), critical illness polyneuropathy (CIP) or a combination of both, known as critical illness neuromyopathy (CINM) (Hermans and Van den Berghe, 2015). Differentiating between neurogenic dysfunction (dysfunction originating from the disturbance of the nervous system) and myogenic dysfunction (dysfunction originating from the disturbance of the skeletal muscle) often involves complex or invasive electrodiagnostic or histological testing. For this reason, generalised muscle weakness that occurs in critical illness is often referred to under the umbrella term Intensive Care Unit-Acquired Weakness, or ICUAW.

Pathophysiology

Most ICUAW is myogenic in origin (CIM) and occurs due to dysfunction in muscle protein homeostasis, skeletal muscle inflammation and mitochondrial dysfunction. Critical illness polyneuropathy (CIP) occurs less frequently but is associated with slower functional recovery than myopathy. CIP is caused by injury to the neuron and axonal degeneration, believed to be caused by dysfunctional microcirculation. In addition to specific polyneuropathies and myopathies that occur within the process of critical illness, other variables such as drug effects, metabolic affects and disuse atrophy due to reduced physical activity can also contribute to ICUAW (Kress and Hall, 2014).

Medications management – Neuromuscular blocking agents (NMBAs)

Also called paralysing agents. The most common paralysing agents used in critical care are non-depolarizing NMBAs. These act as competitive acetylcholine antagonists at the neuromuscular junction, examples include rocuronium, atracurium, and vecuronium. Accepted best clinical practice is to achieve deep sedation prior to and during neuromuscular blockade.

Muscle protein homeostasis

Critical illness is a complex metabolic state, characterised mostly by hypermetabolism due to a profound physiological stress. Physiological stress results in an increased release of catabolic hormones and a reduction in anabolic hormones. This net catabolic state leads to an increased rate of muscle protein (Puthucheary *et al.*, 2013) breakdown, and a depletion of protein reserves within the skeletal muscle, leading to rapid loss of muscle mass early on within the period of critical illness (van Gassel, Baggerman and van de Poll, 2020). The rate of muscle breakdown is known to correlate with the severity of critical illness and multi-organ dysfunction (Puthucheary *et al.*, 2013)

Skeletal muscle inflammation and structural disorganisation

Higher levels of circulating inflammatory markers are associated with marked decrease in muscle strength and mass (Tuttle, Thang & Majer 2020). Muscle biopsies from critically unwell patients have demonstrated inflammation, cellular infiltrates and necrosis on day 7 of critical illness (Puthucheary *et al.*, 2013).

Bioenergetic disturbance

Mitochondrial dysfunction in skeletal muscle is a recognised complication of sepsis and multiorgan failure (Arulkumaran *et al.*, 2016). Altered mitochondrial function is likely to compromise ATP production, and thus the ability to generate energy required for muscle contraction and force generation. Immobilisation also results in decreased mitochondrial efficiency (Bear, Parry and Puthucheary, 2017).

Disuse atrophy

Although not the primary cause of ICUAW, disuse atrophy due to immobilisation, can exacerbate the skeletal muscle degradation that occurs due to the complex pathophysiological processes outline above. The musculoskeletal effects of 'bed rest' and physical inactivity, outside of the context of critical illness are well recognised. Immobilisation and disuse results in an overall reduction in muscle mass, a reduction in muscle fibre size and a reduction in type II muscle fibres compared with type I muscle fibres (Parry and Puthucheary, 2015). This results in a reduced force-generating capacity and overall reduction in muscle strength.

Axonal degeneration

The mechanisms of axonal degeneration leading to CIP is not completely understood. It is suggested that disruption to microcirculation, and microvascular changes in the endoneurium caused by sepsis, lead to axonal degeneration and neuronal injury in critical illness polyneuropathy. This can be exacerbated by hyperglycaemia (Kress and Hall, 2014; Hermans and Van den Berghe, 2015).

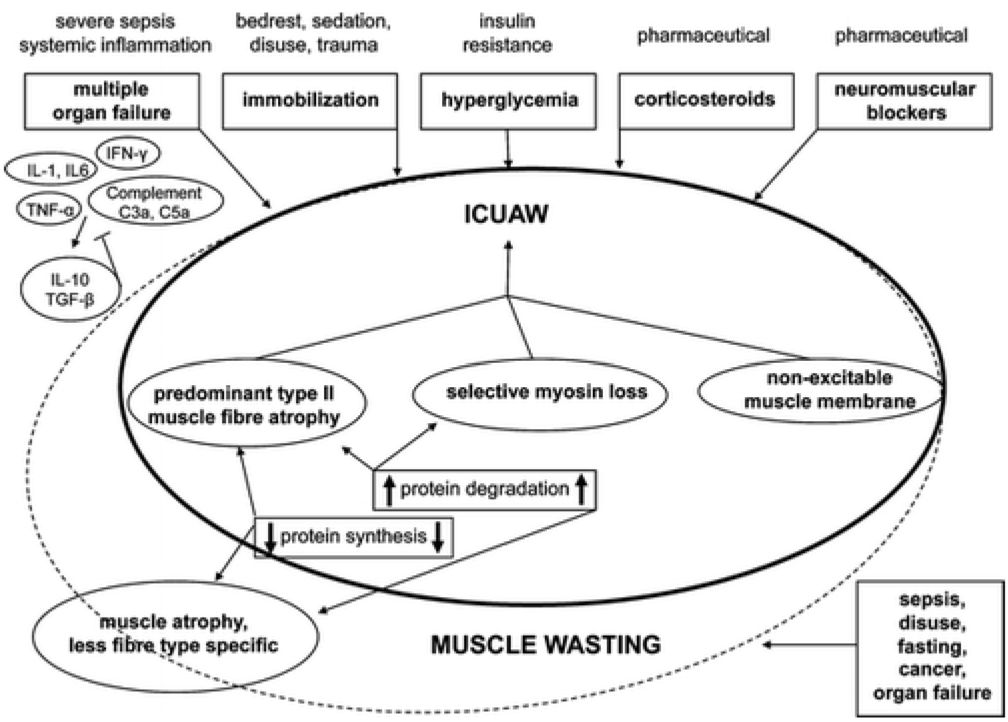


Fig 27.2 – Pathophysiological processes and risk factors in ICUAW (Schefold, Bierbrauer and Weber-Carstens, 2010) – Wiley Source - https://onlinelibrary.wiley.com/doi/10.1007/s13539-010-0010-6

Clinical Presentation

ICUAW typically presents as generalised, symmetrical weakness, which affects the limbs and respiratory muscles. Facial and ocular muscles are often spared. Proximal limb muscles are usually more affected than distal limb muscles which can often impact on joint stability in joints such as the shoulders and hips. Anti-gravity muscles, such as the quadriceps muscles, gluteal muscles and erector spinae muscles, are often most affected, leading to functional dysfunction in sitting, standing and walking. Tendon reflexes are generally reduced, although these are not often assessed at the bedside. Patients with CIP may present with altered or impaired sensation, although this is often difficult to assess in the critically unwell patient.

Prolonged weaning from mechanical ventilation is often a complication of ICUAW, due to atrophy of the diaphragm and respiratory muscles. Peak cough flow (PCF) and the ability to clear secretions effectively can be compromised due to reduced strength in the abdominal muscles.

Diagnosis and assessment of ICUAW

ICUAW is diagnosed with the use of the Medical Research Council (MRC), whereby a sum score of less than 48 is indicative of ICUAW.

Examination Scenario – The MRC Sum Score

The MRC sum score (MRC-SS) is made up of 12 measurements of strength, 6 on each side of the body (3 in the upper limb, and 3 in the lower limb).

The MRC grading scale is used assess each movement listed below, and the 12 scores are added together. The MRC-SS has a minimum score of 0, and maximum of 60.

1. Shoulder abduction
2. Forearm flexion
3. Wrist extension
4. Hip flexion
5. Knee extension
6. Ankle dorsiflexion

Procedure:

Assess each movement on both the left and right sides, grading them out of 5 using the MRC scale (Fig 27.2). Add the 12 measurements together to give the MRC-SS.

Learning event – reflection

Reflect on the differences between the pathophysiology and management of primary injury to the musculoskeletal system (trauma), versus injury to the musculoskeletal system secondary to critical illness (ICUAW).

Assessment of musculoskeletal impairment or injury

Assessment of musculoskeletal injury or impairment will need to be specific to the patient and how they are presenting. This is likely to include joint range of motion, muscle power and pain. In the presence of traumatic injury, neurovascular observations are also recommended.

Joint range of motion

Joint range of motion (ROM) refers to the distance and direction a joint can move. The movement that is available at any joint is determined by the articulating surfaces of the joint, the type of joint and the movement allowed for by the regional muscles, ligaments and the joint capsule. Active movement at the joint is created by muscle contraction, whilst ligaments and joint capsules exist to limit excessive movement at a joint. Each joint has an available ROM, expressed in degrees, and moves through specific planes of movement (Muscolino, 2016).

Separate assessment of passive ROM and active ROM should take place. Passive ROM assessment determines the available range that the joint can be taken through passively, by an applied external force, such as a therapist. Passive ROM of a joint can be limited by swelling, surrounding capsular and ligamentous structures, shortened muscles or connective tissue. Active ROM is determined by the contraction of the agonist muscle creating a force on the bones of a joint. Active ROM is often limited by muscle weakness, muscle imbalance and pain.

Muscle Power

In critical care, manual muscle testing usually follows the Medical Research Council (MRC) system as in Fig 27.2.

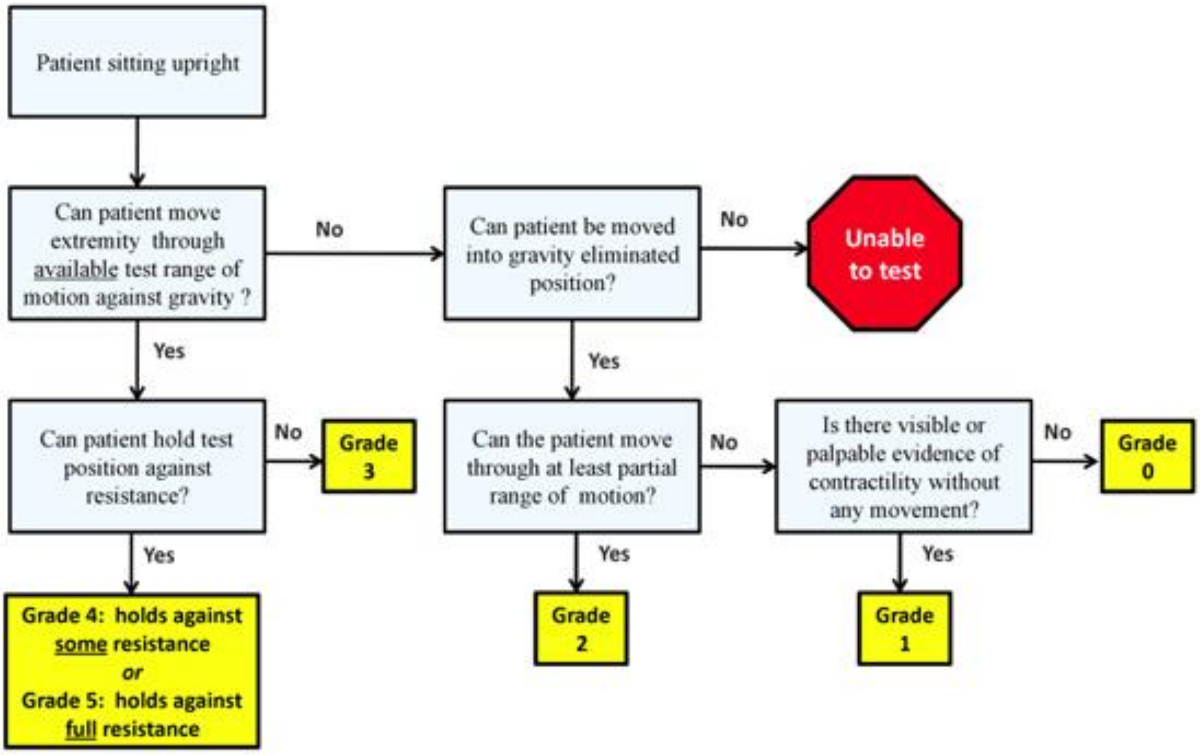


Fig 27.2 – Manual Muscle Testing algorithm (From Ciesla *et al*. (2011)) – Copyright permissions requested, awaiting response.

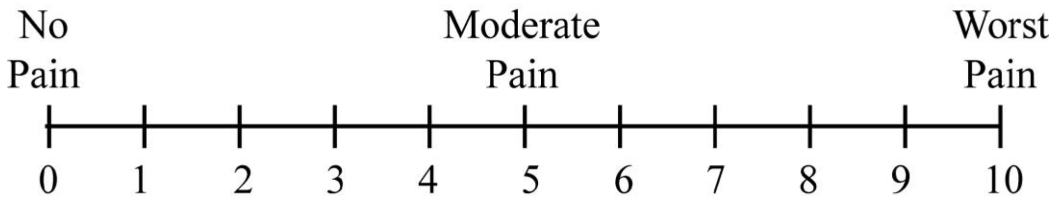
Clinical Investigations – MRC scale	
MRC Grade	**Muscle state**
0	No contraction
1	Flicker of contraction
2	Active movement with gravity eliminated
3	Active movement against gravity
4	Active movement against gravity and resistance
5	Normal power

Pain

Musculoskeletal injury is commonly accompanied by pain, both at rest and particularly with movement. Assessment and management of pain is particularly important when passively moving or engaging a patient in active mobilisation. Pain intensity can be assessed using a number of simple tools. The Numerical Rating Scale (NRS) is commonly used with alert patients in the critical care unit. Patients are asked to identify a number which best fits their pain intensity, usually on a scale of 0 and 10 (Haefeli and Elfering, 2006).

In patients who are unable to self-report their pain, due to reduced consciousness, sedation and intubation, the Critical Care Pain Observation Tool (CPOT) can be used to assess pain (Severgnini *et al.*, 2016).

Clinical Investigations – Numerical Rating Scale



Medications management - Analgesia

Effective pain management is essential for all critical care patients, but particularly important to consider prior to mobilisation. Opioid agonists, such as morphine or fentanyl, are commonly used analgesics on critical care. Morphine can be prescribed orally, intravenously (IV), intramuscularly (IM), subcutaneously, rectally, intrathecally or rectally. Fentanyl can only be given IV.

Neurovascular assessment

It is crucial that neurovascular assessment is undertaken for patients admitted to the critical care unit following musculoskeletal trauma, orthopaedic surgery (both internal and external fixation) or crush injury (Johnston-Walker and Hardcastle, 2011). Neurovascular assessment is performed to evaluate the sensory and motor function of a limb and the peripheral circulate to allow for the early identification of neurovascular compromise or impairment (Schreiber, 2016). Healthcare professionals managing trauma patients should be competent in carrying out a neurovascular assessment and in recognising impairment or early signs of acute compartment syndrome. The Royal College of Nursing (2014) emphasise that of the neurovascular observations, pain is deemed the most important indicator of compartment syndrome, particularly pain experienced on passive stretch of the muscle group affected, or that is out of proportion to the injury.

Examination Scenario – Neurovascular observations.

Neurovascular observation of limb extremities is essential, particularly in the case of long bone injury, or in the presence of any risk factors for compartment syndrome. When completing a neurovascular examination, it can be helpful to think of the ‘6 Ps’:

1. Pain
2. Poikilothermia (cool Peripheries)
3. Paraesthesia
4. Paralysis
5. Pulselessness
6. Pallor

When completing neurovascular observations, remember that compromise could be caused by one or more pathophysiological mechanisms. These include acute compartment syndrome, cellulitis, deep vein thrombosis, neuropraxia, or peripheral arterial injuries (Donaldson, Haddad and Khan, 2014). Use the findings of the neurovascular examination as part of a holistic assessment to narrow down a differential diagnosis.

Management of Musculoskeletal Injury and Impairment

Joint positioning and passive movements

Positioning of the critical care patient should aim to reduce risk of joint damage and contracture. Joint contracture is a limitation in the passive range of motion, secondary to shortening of the connective tissues and muscle. It commonly occurs when a muscle is immobilised in a shortened position (Farmer and James, 2001). Periods of prolonged immobility often associated with severe critical illness predispose patients to joint contractures, which can persist after the critical illness has resolved, and have functional implications (Clavet *et al.*, 2008). Joint position should aim to maintain the natural alignment of the limbs wherever possible, using pillows, splints or specialist equipment as indicated (Griffiths and Gallimore, 2005; Christie, 2008). Care should particularly be shown in the handling and positioning of shoulders, especially within the context of ICUAW. Gustafson *et al.* (2018) demonstrated high prevalence of shoulder impairment and subsequent upper limb dysfunction 3-6 months post ICU discharge. They recognise that the rapid loss of muscle mass in ICUAW is likely to place the glenohumeral joint at risk of increased instability. Handling and positioning of the shoulder should be performed in a way which does not place the joint at risk of repetitive subluxation.

It is recommended that passive joint movements, through full available range of motion, are carried out daily to assess for joint contractures or changes in muscle tone in the unconscious patient (Sommers *et al.*, 2015). It may be judicious to avoid full shoulder flexion or abduction past 100-120° with a patient in supine, due to restricted scapular movement.

Orange flag – Psychological distress

Acute distress is common among critical care patients. The environment, sleep deprivation, discomfort, isolation from friends and family, inability to participate in work or leisure activities, and worry about their own health can all contribute.

This distress may present differently in different individuals, perhaps as low mood, or anxiety. Its presence can make it difficult for an individual to engage in physical rehabilitation.

Early mobilisation

Early mobilisation is a key component of an evidence-based approach to optimise ICU patients' recovery and outcomes.

6Cs - Healthcare professionals must be **committed** to their own continuing professional development. Ensure you are up to date with your knowledge and understanding**.**

Physiological assessment for mobilisation

When considering how appropriate it is to commence a mobilisation intervention with a patient, it is important to first understand the physiological effects of activity and movement. This will allow you to make an informed decision as to the physiological stability of a patient and the safety of the intervention.

Red flag – Bleeding

Patients with known uncontrolled active bleeding should not be mobilised. Those with suspicion of active bleeding or increased bleeding risk may not be appropriate to mobilise, particularly if the risk of an adverse event such as a fall or line displacement is considered non-negligible.

Medications management – anticoagulation

Anticoagulant drugs commonly used in critical care include low molecular weight heparins (e.g., heparin, enoxaparin, tinzaparin); factor Xa inhibitors (e.g., rivaroxaban, fondaparinux, apixaban); or direct thrombin inhibitors (e.g., dabigatran).

Airway

The presence of an endotracheal tube does not, itself, contraindicate mobilisation. In fact, multiple research studies have attested to the safety and feasibility of early mobilisation of the intubated and ventilated patient (Clarissa *et al.*, 2019). Despite this it is still not routine practice in UK critical care units to mobilise patients on mechanical ventilation delivered via endotracheal tubes. This is less to do with the presence of the ETT per se, but because these patients are often less physiologically stable, and therefore unable to safely engage in physical activity.

When engaging any patient with an artificial airway in out-of-bed mobilisation, it is important that somebody has delegated responsibility for maintaining the safety of the airway. Length of ETT should be clearly noted prior to and after mobilisation to assess for any inadvertent displacement.

Breathing

Any active physical movement will increase cellular respiration within skeletal muscle, leading to an increase in partial pressure of carbon dioxide (pCO_2) in the blood. This increase in pCO_2 will cause the respiratory control centres in the hypothalamus to send signals to the respiratory muscles to increase the force of contraction, resulting in increased tidal volume and overall minute ventilation. Once the increase in tidal volume alone is not sufficient to meet the increased need to expire CO_2, the rate of breathing will also increase. It is key to note that many patients with ICUAW have respiratory muscle weakness and may have a reduced ability to generate sufficient muscle contraction to increase tidal volume adequately, leading to premature increase in respiratory rate. For this reason, if a patient already has an increased respiratory rate or work of breathing at rest, it may not be appropriate to engage in a mobilisation intervention which will increase their respiratory effort further.

An increase in cellular respiration within skeletal muscle will also increase oxygen (O_2) demand. If a patient is requiring a high concentration of supplemental oxygen at rest, i.e., in the presence of a pathology which causes a physiological shunt, they may not be able to supply a significant increased demand of oxygen at skeletal muscle tissue. In some instances, the cause of the physiological shunt (i.e. atelectasis or secretion retention) may respond favourably to mobilisation and positioning (Pathmanathan, Beaumont and Gratrix, 2015). In such cases, clear clinical reasoning, appropriate monitoring and ensuring adequate availability of supplementary oxygen in crucial. Liaison and joint assessment with other MDT specialists may be indicated.

Circulation

The cardiovascular response most commonly associated with increased physical activity is an increase in cardiac output to supply the increased demand of oxygen-rich blood at working skeletal muscle tissue. This manifests as an increase in both stroke volume and an increase in heart rate. Therefore, if a patient has a high resting heart rate it may be advisable to monitor the cardiovascular response to physical activity closely.

Red flag – Cardiovascular instability

This may present as extreme brady or tachycardia, such as HR < 50 or HR > 150; hypo or hypertension, most commonly assessed via a target range for either mean arterial pressure (MAP), or systolic pressure; some rhythm abnormalities, such as new or uncontrolled fast atrial fibrillation.

Any active mobilisation will place an increased demand on the cardiovascular system, at least temporarily, so instability at rest is likely to contraindicate active mobilisation.

A period of immobility is often associated with a reduction in normal orthostatic responses. This often manifests as orthostatic hypotension on changes of postural set on commencement of mobilisation. Assessment of mean arterial pressure (MAP), the amount of vasoactive support that is required to maintain adequate MAP and any associated symptoms is key prior to mobilisation intervention.

Medicines management – Treating hypotension

Medical management of blood pressure is complex, and optimal therapy depends on the pathological cause of hypo or hypertension.

Hypotension is commonly treated with one or more drugs that have a vasopressor or inotropic effect. These include pure vasopressors, such as phenylephrine and vasopressin; and inotropic vasopressors (‘inopressors’), such as noradrenaline and adrenaline.

Blood pressure increases during physical activity and exercise to provide oxygenated blood to skeletal muscle. In the event of a hypertensive crisis, or when patients are requiring intravenous antihypertensive therapy, the risks associated with exercise are likely to outweigh the benefits (Hodgson *et al.*, 2014).

Disability

Mobilisation and exercise should be avoided with the very agitated, combative or difficult to rouse patient. Ideally, sedation should be interrupted prior to engaging a patient in mobilisation or activity. As discussed previously, assessment of pain, muscle power, joint range and consideration of any limitation to movement or weight-bearing should be considered.

Orange flag – Delirium

Acute delirium is common in critical care. Delirium is frequently characterised by a disturbance in attention and awareness, disorientation, reduction in cognitive ability, and sometimes altered consciousness. These symptoms provide an obvious challenge for safe active mobilisation. However, delirium does not contraindicate mobilisation, and in fact mobilisation may help to reduce delirium.

Exposure/Environment

It is important to be aware of wounds and skin breakages to limit any potential further damage to vulnerable areas. Open surgical wounds (such as an open abdomen) may limit the ability to engage in mobilisation and should be discussed with the responsible surgeon.

There are few attachments that would limit engagement in early mobilisation intervention if physiological assessment deems it safe to proceed. It is, however, key to ensure that attachments are adequately secured and not put under undue tension. Risk assessment of attachments, including drains, intravenous therapies and monitoring devices; environment, including footwear and obstacles; and moving and handling, including competence and number or personnel should all be considered.

As there are no current internationally accepted physiological parameters that determine the safety of mobilisation in critical care, healthcare professionals should adhere to any locally published guidance which reflects the practices within their units. It is important to have regular discussions as a multi-disciplinary team to determine safety and readiness for mobility and physical rehabilitation interventions. Hodgson, *et al.* (2014) developed a Red-Amber-Green (RAG) rating system based on clinical expert consensus which healthcare professionals may find useful to aid in clinical decision-making (see Fig 27.3). These parameters are expert consensus-based guidance and should be used as such. They are not exhaustive, and do not replace the need for a comprehensive clinical assessment by one or more suitably qualified members of the ICU MDT prior to each mobilisation episode.

6 Cs Effective **communication** is a lynchpin of any MDT, for all pathways of care.

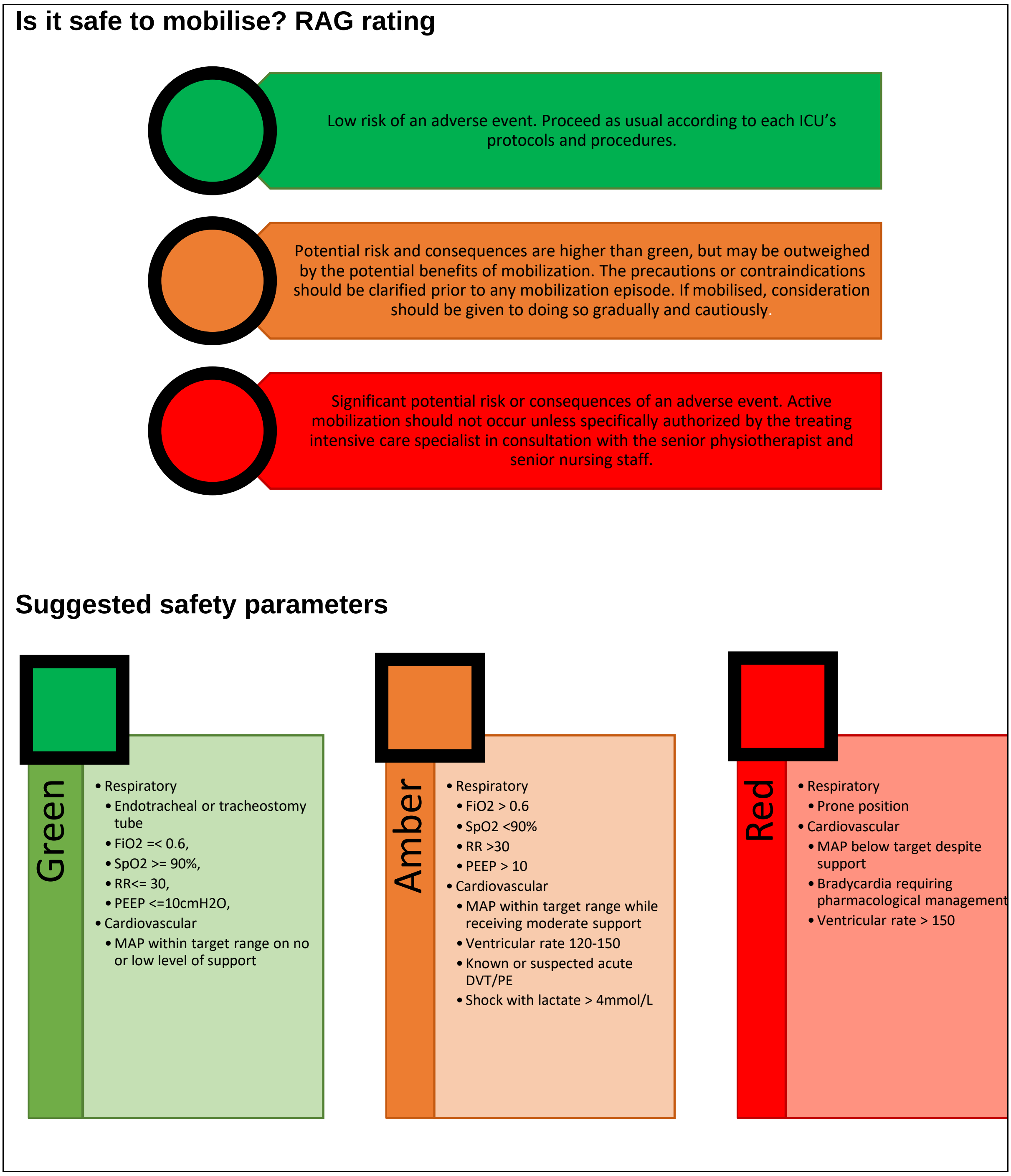


Fig 27.3 – Adapted by the permission from Springer Nature: Springer. Critical Care. *Expert consensus and recommendations on safety criteria for active mobilization of mechanically ventilated critically ill adults*, Hodgson *et al*., Copyright (2014)

Measuring mobility and function

Measuring physical function in the critical care unit is important to monitor the efficacy of rehabilitation interventions, document patients' progress and recovery and to identify patients at risk of poor physical outcomes (Parry et al, 2017). One simple and appropriate outcome measure is the ICU Mobility Scale, shown in Figure 27.4.

ICU Mobility Scale

	Classification	Definition
0	Nothing (lying in bed)	Passively rolled or passively exercised by staff, but not actively moving.
1	Sitting in bed, exercises in bed	Any activity in bed, including rolling, bridging, active exercises, cycle ergometry and active assisted exercises; not moving out of bed or over the edge of the bed.
2	Passively moved to chair (no standing)	Hoist, passive lift or slide transfer to the chair, with no standing or sitting on the edge of the bed.
3	Sitting over edge of bed	May be assisted by staff, but involves actively sitting over the side of the bed with some trunk control
4	Standing	Weight bearing through the feet in the standing position, with or without assistance. This may include use of a standing lifter device or tilt table.
5	Transferring bed to chair	Able to step or shuffle through standing to the chair. This involves actively transferring weight from one leg to another to move to the chair. If the patient has been stood with the assistance of a medical device, they must step to the chair (not included if the patient is wheeled in a standing lifter device).
6	Marching on spot (at bedside)	Able to walk on the spot by lifting alternate feet (must be able to step at least 4 times, twice on each foot), with or without assistance.
7	Walking with assistance of 2 or more people	Walking away from the bed/chair by at least 5 metres (5 yards) assisted by 2 or more people.
8	Walking with assistance of 1 person	Walking away from the bed/chair by at least 5 metres (5 yards) assisted by 1 person.
9	Walking independently with a gait aid	Walking away from the bed/chair by at least 5 metres (5 yards) with a gait aid, but no assistance from another person. In a wheelchair bound person, this activity level includes wheeling the chair independently 5 metres (5 yards) away from the bed/chair.
10	Walking independently without a gait aid	Walking away from the bed/chair by at least 5 metres (5 yards) without a gait aid or assistance from another person.

Fig 27.4 – The ICU Mobility Scale (Hodgson *et al.*, 2014)

Level 1 Patient and Enhanced Care Areas Competencies

7.2.1 – Physiological changes to acute illness – Promoting independence through function:

Demonstrate through discussion:

- The physiological impact of reduced physical function/immobility on the body's systems
- Awareness of how acute and chronic medical conditions impact on a patient's physical function ability
- Clinical presentation of patients who are recovering from an acute illness and may be deconditioned/suffering with muscle wasting and/or fatigue
- Awareness of when patients are too medically unstable to engage in functional activities.

Demonstrate through practice:

- Accurate social history taking to establish previous levels of function
- A comprehensive risk assessment including
  - Moving and handling
  - Falls
- Encouragement of independent function by:
  - Ensuring a safe environment
  - Limiting constraints such as catheters, drips etc.
  - Management of pain
- Education of patients and relatives of the benefits of maintaining independent function
- An ability to follow instruction provided by other MDT specialists outlining safe moving and handling, equipment requirements and strategies to achieve 24-hour approach to rehabilitation.
- Referrals to relevant multi-disciplinary team members if strategies to promote independent function are unsuccessful or patient is not at baseline level.

Snapshot - ICUAW

James is a 58-year-old man who was admitted to critical care with pneumonia 2 weeks ago. He was intubated and ventilated for 8 days and extubated onto HFNC 6 days ago. Prior to this hospital admission James was still working (as an administrator at the local council offices), and walked and cycled regularly. He is an ex-smoker, with a 20-pack-year history, who quit 10 years ago. When his sedation stopped 6 days ago, the MDT ward round noted that he has ICUAW. Yesterday James was able to step-transfer from his bed to a chair with the assistance of a nurse, a physiotherapist, and a zimmer frame. He reports that he was "knackered" after this.

How would you assess James' musculoskeletal function?

1. Calculate James' MRC-SS
2. What else would you assess or document in relation to James' physical function?
3. Are you able to utilise clinical guidelines or quality standards to suggest a plan for James' rehabilitation? Who else might be involved in this plan?

Conclusion

Musculoskeletal injury in critical care can be complex in its management. Comprehensive assessment, liaison with relevant speciality teams and multi-disciplinary colleagues is essential. Long-term disability and reduction in physical function is common after a period of critical illness.

Take home points

1. Musculoskeletal complications following critical illness are common, particularly for patients who have a protracted critical stay.

2. Major traumatic injury and ICUAW are just two examples of musculoskeletal and/or neuromuscular causes of weakness and impaired function in critical care.
3. The key to safe early mobilisation for patients recovering from critical illness is thorough physiological, clinical and environmental assessment.
4. Multi-disciplinary communication is important for coordinating early and ongoing physical rehabilitation intervention.

6Cs - Care – Remember that **self-care** is also important, to ensure that you can provide the best care to patients. Consider how you manage your own physical, psychological, and spiritual wellbeing during your training, and career.

Glossary

Anabolism	Metabolic process that constructs larger molecules from smaller molecules.
Adenosine Triphosphate (ATP)	Energy-carrying molecule that in cells of living organisms.
Catabolism	Metabolic process involving the breakdown of nutrients resulting in the release of energy
Compartment	Groupings of muscles, nerve and blood vessels surrounded by fascia
Conservative	Managed non-surgically
Contraction	An increase in tension of a muscle.
Homeostasis	Self-regulating processes that maintain the stability and consistency for an organism to function properly.
Joint capsule	Fibrous connective tissue that surrounds a synovial joint
Neuromuscular	Nervous system, muscles and their interaction
Neurovascular	Relating to the nerves and blood vessels
Plantargrade	90-degree angle at the ankle joint. Required for functional standing and walking.
Subluxed	Partial dislocation of a joint.
Tone	Muscle tone is controlled via the central nervous system (CNS), with a constant balance of excitatory and inhibitory signal sent to skeletal muscles via the peripheral nervous system (PNS).

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