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Review Article

Management of acute cervical spinal cord injury in the non-specialist intensive care unit: a narrative review of current evidence

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Summary
Each year approximately one million people suffer spinal cord injury, which has significant physical, psychosocial and economic impacts on patients and their families. Spinal cord rehabilitation centres are a well-established part of the care pathway for patients with spinal cord injury and facilitate improvements in functional independence and reductions in healthcare costs. Within the UK, however, there are a limited number of spinal cord injury centres, which delays admission. Patients and their families often perceive that they are not receiving specialist care while being treated in non-specialist units. This review aimed to provide clinicians who work in non-specialist spinal injury centres with a summary of contemporary studies relevant to the critical care management of patients with cervical spinal cord injury. We undertook a targeted literature review including guidelines, systematic reviews, meta-analyses, clinical trials and randomised controlled trials published in English between 1 June 2017 and 1 June 2023. Studies involving key clinical management strategies published before this time, but which have not been updated or repeated, were also included. We then summarised the key management themes: acute critical care management approaches (including ventilation strategies, blood pressure management and tracheostomy insertion); respiratory weaning techniques; management of pain and autonomic dysreflexia; and rehabilitation.

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Introduction
Each year approximately one million people suffer spinal cord injury (SCI) worldwide, which has a significant impact for patients and their families in terms of physical, psychosocial and economic effects [1]. Spinal cord injury is a leading cause of disability; over 27 million people are living with SCI, resulting in over 9 million years lived with disability [1]. Patients will often require extended periods of

hospitalisation and rehabilitation, with associated high financial costs; it is estimated that each new SCI case in the UK will result in direct and indirect costs totalling £1.12 million ($1.35 million; €1.29 million) with the costs almost doubling for complete injuries [2].

Spinal cord rehabilitation centres are a well-established part of the care pathway for patients with SCI. They improve functional independence measures, leading to an estimated annual saving of over £250,000 ($303,600; €288,800) per patient [3]. Within the UK, however, there are a limited number of SCI centres, leading to admission delays, especially when mechanical ventilation is required after high cervical cord injury. This results in patients with SCI spending long periods of time in general intensive care units before transfer. Patients and their families often perceive that they do not receive specialist care while being cared for in non-specialist units and worry that this will worsen their rehabilitation outcome [4].

The aim of this review is to provide healthcare professionals who work in non-specialist centres with a summary of contemporary studies relevant to the management of patients with SCI. While SCI can affect any area of the spine, this review will primarily focus on the management of patients with injury to the cervical spine, as it is this patient cohort that is managed most commonly on intensive care units (ICUs).

Search strategy

A targeted literature review was performed for studies relating to the acute management of adult patients (aged ≥ 16 y) with SCI, with a focus on injuries involving the cervical spine. Search terms are detailed in online Supporting Information Appendix S1 and included meta-analyses, strategy documents, standards, guidelines, systematic reviews and randomised controlled trials published in English in the preceding 6-year period (1 June 2017 to 1 June 2023). The studies selected for inclusion were those published most recently or those the authors believed to be of the greatest relevance to contemporary clinical practice in the UK. Studies involving key clinical management strategies published before this time, but which had not been updated or repeated, were eligible for inclusion. Where possible, identified studies were grouped into clinically relevant themes.

Acute ICU management of spinal cord injury

Airway management

Tracheal intubation may be required for a number of reasons including airway maintenance (especially in the presence of coexisting traumatic brain injury); respiratory failure (e.g. high cervical SCI and/or hospital-acquired pneumonia); and to facilitate operative intervention for surgical management of the SCI and/or other injuries. The optimal tracheal intubation technique for minimising the risk of secondary SCI remains unclear; this has been discussed in depth in a recent review article [5]. In brief, all airway interventions result in some cervical spine movement, but these are typically very small, and it is uncertain whether this movement increases the risk of clinically significant spinal cord impingement even in cases of severe cervical spine instability. Practitioners should select the tracheal intubation technique that they are most experienced with, and that is judged most likely to minimise cervical spine movement, on a case-by-case basis.

Patients with SCI often require a tracheostomy to facilitate weaning from mechanical ventilation. The factors that increase the likelihood of tracheostomy requirement are shown in Box 1 [6].

Among these factors, the more complete the injury (according to the American Spinal Injury Association (ASIA) impairment scale) and neurological level of injury above C5 appears to have the greatest predictive value for acute respiratory failure [7] and subsequent need for tracheostomy [8]. In older patients (aged > 60 y) with traumatic SCI, ASIA impairment scale A is the most significant risk factor for tracheostomy [9]. The timing of tracheostomy insertion has been a matter of some debate. A recent meta-analysis of 17 studies involving 2804 patients found that early tracheostomy (defined as < 7 days after tracheal intubation) did not alter mortality but was associated with reductions in

Box 1 Factors increasing the likelihood that a patient will require a tracheostomy after traumatic cervical spinal cord injury. Adapted from [6].

- American Spinal Injury Association impairment scale A (complete; no motor or sensory function preserved below the level of the injury, including the sacral segments S4–S5)
- American Spinal Injury Association scale impairment B: (incomplete; sensory, but not motor function is preserved below the neurological level of injury, and includes the sacral segments S4–S5)
- Neurological level of injury at or above C5
- Increased injury severity scale
- GCS ≤ 8
- Coexisting thoracic injury
- Post-injury respiratory complications

duration of mechanical ventilation, ICU/hospital stay and incidence of ventilator-acquired pneumonia [10]. In patients who have undergone surgical fixation of a cervical fracture/dislocation, tracheostomy insertion has traditionally been delayed due to concerns regarding an increased risk of surgical site infection. However, more recent data have shown that tracheostomy insertion within 7 days of cervical fixation is not associated with an increased rate of surgical site infection, and that delaying tracheostomy until ≥ 7 days after surgery is associated with greater morbidity [11]. In most cases, open surgical tracheostomy will be preferred to a percutaneous approach, due to concerns regarding spinal stability and/or difficulties positioning the neck in extension after surgical fixation.

Acute ventilation strategies

Impairment of the respiratory musculature results in weakening of cough, so intensive physiotherapy is necessary including the use of mechanical assist devices. Historically the use of high tidal volumes (15–20 $ml.kg^{-1}$) was recommended in the belief that this increased surfactant production. Similarly, zero positive end-expiratory pressure (PEEP) was advised to avoid gas-trapping secondary to impaired expiratory function. However, ventilation with high tidal volumes has now been shown to increase the risk of ventilator-associated pneumonia and other adverse pulmonary events, with no reduction in duration of mechanical ventilation [12]. As such, ventilation strategies with volumes up to 15 $ml.kg^{-1}$ are now recommended in the acute phase of SCI, with individualised levels of PEEP to prevent atelectasis [13]. Vigilance is needed to avoid atelectasis and pulmonary complications arising from hypoventilation with use of lung-protective ventilation strategies, as these could impact negatively upon subsequent weaning.

Blood pressure management

The Congress of Neurological Surgeons recommends a target mean arterial pressure (MAP) ≥ 85 mmHg for 5–7 days after injury to maintain spinal cord perfusion and reduce the risk of secondary cord injury [14]. This is based on studies that have seen improvements in ASIA scores with augmentation of blood pressure [15], but the overall evidence base for this practice remains weak (class 3 evidence). The optimal strategy for blood pressure augmentation has not been determined, but typically consists of maintenance of euvolemia plus administration of vasopressors. In a porcine model of SCI, noradrenaline was associated with superior restoration of spinal cord blood flow and oxygenation compared with phenylephrine [16].

Research is now investigating the utility of spinal cord perfusion and/or intraspinal pressure (mainly with the use of intradural sensors) to try to individualise blood pressure targets and optimise spinal perfusion [17]. Microdialysis catheters have also been trialled to monitor injury site metabolic changes in response to blood pressure augmentation [18]. However, at present, these concepts remain hypothetical and further prospective work in randomised controlled trials is necessary before these can be introduced into clinical practice.

Weaning from mechanical ventilation

The goals for critical care units managing patients with SCI are to prevent respiratory complications and optimise patients for early transfer to a specialist centre for rehabilitation. Within the UK there are often lengthy delays before this transfer occurs, and therefore there is a need to progress with weaning and rehabilitation of patients during this period. A recent systematic review of 39 studies found that two-thirds of patients with cervical SCI can be successfully weaned from mechanical ventilation while in ICU, and that 80% of the patients who remained ventilator-dependent subsequently were weaned successfully within a specialist rehabilitation centre [19]. This highlights the benefits of transfer to specialist centres for expert respiratory management, and patients should not be labelled as being ´ventilator-dependent´ or ´non-weanable´ in the acute setting.

The need for mechanical ventilation after SCI arises from a failure of the respiratory muscle ´pump´, rather than lung pathology. This is a key difference that shapes the ventilation, weaning and life-long respiratory management of this patient cohort, as this underlying cause is unlikely to be reversible. As such, traditional critical care weaning plans used for patients without SCI may not be appropriate. Up to 20% of patients with cervical SCI fail tracheal extubation (variably defined in the literature), with the odds ratio (95% CI) being greatest in patients with complete lesions, namely 2.76 (1.14–6.70) [20].

Identifying when to start to wean from mechanical ventilation

Vital capacity is a widely available, non-invasive and simple assessment tool. Korupolu et al. found a vital capacity of at least 5.8 $ml.kg^{-1}$ (predicted body weight) to significantly predict weaning success [21], noting however that spirometry alone cannot identify unilateral diaphragmatic paralysis. Nonetheless, the ability to perform diagnostic spirometry to initiate and maintain a weaning protocol offers reliable guidance and can also indicate the development of fatigue before respiratory failure becomes outwardly obvious. All critical care teams managing patients with SCI should be able to monitor them using this test at appropriate strategic intervals.

Significant differences have been found in the primary measures used to assess weaning suitability between critical care facilities and rehabilitation centres. Arterial blood gas analysis is often used in ICUs, whereas vital capacity measurement and chest radiographic findings are preferred in rehabilitation facilities [22]. There are several prerequisites before starting to attempt to wean a patient from a ventilator: the patient should be afebrile; the lung fields should be clear, without atelectasis; a reliable secretion management strategy should be established; and ventilation parameters should be optimal. The patient must be fully informed of the process to come. The goal is to use a mode of ventilation that will provide absolute rest, with mandatory modes preferred over pressure support modes so as to avoid fatigue of the respiratory muscles.

Tracheostomy cuff deflation

Early cuff deflation is recommended in patients with SCI while on a ventilator. Communication is of utmost priority for critical care patients with tracheostomies [23], and early cuff deflation means that this can be achieved without worsening respiratory effort and making weaning less urgent. Cuff deflation may help to improve swallowing, reduce time to decannulation and provide a functional alternative for those who cannot be weaned from mechanical ventilation [24]. These factors are especially relevant as weaning from ventilation can take weeks to months and therefore there is a need to provide functional ability to engage in a rehabilitation programme as weaning progresses. Cuff deflation also promotes early use and conditioning of accessory muscles to augment diaphragmatic function during weaning, as well as enabling the process of assessment and rehabilitation of swallowing function to begin.

A switch to a domiciliary ventilator with leak compensation ability simplifies the cuff deflation process, but this might not be an option within a non-specialised critical care unit. Anecdotal success has been found with manipulation of the critical care ventilator modes and parameters, but this risks introducing other difficulties such as continuous leakage alarms, alongside an unknown degree of leak compensation.

Respiratory weaning strategy

The preferred method of weaning is with progressive ventilator-free breathing. This consists of alternating graded periods of ventilator-free breathing with prescribed rest periods on unaltered ventilator parameters, thus offering a training effect on the respiratory musculature [25]. Detailed guidance for weaning from mechanical ventilation for patients with SCI in the UK and Ireland has been developed by the special interest group, Respiratory Information in Spinal Cord Injury [13]. The starting point for progressive ventilator-free breathing is based on vital capacity with progressive increments building to overnight ventilation only, then full 24-h weaning. Regular end-tidal carbon dioxide monitoring and vital capacity assessment, arterial blood gas analysis and chest radiography are recommended as weaning progresses, as they can reveal early signs of intolerance. This can then be promptly acted on to avoid weaning regression. Weaning intolerance invariably leads to a prolonged duration of time on mechanical ventilation. Inadequately managed fatigue can lead to an overwhelming and unsustainable workload for the patient and should be avoided.

In patients with SCI who are tetraplegic, diaphragmatic excursion is greater in the supine position and reduced when upright. This reduction can be minimised with the use of an elastic abdominal binder [26]. Progressive ventilator-free breathing should therefore begin in a supine position in bed. The sitting position (with an abdominal binder) can be incorporated into the weaning plan as the patient progresses.

Secretion clearance

Regular and attentive mechanical secretion clearance is a key component of a successful weaning programme to reduce avoidable work of breathing and reduce the incidence of atelectasis. Postural drainage, assisted coughing, mechanical insufflation–exsufflation, suction and intermittent positive pressure breathing are commonly used modalities. Bronchodilators are often used prophylactically, alongside mucolytics to aid sputum clearance, although the evidence supporting these practices is poor.

Autonomic dysreflexia

Autonomic dysreflexia is acute hypertension with baroreceptor-induced bradycardia resulting from dysfunctional sympathetic nervous system reflexes in patients with an SCI above T6. It is more common in patients who have a complete rather than incomplete SCI (25% vs. 10% respectively [27]) although estimates of the prevalence vary widely between studies. Although autonomic dysreflexia most commonly presents 3–6 months after injury, it can present more acutely in around 5% of patients [28] and may require management in the ICU setting.

There are five major brain regions that modulate sympathetic function, with the rostral ventromedial medulla being the primary source of input into supraspinal vasomotor pathways in the spinal cord that regulate cardiovascular function. Sympathetic outflow via the sympathetic chain innervates blood vessels throughout the body, and the heart is innervated by neurons from the T1 to T4 region of the spinal cord. Damage to this region can lead to autonomic dysfunction. Damage to serotonergic signalling pathways may have a role in this dysregulation [29]. Following acute injury there is a state of neurogenic shock, with areflexia and profound unopposed parasympathetic dominance due to sympathetic blunting with SCI above T6 [30]. Once sympathetic reflexes have returned, at around 6 weeks after injury, the patient is at risk of autonomic dysfunction. Sympathetic outflow to the vessels supplying the splanchnic region is particularly important to blood pressure regulation, as this region contains approximately 25% of total blood volume and is the primary capacitance bed capable of rapid redistribution of blood [31]. The greater splanchnic nerve commonly arises from T7/T8 and innervates the splanchnic vascular bed, meaning that injuries above this level can result in loss of higher inhibitory control. This unopposed sympathetic activity and vasoconstriction result in the displacement of a large volume of blood.

Autonomic dysreflexia is clinically diagnosed by a rise in systolic blood pressure > 20 mmHg. Systolic pressure may rise to 300 mmHg, which may result in life-threatening complications such as seizures, acute stroke or intracerebral haemorrhage (Box 2) [30]. In patients with SCI, typical systolic blood pressure may only be 90–110 mmHg, so relatively modest rises in blood pressure that might not prompt treatment in the general ICU population may be overlooked.

The most common precipitants for autonomic dysfunction are related to stimulation of the hollow viscera and can be managed as summarised in Box 3. Immediate intervention should include: sitting the patient up and lowering the legs; loosening any constrictive clothing or devices; and identifying precipitants. As SCI results in interruption to descending modulatory pathways, autonomic dysfunction will persist until the stimulus is removed [32]. There is a lack of consensus regarding the threshold and drug therapy for hypertension. Usually, treatment is given with a systolic blood pressure > 150 mmHg, with short-acting drugs initially preferred (e.g. topical or sublingual nitrates (not if the patient is on phosphodiesterase type-5 inhibitors, e.g. sildenafil) or immediate release nifedipine) [30, 33]. Patients should be monitored closely for rebound hypotension. If hypertension does not resolve, then second-line drugs include phentolamine, clonidine and hydralazine [34].

Box 2 Clinical features of autonomic dysreflexia.

Cardiovascular	Myocardial infarction
	Atrial fibrillation
	Premature ventricular complexes
	Atrioventricular conduction abnormalities
Central nervous system	Cerebrovascular accident
	Sudden onset headache
	Seizures
	Encephalopathy
	Feelings of anxiety and/or apprehension
Visual	Retinal detachment
	Blurred vision
Respiratory	Pulmonary oedema
Skin	Flushing and sweating above the level of injury
	Pale and cool below the level of injury, with piloerection

Box 3 Management of autonomic dysreflexia.

Positioning	Sit patient upright (if spine is stable) and loosen clothing
Precipitant	Investigation and treatment
Bladder distension	Insert, flush with warmed saline or change bladder catheter
	Ensure topical urethral lidocaine is used for procedures
	Exclude testicular pathology (e.g. torsion or abscess)
	Avoid rapid emptying of a full bladder
Faecal impaction	Digital rectal examination with lidocaine gel
	Laxative therapy
	Avoid large volume enemas
	Gentle manual disimpaction
	Exclude acute surgical abdomen/anal pathology (e.g. fissures)
Pain	Analgesia
Pressure areas	Check for infected pressure ulcers/ingrowing toenails

Venous thromboembolism

Patients with SCI are at increased risk of venous thromboembolism, with pulmonary embolism being the primary cause of death in 8% of patients in the USA in the first year after injury [35]. The risk of venous thromboembolism is increased in patients with complete injuries [36]. In light of this, guidelines recommend the use of mechanical and chemical prophylaxis; low molecular weight heparin is preferred to unfractionated heparin and chemical prophylaxis should be continued for at least 8 weeks after injury [36]. Patients with SCI remain at increased risk of venous thromboembolism, and long-term prophylaxis may be needed during the rehabilitation period [37], with direct oral anticoagulants now also being used.

In patients at increased risk of bleeding (e.g. due to other traumatic injuries or following surgery), this risk should be assessed daily, with prophylaxis started as soon as it is deemed safe [36]. Starting low molecular weight heparin ≤ 48 h after admission reduces the incidence of venous thromboembolism, the odds ratio (95%CI) being 0.45 (0.10–0.9) [38].

Monitoring of neurological injury

The assessment of the level and degree of neurological impairment after SCI is essential to both patient care and national and international epidemiology. The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) tool (https://asia-spinalinjury.org/expedited-isncsci-exam) is the most widely and well-established way of measuring, recording and communicating this. However, documentation quality is often poor [39] and individual training in how to perform the assessment is limited, especially in non-specialist centres. Both ASIA and the European Multicenter Study about SCI (EMSCI) have resources to assist with training.

In SCI, especially if injury is incomplete, over time and with rehabilitation neurological impairment may change, but there is no recommended frequency at which re-assessments should be performed. The ASIA advises that full ISNCSCI assessment should be performed in the '*acute setting, on admission and discharge from rehabilitation, in patients with chronic SCI and suspected neurological changes*'.

Management of pain

Both acute and chronic pain are common in patients with SCI, the latter recently found to have a prevalence as high as 68% [40]. Identifying the cause(s) of pain and tailoring treatments accordingly is a challenging but important aspect of holistic patient management. Intensive care teams will most often be faced with acute pain management, but chronic pain may be encountered, especially in patients with high SCI who require prolonged ventilation. Musculoskeletal, visceral and neuropathic pain may occur separately or in combination.

Musculoskeletal pain is common, due to coexisting traumatic injuries and subsequent immobility. Significant injuries should be identified, appropriately imaged and treated, which may require surgery or reduction and immobilisation. Pharmaceutical management centres around the well-described multimodal approach including peripheral nerve blockade, paracetamol, non-steroidal anti-inflammatory drugs (NSAIDs) and titrated opioids.

Visceral pain may occur due to secondary complications of SCI such as nephrolithiasis, urinary tract infections or constipation, and affects around 20% of patients who have SCI [40]. The incidence of constipation may be reduced by a neurogenic bowel management programme. Discussion of this is beyond the scope of this review, but detailed national guidelines are available [41, 42].

Neuropathic pain has a prevalence of 58% following SCI [40] and may be experienced below, at, or above the level of the SCI. Identifying the cause may be difficult as it can be due to an insult at the spinal cord or peripheral nerve level. 'At-level' neuropathic pain can be described as pain which originates, or is felt, in the dermatome of the level of cord injury or within one level above to three levels below. Proposed mechanisms include direct generation of painful signals at the site of injury, abnormal amplification of distal pain signals and impaired descending inhibitory pathways [43]. 'At-level' pain due to worsening nerve root compression or expanding syringomyelia may be amenable to intervention and should be investigated to avoid worsening disability and pain. 'Below-level' neuropathic pain is similar in character to 'at-level' pain, but it is located more diffusely below the level of injury often bilaterally in the buttocks and legs.

There are no neuropathic pain management recommendations specific to patients with SCI. Generic guidance for treating neuropathic pain includes offering one of four drugs (amitriptyline, pregabalin, gabapentin or duloxetine) and considering adding a second of these if the response after 6–8 weeks has been assessed to be inadequate [44].

Gabapentinoids are often first-line therapy in patients who are in the ICU; a recent meta-analysis has shown pregabalin and gabapentin to have a similar efficacy and adverse effect profile in patients with SCI [45]. Although evidence about analgesic regimes is lacking, it is generally accepted that a thorough assessment of the pain the patient is experiencing, tailoring treatment to the patient's mental and physical state and adjusting treatment to response, is the best management strategy. The patient's psychosocial circumstances will also impact on the severity and experience of pain. Anxiolytics and antidepressants may be appropriate adjuncts in many cases. Cognitive behavioural pain management may be a key part of chronic pain management and it is recommended that a pain specialist is involved in the patient's care early when there is difficulty achieving an adequate response to the above strategies.

Rehabilitation

Management of spasticity

Spasticity, defined as `*disordered sensorimotor control resulting from an upper motor neuron lesion, presenting as intermittent or sustained involuntary activation of muscles*´ [46] is a common consequence of SCI [47]. Individuals with injuries at a higher spinal level (particularly cervical), and those with more severe injuries are more likely to report spasticity than those with injury lower down the spinal cord [48, 49]. The time of onset of spasticity may vary. The period of `spinal shock´ with reduction in muscle tone and reflexes in the acute phase of SCI tends to persist for some weeks; the end of this period is suggested to coincide with the return of reflexes [50, 51]. In one study, at an average of 125 days post-injury, 65% of patients reported spasticity [49], indicating that it is important to monitor for the development of spasticity during the acute hospital stay. While there are some proposed advantages of spasticity (e.g. reduction in risk of venous thrombosis [52]; helping with transfers [53]; and maintenance of muscle mass [54]), managing spasticity appropriately can reduce pain, spasms, involuntary movement, soft tissue shortening, contractures and skin damage, and ultimately may improve rehabilitation progress [55]. Early recognition and treatment of spasticity are therefore likely to be vital, but high-quality research is lacking [56].

Mood

The lives of people with SCI, along with their families and friends, experience profound long-lasting change across biological, psychological and social domains [57]. It is unsurprising that after a life-changing event such as SCI, depression (affecting around 25% of patients [58]), anxiety and post-traumatic stress disorder are common [59]. Suicide is a cause of death in up to 11% of patients following SCI, and risk is highest in those with psychiatric disorders [60]. It is therefore crucial to identify and treat mood and adjustment disorders as early as possible. Psychological support and a holistic and individualised approach to treatment are important, although this is a field in need of more research [61, 62]. Peer support can be helpful for both staff and patients [63]. Within the UK, relevant support organisations include the Spinal Injuries Association (https://www.spinal.co.uk), Back Up Trust (https://www.backuptrust.org.uk) and Aspire (https://www.aspire.org.uk).

Communication with patients and relatives

Patients with SCI have multimodal impairment and are at risk of significant psychological problems given the life-changing impact of many of these injuries. Involvement of both patients and their families at an early stage is important in maintaining a trusting relationship between them and the healthcare team. Involvement of families, where possible, should be at the request of the patient themselves.

Multidisciplinary case conferences during the rehabilitation phase should involve the patient, and if requested by them, family members also. It is beneficial for the critical care multidisciplinary team to establish these regular conferences as soon as possible during the subacute phase of their injury, in order to establish and maintain effective communication between patients, relatives and the healthcare team. Non-specialist professionals should seek assistance and guidance from specialist centres to help support and reassure patients and their families [4]. This is important when transfer to a dedicated rehabilitation facility is delayed, as patients and their families may feel that they are not receiving specialist care, and this is delaying their rehabilitation as a result.

Readiness for discharge to rehabilitation

Rehabilitation is defined by the British Society of Physical and Rehabilitation Medicine (BSPRM) as `*a process of assessment, treatment and management by which the individual (and their family/carers) is supported to achieve their maximum potential for physical, cognitive, social and psychological function, participation in society and quality of living*´ [64]. Rehabilitation should begin at the time of initial assessment by emergency services and continue throughout the hospital admission to discharge and beyond; indeed, recent BSPRM guidelines state that patients with SCI in England should be referred to their local SCI centre within 24 h of admission, with the centre subsequently guiding a `*lifetime of personalised care*´ [65]. Following discharge from ICU, patients may be discharged to a variety of locations, including medical, surgical or orthopaedic wards; major trauma wards; or rehabilitation units, including specialist spinal units. Due to the paucity of spinal unit beds (there are only eight specialist spinal units in England [65]), there may be a delay before patients can be admitted there, leading to a period of inpatient stay in an alternative location, including local neurorehabilitation units [64]. Furthermore, some patients may also prefer to stay locally, rather than travel to a specialist centre, or may not be accepted for admission to a specialist centre. It is important that patient preferences are taken into account when considering suitable locations for discharge and onward care. Different rehabilitation units will have different criteria for accepting patients depending on a range of factors, often including staffing levels and expertise, location and local agreements, e.g. some units are able to accept patients with tracheostomies and some are unable to take patients who are receiving intravenous fluids or medication. Early liaison with the local rehabilitation unit is therefore imperative.

Prognosis

Thorough and accurate neurological examination at baseline and subsequent key points is the most helpful indicator of prognosis, using the ASIA/ISNCSCI tools [66]. This includes the testing of motor and sensory function through dermatomes and myotomes, with the presence or absence of sacral involvement or sacral sparing being particularly important for prognostication [67]. Prognostication is beyond the scope of this article and in-depth reviews have been published recently elsewhere [68].

Conclusion

Given the significant impact of SCI on patients, their families and society in general, it is essential patients with SCI receive care that will help achieve their rehabilitation goals as quickly as possible. While there may be delays in transfer to specialist SCI rehabilitation centres, this should not stop early contact with such centres for advice on management, nor result in a failure to initiate specialist therapy practices while the patient is being cared for in a general ICU. We hope that the practices highlighted in this review article will allow patients with SCI to commence their recovery journey as soon as is practically possible following their injury.

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Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. Details of literature search strategies.

