Survey

A Scoping Review of Clinical Practice Guidelines for the Acute Care of Patients with Spinal Cord Injury: Respiratory, Hemodynamic and Neuroprotective Management

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Citation: Gregorio MP, Manhas K, Brehon K, Vaska M, Moore G, Ho C, Papathanassoglou E (2022). A scoping review of clinical practice guidelines for the acute care of patients with spinal cord injury: respiratory, hemodynamic, and neuroprotective management. *International Journal of Critical Care* 16(3);35-72.

Academic Editor(s): Ged Williams, RN, Crit. Care Cert., LLM, MHA, FACN, FACHSM, FAAN and Elizabeth Papathanassoglou, PhD, MSc, RN

Managing Editor: Patricia Zrelak, PhD, RN, NEA-bc, SCRN, CNRN, ASC-BC, CCRN-K, FAHA

Published: January 2022

Acknowledgments: None

ABSTRACT

Background: Given the complex nature of acute spinal cord injury (SCI) management, there is a pressing need to review and evaluate existing clinical practice guidelines (CPGs). This study aims to evaluate SCI-related CPGs and create a summary of recommendations related to the acute in-hospital management of SCI in three different areas: respiratory management, hemodynamic management, and the use of neuroprotective agents.

Method: This study was conducted in accordance with the guidelines set by the Joanna Briggs Institute, and PRISMA-ScR. A search was conducted in thirteen databases and the gray literature. Screening and data extraction was completed by two independent reviewers against pre-specified eligibility criteria. The AGREE II tool was used to appraise the quality of the CPGs.

Results: The search identified 12 eligible CPGs. Seven (n=7) CPGs were published in the last five years. Overall, the recommendations were supported by low-quality evidence. Based on the AGREE II quality appraisal, seven of twelve CPGs can be recommended for use, and one can be recommended with modification. The following domains scored the highest average score: "Clarity of Presentation," "Scope and Purpose," and "Editorial Independence." Domain 5 "Applicability" and domain 2 "Stakeholder Involvement" scored the lowest average score. While most of the recommendations were consistent, there were contradicting recommendations concerning the use of methylprednisolone.

Conclusion: The CPGs in the management of acute SCI are overall based on low-quality evidence. More evidence is needed to recommend for or against the use of methylprednisolone in acute SCI patients. Indeed, there is a need for the development of rigorous and up-to-date CPGs that are based on high-quality evidence.

Keywords: Scoping review, spinal cord injury; clinical practice guidelines, respiratory, neuroprotection, hemodynamics

INTRODUCTION

Evidence-based practice (EBP) is a fundamental element for the delivery of high-quality and safe patient care (Ten Ham-Baloyi et al., 2020). The EBP approach improves clinical practice because it involves the use of the most current, valid, and reliable evidence, thereby reducing care variability and improving patient outcomes (Esteban-Sepulveda et al., 2021; Ten Ham-Baloyi et al., 2020). In spinal cord injury (SCI), where secondary adverse events post-injury are prevalent during the acute care period, adherence to up-to-date and robust evidence-based management strategies is vital to reduce premature mortality and prolonged morbidity (Jiang et al., 2019).

Secondary adverse events may include complications of the injury itself or from the care provided and may occur at any point on the care continuum (Atkins et al., 2012; Jian et al., 2019; Marion et al., 2017). The period during acute in-hospital admission is when SCI patients are at the highest risk for life-threatening secondary adverse events such as pulmonary and cardiac complications (Hagen et al., 2015; Jian et al., 2019; Marion et al., 2017). Patients who experience secondary adverse events have been found to have poorer neurological outcomes, worse functional recovery, and longer hospital stays (Jiang et al., 2019; Wahman et al., 2019).

Pulmonary and cardiac complications are two of the leading complications in SCI worldwide, respectively accounting for 39.2% and 15.3% of secondary complications in patients treated in Canada (Marion et al., 2017; Wahman et al., 2019). Regardless of whether the secondary injury is a result of mechanical insult, dysmetabolic or vascular cause, healthcare providers should also be vigilant about neuroinflammation which, could lead to a cascade of irreversible sensory and motor dysfunction (Bracken 2012; Samano et al., 2016). Neuroinflammation is primarily addressed through the use of neuroprotective agents such as methylprednisolone. While *in vivo* and *in vitro* studies proved methylprednisolone to be beneficial in promoting functional recovery, its use among SCI patients remains controversial (Liu et al., 2019; Samano et al., 2016; Sultan et al., 2020; Zou et al., 2021). Multiple studies either agree with the limited use of methylprednisolone to some extent, while some recommend against its use (Samano et al., 2016; Sultan et al., 2020), including a recent meta-analysis (Liu et al., 2019), where it was concluded that methylprednisolone does not improve neurologic outcomes and may be implicated in an increased risk of adverse events

Secondary adverse events are preventable and early management and treatment are crucial in improving health outcomes (Jian et al., 2019; Sezer et al., 2015). Up-to-date clinical practice guidelines (CPGs) would strengthen the acute SCI management strategies, reducing variability in care delivery among SCI patients (Patsakos et al., 2021). CPGs are systematically developed statements of high-quality clinical practice used by health care providers to support their clinical decision-making process (Patsakos et al., 2021; Pereira et al., 2022). The rapidly growing body of knowledge across different conditions makes it challenging for

healthcare providers to stay-up-date on the latest clinical recommendations, hindering the majority of patients from receiving evidence-based care (Patelarou et al., 2013; Perreira et al., 2022; Warren et al., 2016). Although guidelines were developed for SCI management, guideline adherence remains suboptimal leading to inconsistent care across healthcare facilities (Charbonneau et al., 2017; Sharwood et al., 2017).

Recently published practice guidelines on SCI primarily focus on the subacute phase of SCI with limited focus on respiratory, hemodynamic management, and use of neuroprotective agents in the acute phase of SCI (Can-SCIP Recommendations 2021; Houghton et al., 2013; Loh et al., 2022**).** Given the complex nature of acute SCI management, the multiple irreversible complications that may arise from secondary adverse events, and the inconsistencies in SCI care practices, there is a pressing need to review and evaluate existing CPGs and compile the most recent evidence-based recommendations. This study aims to critically evaluate CPGs and create a summary of recommendations related to the acute in-hospital management of SCI in three different areas: respiratory management, management of hemodynamic abnormalities, and the use of neuroprotective agents.

METHODS

This scoping review was conducted in accordance with the guidelines set by the Joanna Briggs Institute, and the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) to ensure adherence to the reporting standard (Peters et al., 2020; Tricco et al, 2018). We followed the steps as outlined in the scoping review protocol developed in 2020 (Gregorio et al., 2021). Only the findings related to respiratory, hemodynamic, and neuroprotective management were presented in this manuscript. The recommendations retrieved from the eligible CPGs were compiled in a tabular format followed by narrative summaries.

Inclusion and exclusion criteria

PICAR, an acronym for population/patients, interventions, comparisons, attributes of CPGs, and recommendations, was the framework used to guide the inclusion and exclusion criteria of this scoping review (Johnston et al., 2019). For inclusion, the CPGs were required to meet the following criteria: (P) targeted adult patients with an SCI, (I) admitted to the hospital for care intervention in the acute phase of the primary injury, (C) with or without comparison criteria, (A) used any type of tool to critically appraise the evidence during guideline development, published in English language between 1 January 2005 to 1 June 2020, (R) contained evidence-based recommendations addressing SCI respiratory, hemodynamic and neuroprotective management. Empirical studies, systematic reviews, and guidelines developed for the general public were excluded.

Search strategy

A three-step search strategy was used in this study in accordance with the Joanna

Briggs Institute scoping review guidelines (Peters et al., 2020). The first step involved an initial search of PubMed and CINAHL (EBSCO), followed by an analysis of the relevant retrieved papers to create a list of search strings (Appendix A). The second step involved a comprehensive search of the following academic databases using the list of search terms developed: CINAHL, MEDLINE (Ovid), PubMed, MEDLINE (Ebsco), Cochrane Library, TRIP Pro, DynaMed, Evidence-Based Medicine, Evidence-Based Nursing, CIRRIE Database of International Rehabilitation Research, OT Seeker, PEDro: The Physiotherapy Evidence DatabaseRehabData, and the Rehabilitation Measures Database. The third step involved searching for additional sources from the reference list of the eligible CPGs as well as grey literature sources.

Study selection

Retrieved CPGs were imported to Covidence, a reference management software platform used for deduplication, screening, and data extraction (Covidence Systematic Review 2019). This study followed a two-step study selection process in accordance with the JBI scoping review guidelines: title and abstract screening and full-text screening (Peters et al., 2020). Two authors (MPG and KB) independently screened the CPGs against the pre-specified inclusion criteria. Any disagreements were resolved by the decision of a third reviewer. Reasons for exclusion were recorded. The details of the flow of the selection process were reflected in the PRISMA flow diagram (Figure 1).

Data collection and extraction

Data extractions were performed by the two reviewers (MPG & KB) and were extracted into Microsoft Excel. The information that was extracted included the following: Author, title, year of publication, target population, target care phase, and target patient outcomes. All the recommendations related to the acute in-hospital SCI care management on respiratory, hemodynamics, and neuroprotection were extracted, along with the level of evidence-base as indicated in each CPGs. The levels of evidence were then classified as high, moderate, or low (Appendix A).

Quality appraisal

All the selected CPGs were subjected to quality appraisal using the Appraisal of Guidelines for Research & Evaluation (AGREE) II tool (Brouwers et al, 2010). The AGREE II tool consists of 23 appraisal criteria divided into six domains (Scope and purpose; Stakeholder involvement; Rigour of development; Clarity of presentation; Applicability; Editorial independence), followed by two global scoring items: overall guideline quality and recommendation for use (Hoffmann-Eber et al, 2017). Domain scores were calculated based on the guideline set by the Agree II User Manual (Brouwers et al, 2010). CPGs were classified as "recommended" (R) when at least 3 domains scored ≥ 60%, "recommended with modifications" when domains scored between 30% to 60%, and "not recommended" (NR) when at least 3 domains are ≤ 30% (Arieta-Miranda et al., 2020).

RESULTS

There were 1247 studies identified from academic databases and 26 studies from additional resources as per the methods described above. After the deduplication of studies, 1268 studies were screened by reviewing the title and abstract. Of these, 130 met the pre-specified inclusion criteria and were included in the full-text screening. One hundred four more studies were subsequently excluded for the following reasons: wrong intervention (n=36), wrong study design (n=10), pre-hospital care (n=5), more recent version available (n=2), not a CPG (n=32), wrong patient population (n=2), wrong setting (n=4), decision regarding specialized aspect of radiologic evaluation for radiologist (n=1), empirical study (n=1), wrong outcomes (n=1). Twenty-six studies met the inclusion criteria and underwent data extraction (Figure 1).

Study Characteristics

Out of the 26 eligible CPGs identified in this scoping review, 12 CPGs contained recommendations related to the acute in-hospital SCI management in the following areas: respiratory, hemodynamic abnormalities, and neuroprotection. Hence, we only examined these 12 CPGs as per the scope of this scoping review. A summary of the included CPGs appears in table 1.

Out of the twelve CPGs included in this scoping review, only seven were published in the last five years. Most of the included CPGs were from North America (USA and Canada) (n=8) while the rest were from countries in Europe and Australia (Table 1). The study designs were mostly practice guidelines (n=10) and two (n=2) were reviews resulting in clinical recommendations. The target population of the included CPGs were adult patients with SCI, with some CPGs containing few recommendations made specifically for pediatric patients. All of the included CPGs were intended for use by a multidisciplinary team of health care professionals, including physicians, nurses, critical care specialists and etc. The majority (n=10) of the included CPGs contained total care management recommendations for SCI such as respiratory management, bladder and bowel care and etc. Two CPGs contained recommendations specifically for methylprednisolone use and venous thromboembolism (VTE) prevention.

Study Quality

The 12 CPGs were also subjected to quality analysis with the AGREE II tool (Brouwers et al, 2010) (Table 2). Seven CPGs obtained at least 3 domains with ≥60% and were classified as 'recommended'. One CPG was classified as 'recommended with modifications' while the remaining four were considered as 'not recommended'. Domain IV "Clarity of Presentation" (78.8%) scored the highest average score, followed by Domain I "Scope and Purpose" (66%). The domain corresponding to "Applicability" scored the lowest (21.2%).

Figure 1.

PRISMA Flow Diagram for Study Selection (Adapted from Tricco et al., 2018)

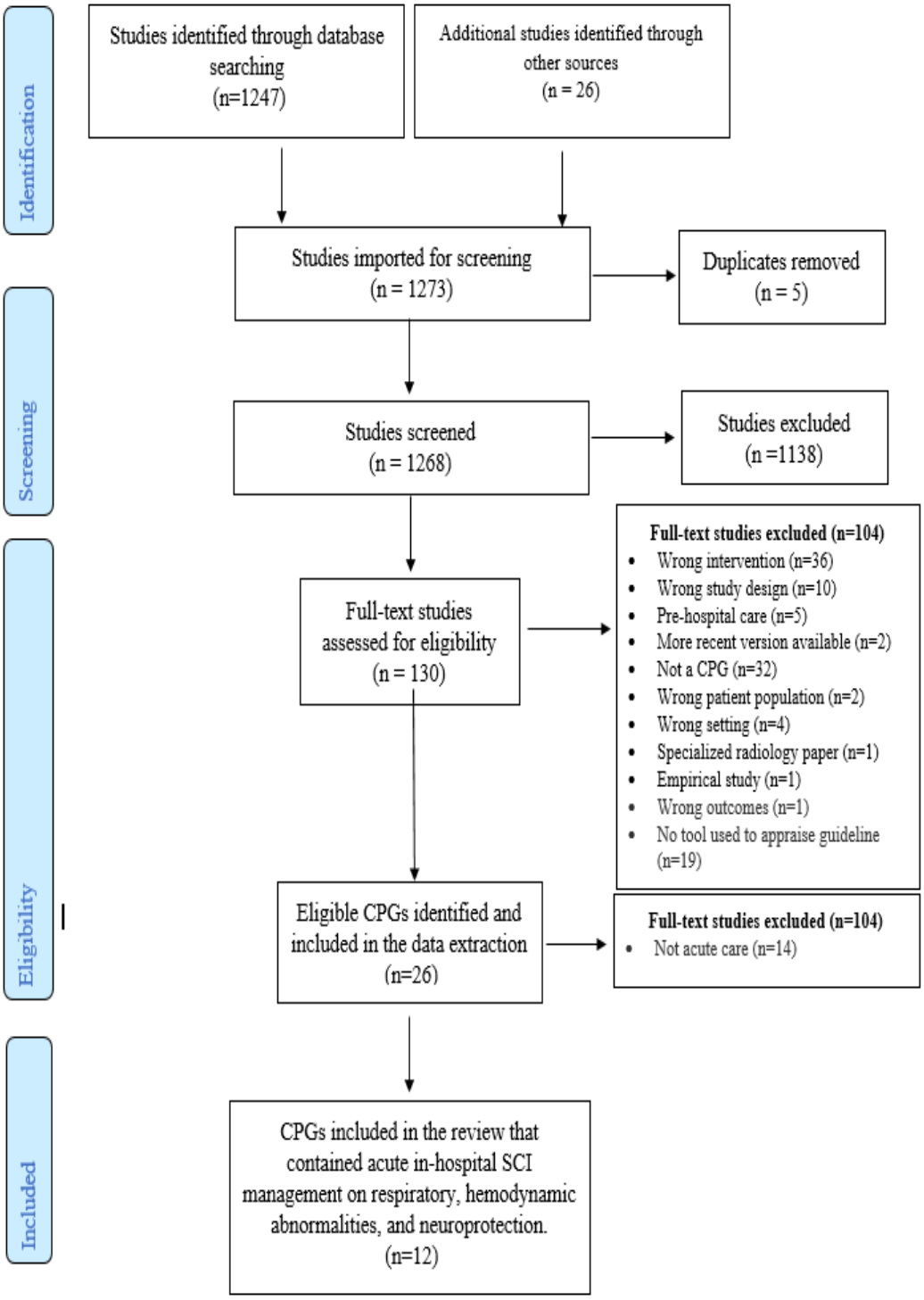

Table 1.

Characteristics of included CPGs targeting the care of adult patients with a spinal cord injury

Title/Acronym	Year Published	Country	Design	Target Population	Disciplines Involved	Outcomes In this recommendation (ex. pain management, bladder management, etc)
Guidelines for the management of acute cervical spine and spinal cord injuries: 2013 update (Walters et al., 2013)	2013	USA	Practice guideline	Adult and pediatric populations with SCI	Multidisciplinary	Total recommendations
French recommendations for the management of patients with spinal cord injury or at risk of spinal cord injury (Roquilly et al., 2020)	2020	France	Practice guideline	Adults with SCI	Multidisciplinary	Total recommendations
Early acute management in adults with spinal cord injury (Consortium for	2008	USA	Practice guideline	Adolescent and adult population	Multidisciplinary	Total recommendations

Spinal Cord Medicine, 2008)						
Traumatic spinal cord injury (DynaMed, 2020)	2020	USA	Recommendations	Adult and pediatric populations with SCI	Multidisciplinary	Total recommendations
Pharmacological therapy for acute spinal cord injury (Hurlbert et al., 2013)	2013	USA & Canada	Review	Adult population with acute SCI	Multidisciplinary	Pharmacological therapy
Spinal injury: assessment and initial management (National Clinical Guideline Centre UK, 2016)	2016	United Kingdom	Practice guideline	Adult and pediatric populations with acute SCI as a result of the traumatic physical event	Multidisciplinary	Total recommendations
A clinical practice guideline for the management of patients with acute spinal cord injury: recommendations on the use of methylprednisolone sodium succinate (Fehlings et al., 2017)	2017	Canada & USA	Practice guideline	Adult patients with acute SCI	Multidisciplinary	Recommendations for the use of Methylprednisolone Sodium Succinate

Acute spinal cord injury management (Birrer et al., 2018)	2018	USA	Practice guideline	Adult population with SCI	Multidisciplinary	Total recommendations
Early neurological care of patients with spinal cord injury (Kessler et al., 2018)	2018	Switzerland and Australia	Review	Adults with SCI	Multidisciplinary	Total recommendations
Chronic spinal cord injury: management of patients in acute hospital settings (Royal College of Physicians et al., 2008)	2008	United Kingdom	Practice guideline	Adult population with SCI who present in an acute hospital setting with related or unrelated condition	Multidisciplinary	Assessment and management of adults with SCI admitted to hospital with related or unrelated condition
Cervical spinal injury (DynaMed, 2018)	2018	USA	Recommendations	Adult and pediatric patients with SCI	Multidisciplinary	Total recommendations
Prevention of VTE in non-orthopedic surgical patients (Gould et al., 2012)	2012	USA, Canada, France, Spain	Practice guideline	Adult non-orthopedic surgical patients	Multidisciplinary	VTE prevention

Table 2.
Quality of the 12 CPGs targeting care of the adult patient with a spinal cord injury by AGREE domain scores

Title	AGREE II Domains						Global Average	Domain Score			Recommendations
	I	II	III	IV	V	VI	Mean	≤30	30-60	≥60	
Guidelines for the management of acute cervical spine and spinal cord injuries: 2013 update (Walters et al., 2013)	33.3	11.1	14.6	66.7	6.3	79.2	**35.2**	3	1	2	Not recommended
French recommendations for the management of patients with spinal cord injury or at risk of spinal cord injury (Roquilly et al., 2020)	80.6	25.0	36.5	61.1	10.4	91.7	**50.9**	2	1	3	Recommended
Early acute management in adults with spinal cord injury (Consortium for Spinal Cord Medicine, 2008)	100.0	52.8	63.5	75.0	20.8	12.5	**54.1**	2	1	3	Recommended
Traumatic spinal cord injury (DynaMed, 2020)	8.3	0.0	12.5	58.3	0.0	8.3	**14.6**	5	1	0	Not recommended
Pharmacological therapy for acute spinal cord injury (Hurlbert et al., 2013)	88.9	41.7	61.5	88.9	0.0	75.0	**59.3**	1	1	4	Recommended
Spinal injury: assessment and initial management (National Clinical Guideline Centre UK, 2016)	100.0	94.4	80.2	97.2	66.7	83.3	**87.0**	0	0	6	Recommended

A clinical practice guideline for the management of patients with acute spinal cord injury: recommendations on the use of methylprednisolone sodium succinate (Fehlings et al., 2017)	97.2	80.6	81.3	83.3	70.8	91.7	**84.2**	0	0	6	Recommended
Acute spinal cord injury management (Birrer et al., 2018)	44.4	0.0	19.8	88.9	0.0	0.0	**25.5**	4	1	1	Not Recommended
Early neurological care of patients with spinal cord injury (Kessler et al., 2018)	75.0	52.8	33.3	77.8	41.7	91.7	**62.1**	0	3	3	Recommended
Chronic spinal cord injury: management of patients in acute hospital settings (Royal College of Physicians et al., 2008)	61.1	38.9	4.2	55.6	0.0	100	**43.3**	2	2	2	Recommended with Modifications
Cervical spinal injury (DynaMed, 2018)	2.8	0.0	24.0	91.7	0.0	0.0	**19.8**	5	0	1	Not Recommended
Prevention of VTE in non-orthopedic surgical patients (Gould et al., 2012)	100.0	58.3	68.8	100.0	37.5	100.0	**77.4**	0	2	4	Recommended
Domain average score	66.0	38.0	41.6	78.8	21.2	61.1					

GUIDELINE RECOMMENDATIONS

Respiratory Management

Seventeen recommendations were associated with respiratory management for acute in-hospital SCI management. Most of the recommendations were supported by a low evidence base (n=14). The recommendations for respiratory management fall into four categories: general respiratory management, intubation, mechanical ventilation, and tracheotomy.

General Respiratory Management

Seven recommendations informed general respiratory management (Table 3). It was recommended to secure airway and ventilator support during resuscitation, especially in patients with a higher level of injury. Close patient monitoring should be started as soon as possible, regardless of the level of SCI to prevent respiratory complications and management should depend on the individual case. The overall quality of the evidence base was low.

Table 3.

General Respiratory Management in patients with an acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base

Initial assessment on admission	Initial assessment of all patients on admission should include the following:
	Respiratory assessment
	• Full history and examination including baseline:
	  ○ pulse, respiratory rate, and temperature
	  ○ oximetry, vital capacity, and forced expiratory volume (if possible)
	(Royal College of Physicians et al., 2008)
		Level III/IV	Low

Care planning	All patients with SCI admitted to hospital should have a written care plan which includes: • Respiratory management to prevent or treat chest complications, developed in conjunction with a chest or neurophysiotherapist. This may include: ○ clearing of airway secretions such as assisted coughing, suctioning (be aware of the risk of bradycardia induced by suction)	Level III/IV	Low

	○ re-expansion of affected lung including deep breathing, positioning, intermittent positive pressure ventilation, BiPAP, bronchoscopy with lavage and medications (Royal College of Physicians et al., 2008)		
Patient monitoring	In days immediately following injury, monitor closely for respiratory failure. • Obtain baseline respiratory parameters (vital capacity, forced expiratory volume) • Obtain baseline arterial blood gases at first evaluation and regular intervals until stable • Consider mechanical ventilation for patients with tetraplegia Admit patients with complete tetraplegia and injury level at C5 or rostral to intensive care unit (Consortium for Spinal Cord Medicine, 2008)	Level II/III/IV	Low
	The possibility of the following complications should be considered in any patient with established SCI admitted to hospital: • respiratory problems – including respiratory failure and infection (Royal College of Physicians et al., 2008)	Level III/IV	Low
Respiratory Management: ABCs of resuscitation:	Provide airway and ventilatory support in patients with high tetraplegia early in the clinical course (Consortium for Spinal Cord Medicine, 2008)	Level IV	Low
Anesthetic Concerns in Acute Spinal Cord Injury:	Secure the airway, support respiratory status, and consider postoperative ventilatory support when administering general anesthesia (Consortium for Spinal Cord Medicine, 2008)	Expert consensus	Low
Weak expiratory muscles	Treat retained secretions due to expiratory muscle weakness with manually assisted coughing ("quad coughing"), pulmonary hygiene, mechanical insufflation-exsufflation, or similar expiratory aids in addition to suctioning (Consortium for Spinal Cord Medicine, 2008)	Level IV/V	Low

Recommendations on intubation

There were four recommendations related to intubation retrieved (Table 4). Urgent intubation was recommended for patients with a higher level of SCI. Two recommendations addressed ways to minimize intubation failure in emergency and non-emergency situations. One recommendation stated that bradycardia and hypotension are expected in tetraplegic patients during intubation. The overall quality of the evidence base was low.

Table 4.

Recommendations on intubation of patients with an acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base
Parameter for urgent intubation	Early intubation and mechanical ventilation are recommended for patients with high cervical injuries (C1-C5) (Birrer et al., 2018)	Class II/III	Moderate-Low
Reduction of intubation failure	In an emergency condition, it is probably recommended to perform rapid-sequence induction and to use videolaryngoscopy in the first instance to facilitate tracheal intubation and to reduce the risk of intubation failure (Roquilly et al., 2020)	Grade 2+	Low
	In non-emergency conditions and in cooperative patients, it is probably recommended to realize a fiberoptic intubation with spontaneous ventilation in patients with a risk of difficult mask ventilation and/or indirect laryngoscopy difficulties (mouth opening < 2.5 cm), to reduce the risk of intubation failure (Roquilly et al., 2020)	Grade 2+	Low
Anesthetic Concerns in Acute Spinal Cord Injury	Anticipate bradycardia and hypotension during intubation of the tetraplegic patient (Consortium for Spinal Cord Medicine, 2008)	Level III	Low

Recommendations on mechanical ventilation in patients with SCI

There were four recommendations for using mechanical ventilation in patients with SCI (Table 5). Ventilators were recommended for patients with high cervical injury. Careful assessment and weaning protocols must be employed before the discontinuation of mechanical ventilation to prevent complications. Overall, the ventilator-related

recommendations were supported by the mostly low quality of evidence base.

Table 5.

Recommendations on ventilator use in patients with an acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base
Indication for ventilator use	Emergency health care providers must determine if airway and ventilator support are needed in patients with acute high tetraplegia (Kessler et al., 2018)	Level IV	Low
Ventilator-associated pneumonia	Initiate a comprehensive protocol to prevent ventilator-associated pneumonia in patients with acute SCI who require mechanical ventilation for respiratory failure (Consortium for Spinal Cord Medicine, 2008)	Level I/II/IV	High-Low
Weaning	It is probably recommended to use a bundle to facilitate respiratory weaning in patients with traumatic cervical cord injury, combining: • An abdominal contention belt during periods of spontaneous breathing or raising procedures • Active physiotherapy and a mechanically assisted insufflation/exsufflation device to remove bronchial secretions • Aerosol therapy combining beta-2 mimetics and anticholinergics (Roquilly et al., 2020)	Grade 2+	Low
	Experts suggest performing a tracheostomy to accelerate ventilatory weaning within the first 7 days in patients with upper-level SCI (C2–C5), and only after one or more tracheal extubation failures in patients with lower cervical SCI (C6–C7) (Roquilly et al., 2020)	Expert opinion	Expert opinion

Recommendations on tracheotomy for patients with SCI

Three recommendations informed tracheotomy and tracheostomy management in patients with SCI (Table 6). All the recommendations had an overall moderate-low evidence base. Early tracheotomy was recommended in patients with cervical SCI and those who are likely to remain ventilator dependent.

Table 6.

Recommendations on tracheotomy initiation for patients with an acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base
Tracheotomy indication	Perform a tracheotomy early in the hospitalization of patients who are likely to remain ventilator dependent or to wean slowly from mechanical ventilation over an extended period, unless the treating center has special expertise in the use of non-invasive ventilation (Consortium for Spinal Cord Medicine, 2008)	Level IV/V	Low
	Consider early tracheotomy (< 7 days) in high cervical injury (C1-C5) patients (Birrer et al., 2018)	Class III	Low
	Tracheostomy < 7 days after intubation may reduce time on ventilator compared to ≥ 7 days after intubation in patients with traumatic cervical SCI, but may not alter 90-day mortality, early pneumonia risk, or intensive care unit length of stay (DynaMed, 2020)	Level 2	Moderate

Management of Hemodynamic Abnormalities

Twenty-five recommendations informed the management of hemodynamic abnormalities in acute SCI. As detailed below, the recommendation focuses on 4 major areas: management of hemodynamic abnormalities during resuscitation, recommendations for blood pressure management, management of hemostasis, and vertebral arterial injury management. The quality of evidence was rarely high quality (n=2) and the majority was based on low evidence base (n=19).

Management of hemodynamic abnormalities during resuscitation

There were four recommendations related to the management of hemodynamic abnormalities during resuscitation (Table 7). The treatment and prevention of hypotension is critical and should be closely monitored. The overall level of evidence was low.

Table 7.

Management of hemodynamic abnormalities during resuscitation of a patient with an acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base
Resuscitation management	Prevent and treat hypotension (Consortium for Spinal Cord Medicine, 2008; DynaMed, 2018)	Level II/IV	Moderate -low
	Exclude other injuries before assigning the cause of hypotension to neurogenic shock (Consortium for Spinal Cord Medicine, 2008; DynaMed, 2018)	Level III/IV	Low
	Monitor and treat symptomatic bradycardia (Consortium for Spinal Cord Medicine, 2008; DynaMed, 2018)	Level III/IV	Low
Assessment of acid-base and fluid balance	Determine initial base deficit or lactate level to assess severity of shock and need for ongoing fluid resuscitation (Consortium for Spinal Cord Medicine, 2008; DynaMed, 2018)	Expert opinion	Low

Recommendations for blood pressure management

There were five recommendations related to blood pressure management (Table 8). There are different recommendations related to the suggested mean arterial pressure (MAP) level in SCI patients. No specific infusion or inotropes were suggested for maintaining MAP and perfusion. The overall level of evidence was low.

Management of hemostasis

Fourteen recommendations informed the hemostasis management of SCI patients (Table 9). There were four recommendations related to the use of low-molecular-weight heparin early after SCI. Mechanical compression devices were also recommended as adjunct therapy (n=4). Inferior vena cava (IVC) filter was not recommended unless the bleeding is anticipated to last over 72 hours (n=2). There were two recommendations with the high overall evidence base. Most of the recommendations had a low evidence base (n=9).

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Table 8.

Recommendations for blood pressure management in patients with acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base
Target blood pressure (adults)	In patients at risk of SCI, it is probably recommended to maintain a systolic blood pressure level > 110 mmHg, before the injury assessment is performed, to reduce mortality (Roquilly et al., 2020)	Grade 2+	Low
Mean Arterial Pressure (MAP)	Management of patients with acute SCI in a monitored setting is recommended. Maintaining a MAP of 85-90 mmHg after SCI is recommended (Walters et al., 2013)	Level III	Low
	In patients with suspicion of SCI, experts suggest maintaining MAP level up to 70 mmHg during the first week to limit the risk of worsening of the neurological deficit (Roquilly et al., 2020)	Expert opinion	Low
	MAP augmentation with norepinephrine (if needed) is recommended for at least the first 72 hours following injury to a maximum of 7 days. • Goal MAP ≥ 85 mmHg for blunt / incomplete penetrating injury • Goal MAP ≥ 65 mmHg for complete penetrating injury (Birrer et al., 2018)	Class III	Low
Anesthetic concerns in acute SCI	Maintain MAP and perfusion with a balance of infusion and inotropes (Consortium for Spinal Cord Medicine, 2008)	Expert opinion	Low

Table 9.

Management of hemostasis in patients with an acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base
Low-molecular heparin/unfractionated heparin indication	Clinicians must begin low-molecular-weight heparin/unfractionated heparin early after SCI, when there is no contraindication (Kessler et al., 2018)	Level 1	High
	For major trauma patients, use low-dose unfractionated heparin, low-molecular heparin, or mechanical prophylaxis, preferably with intermittent pneumatic compression, over no prophylaxis (Gould et al., 2012)	High - Low	High-Low
	Chemical venous thromboembolism (VTE) prophylaxis, with unfractionated heparin, should be initiated within 24 hours of injury (Birrer et al., 2018)	Class II/III	Moderate-low
	Begin low molecular weight heparin, or unfractionated heparin plus intermittent pneumatic compression, in all patients when primary hemostasis becomes evident. Intracranial bleeding, perispinal hematoma, or hemothorax are potential contraindications to the administration of anticoagulants, but anticoagulants may be appropriate when bleeding has stabilized (Consortium for Spinal Cord Medicine, 2008; DynaMed, 2018)	Level I/IV	High-low

Compression device indication	Clinicians must consider compression devices to prevent VTE after SCI (Kessler et al., 2018)	Level 1	High
	For major trauma patients at high risk for VTE (including those with acute SCI, traumatic brain injury, and spinal surgery for trauma), authors suggest adding mechanical prophylaxis to pharmacologic prophylaxis when not contraindicated by lower-extremity injury (Gould et al., 2012)	Very low	Low
	For major trauma patients in whom low-molecular heparin and low-dose unfractionated heparin are contraindicated, authors suggest the use mechanical prophylaxis, preferably with intermittent pneumatic compression, over no prophylaxis when not contraindicated by lower-extremity injury. Add pharmacologic prophylaxis with either low-molecular heparin or low-dose unfractionated heparin when the risk of bleeding diminishes or the contraindication to heparin resolves (Gould et al., 2012)	Moderate-Low	Moderate-Low
	Apply mechanical compression devices early after injury (Consortium for Spinal Cord Medicine, 2008; DynaMed, 2018)	Levell I/II	High-moderate
Inferior vena cava (IVC)	For major trauma patients, authors suggest that an IVC filter should not be used for primary VTE prevention (Gould et al., 2012)	Low-Very low	Low
	Consider placing a vena cava filter only in those patients with active bleeding are anticipated to persist for more than 72 hours and begin	Level III/IV	Low

	anticoagulants as soon as feasible (Consortium for Spinal Cord Medicine, 2008; DynaMed, 2018)		
Venous compression ultrasonography	For major trauma patients, periodic surveillance with venous compression ultrasonography (VCU) should not be performed (Gould et al., 2012)	Low	Low
Initial assessment on admission	Initial assessment of all patients on admission should include the following: • baseline calf and thigh measurements to allow early detection of DVT (Royal College of Physicians et al., 2008)	Level III/IV	Low
Care planning	All patients with SCI admitted to hospital should have a written care plan which includes: • commencing thromboembolic prophylaxis if immobilised with bed rest or admitted for medical illness or surgery (as per hospital policy) including: o thromboembolism deterrent (TED) stockings unless contraindicated o low molecular weight heparin (Royal College of Physicians et al., 2008)	Level III/IV	Low
Patient monitoring	The possibility of deep vein thrombosis (DVT) should be considered in any patient with established SCI admitted to hospital (Royal College of Physicians et al., 2008)	Level III/IV	Low

Vertebral Arterial Injury Therapy

There were two recommendations regarding vertebral arterial injury (VAI) management (Table 10). There were no recommendations related to a specific therapy that should be carried out to address VAI. Instead, VAI management should be individualized.

Table 10.

Therapy for Vertebral arterial injury in patients with an acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base
Management of Vertebral Arterial Injury therapy (VAI)	It is recommended that the choice of therapy for patients with VAI, anticoagulation therapy vs antiplatelet therapy vs no treatment, be individualized based on the patients' VAIs, their associated injuries, and their risk of bleeding (Walters et al., 2013)	Level III	Low
	The role of endovascular therapy in VAI has yet to be defined. No recommendation regarding its use in the treatment of VAI can be offered (Walters et al., 2013)	Level III	Low

Neuroprotective Agents

Recommendations for neuroprotective agents

We found eleven recommendations associated with neuroprotective agents (Table 11). The overall evidence base varies. Two recommendations were identical and related to steroids failing to improve functional recovery. The overall quality of the evidence base for general steroid administration was rated as high to low. There were conflicting recommendations for and against administering methylprednisolone. The overall quality of the evidence base for methylprednisolone administration was moderate. One recommendation informed against the use of GM1 (monosialotetrahexosylganglioside) ganglioside supported by high overall evidence base.

Table 11.

Recommendations for neuroprotective agents in patients with an acute spinal cord injury

Focus Area	Recommendation Detail	Level of Evidence	Overall Evidence Base
General Principles of corticosteroid administration	After post-traumatic SCI, it is not recommended to administrate steroids early on to improve the neurological prognosis (Roquilly et al., 2020)	Grade 1-	High
	No clinical evidence exists to definitively recommend the use of any neuroprotective pharmacologic agent,	Expert opinion	Low

	including steroids, in the treatment of acute SCI to improve functional recovery (Consortium for Spinal Cord Medicine, 2008)		
Use methylprednisolone as part of initial management of SCI	High-dose IV methylprednisolone ≤ 8 hours after SCI might not improve motor function and may increase the risk of adverse events. It might slightly improve motor function, but the evidence is limited (DynaMed, 2020)	Level 2	Moderate
	Authors suggest a 24-hour infusion of high-dose MPSS be offered to adult patients within 8 hours of acute SCI as a treatment option (Fehlings et al., 2017)	Moderate	Moderate
	Authors suggest not offering a 24-hour infusion of high-dose MPSS to adult patients who present after 8 hours with acute SCI (Fehlings et al., 2017)	Moderate	Moderate
Avoid methylprednisolone and other neuroprotective agents completely	Administration of methylprednisolone for the treatment of acute SCI is not recommended (Walters et al., 2013; Hurlbert et al., 2013)	Class I	High
	Use of high-dose methylprednisolone is not recommended (Birrer et al., 2018)	Class II/III	Moderate-low
	If it has been started, stop administration of methylprednisolone as soon as possible in neurologically normal patients and in those whose prior neurologic symptoms have resolved to reduce deleterious side effects (Consortium for Spinal Cord Medicine, 2008)	Expert opinion	Low
	Authors suggest not offering a 48-hour infusion of high-dose MPSS to adult patients with acute SCI (Fehlings et al., 2017)	Expert consensus	Low
	Do not use the following medications, aimed at providing neuroprotection and prevention of secondary deterioration, in the acute stage after acute traumatic SCI:		

	• methylprednisolone • nimodipine • naloxone (National Clinical Guideline Centre UK, 2016)		
GM-1 ganglioside administration	Administration of GM1 ganglioside (Sygen) for the treatment of acute SCI is not recommended (Walters et al., 2013; Hurlbert et al., 2013)	Class I	High

DISCUSSION

We reviewed twelve CPGs that contain acute in-hospital SCI management in the following areas: respiratory management, hemodynamic abnormality management, and neuroprotective agents. CPGs are essential evidence-based tools used by healthcare providers in clinical decision-making. CPGs incorporate scientific evidence in health decision-making, improving both the quality of care and patient outcomes. This scoping review highlights the need for up-to-date, high-quality, and consistent CPGs for the care of patients with SCI.

CPGs require regular updates to maintain the validity of the recommendations due to the constant change in scientific knowledge. Some authors suggest that CPGs should be updated every three years (Vernooij et al. 2014). Despite this, there were only six CPGs that were published in the last five years, with only three that explicitly described guidance about the updating process.

Twelve CPGs were evaluated in this study using the AGREE II tool. Seven out of twelve CPGs were recommended for use, four were not recommended, and one was recommended with modification. The following domains scored the highest average score: "Clarity of Presentation," "Scope and Purpose," and "Editorial Independence." This demonstrates that the recommendations were specific to the target population and were free from the influence of the funding body. Domain 5 "Applicability" and domain 2 "Stakeholder Involvement" scored the lowest average score. The key strategies, barriers, and facilitators to implementation, as well as the resource implications of implementing the guidelines, were not clearly stated in the published CPGs. These gaps are essential CPG attributes that promote the uptake and use of the recommendations in clinical practice. Shifting the focus on how to effectively implement the guidelines can help reduce the notable lag time in implementing the CPGs into practice (Beauchemin, et al, 2019).

In areas where the development of CPGs is challenged by limited available evidence, expert consensus statements are often developed to guide healthcare professionals in decision-making. In this study, most of the recommendations were made based on expert consensus. Most of these expert consensus statements were classified as low evidence-based because the methods of consensus development were not stated. CPGs should clearly state the evidence used to support the expert consensus statement, such as rigorous systematic reviews of the available evidence, to deem the recommendations as evidence-based (Kwong, et al, 2016).

After the primary insult leading to SCI, the tissue damage continues due to the body's inflammatory response (David et al., 2012). Neuroprotective agents such as methylprednisolone have been used with the hopes of neutralizing the extent of secondary tissue damage through its anti-inflammatory effect (Breslin & Agrawal, 2012; Canseco et al, 2021; Falavigna et al., 2018). However, the use of methylprednisolone has become controversial because of the risk of serious adverse effects (Breslin & Agrawal, 2012; Chikuda et al., 2014; Evaniew et al., 2015). In this review, the recommendations were inconsistent concerning the use of methylprednisolone. Seven recommendations were against the use of methylprednisolone for the treatment of acute SCI. In contrast, one AOSpine recommendation based on a moderate level of evidence suggested a 24-hour infusion of high-dose methylprednisolone to treat acute SCI patients within 8 hours of injury, without, however, presenting new evidence (Fehlings et al, 2017).

The results of the National Spinal Cord Injury Studies (NASCIS) trials have been the basis for the use of methylprednisolone in patients with acute SCI. Results from these large-scale, multicenter clinical trials suggested the efficacy of methylprednisolone in mitigating the neurologic effects of SCI (Bracken et al., 1990; Bracken et al., 1993; Bracken et al., 1997). Patients who received methylprednisolone within 8 hours of injury demonstrated recovery in motor and sensory functions (Bracken et al., 1997). The 2012 Cochrane Database of Systematic Reviews also suggested the same (Bracken et al., 2012). Despite these studies supporting the neuroprotective benefits of methylprednisolone, numerous CPGs were published against its use.

In 2008, the Consortium for Spinal Cord Medicine recommended against the use of methylprednisolone despite the improved motor and sensory scores shown in the NASCIS trials (Consortium for Spinal Cord Medicine, 2008). The results of the trials cannot be generalized because they did not consider the potential confounding variables, such as the extent of rehabilitative therapies received by the participants, that may have affected the result of the study. Furthermore, the post hoc analysis of the trials also failed to show sensory and motor improvements, attributing the improved neurologic scores to random events (Consortium for Spinal Cord Medicine, 2008).

In 2013, Hurlbert et al. also recommended against the use of methylprednisolone in SCI due to the lack of compelling evidence and its associated complications. Two major errors were noted in class III studies that supported the beneficial effects of methylprednisolone: (1) methodological errors (limited sample size and incomplete data which may have skewed the results in favor of methylprednisolone use) and (2) inconsistent beneficial effects (some studies showing sensory improvement but not motor improvement or vice versa) (Hurlbert et al., 2008). Class 1 studies also showed significant side effects with methylprednisolone use, including wound infection, GI hemorrhage, and hyperglycemia (Hurlbert et al., 2013).

The National Clinical Guideline Centre (UK) also recommended against methylprednisolone administration due to the lack of large enough motor score improvement and the significantly increased risk of adverse events (2016). Although the six randomized controlled trials (RCTs) showed improved motor scores in patients who

received methylprednisolone, generalizations of its benefit on individual patients cannot be made due to the following: (1) weaknesses in the scoring system used in the studies, failing to take into account the several improvements that occur across the body (2) the lack of ability to determine whether the improvement has any impact on the individual patient.

In 2017, Fehlings et al. focused on examining a 24-hour versus 48-hour administration of methylprednisolone within 8 hours after the injury. Fehlings et al. recommended the administration of high-dose methylprednisolone within 8 hours post-injury for 24 hours. The study recognized the minimal motor improvement with methylprednisolone use, but this minimal recovery may have a substantial impact on the patient's quality of life (Fehlings et al., 2017). Moreover, the cost-effectiveness of the drug and the lack of significant differences with the control group further supported their recommendation (Fehlings et al., 2017).

In the subsequent years, numerous studies evaluated the therapeutic versus adverse effects of methylprednisolone use. Studies on the effectiveness of methylprednisolone use unanimously reported its insignificant improvement in motor scores and the significantly higher incidence of adverse events (Canseco et al., 2021). A meta-analysis done in Japan and Canada showed that patients who received high-dose methylprednisolone had a significantly increased risk of complications, including gastrointestinal hemorrhage (Chikuda et al., 2014; Evaniew et al., 2015). In a recently published meta-analysis including 3 randomized controlled trials and 13 observational studies, the use of methylprednisolone was not associated with increased motor or sensory recovery (Liu et al., 2019). In addition, studies also showed a significantly higher incidence of adverse events, including respiratory tract infection and hyperglycemia (Liu et al., 2019; Sultan et al., 2020). However, patients with SCI may favor the administration of methylprednisolone. Bowers et al. (2016) conducted a survey of 77 persons with chronic SCI and reported that almost 60% regarded the small neurological benefits of methylprednisolone as "very important" despite the potential side effects.

Despite evidence on the side effects associated with methylprednisolone in acute SCI, its use remains common. A cross-sectional study on steroid prescription by spine surgeons worldwide found that more than half (52.9%) use methylprednisolone to treat acute SCI (Falavigna et al., 2018). In Latin America, the use of methylprednisolone was attributed to the belief in its efficacy, fear of litigation, and outdated hospital protocols. The prescription rate of methylprednisolone drastically declined in Poland from 73% in 2013 to 27% in 2018 (Miekisiak et al., 2018). This change in practice pattern was attributed to the critical appraisal of available clinical evidence and guideline formulation by professional organizations. There were no recent data on the rate of methylprednisolone use in Canada since the last study was conducted in 2008 (Hurlbert et al., 2008). The recently published Can-SCIP Guideline recommendations did not contain any recommendations regarding neuroprotective agents for treating acute management of SCI ("Can-SCIP", 2021).

CONCLUSION

The CPGs in the management of acute SCI are overall based on low-quality evidence. The guidance around updating the recommendations of the CPGs is poor, which lead to limited CPGs published in recent years. The guidance for the applicability and stakeholder involvement were also inadequately described in the existing CPGs. Acute SCI guidelines must be more explicit in stating their applicability during implementation and should also consider their resource implication. More evidence is needed to recommend for or against using methylprednisolone as a neuroprotective agent. Thus, there is a need for updated SCI research studies including clinical trials on methylprednisolone use to support guideline development.

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Disclosures: Declarations of interest, none.

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Appendix A.

Overall Quality of Evidence

Quality	Level of Evidence (per Recommendation)	Definition (per Recommendation)
High	Level I	High-quality randomized controlled trial (RCT) with statistically significant difference or no statistically significant difference but narrow confidence intervals OR systematic review of Class I RCTs (and study results were homogenous) (Walters, 2013).
	Grade 1+/-	High level of evidence: further research is very unlikely to change the confidence level in the estimate of the effect (Roquilly et al., 2020).
	Level I	Evidence based on RCTs (or meta-analysis of such trials) of adequate size to ensure a low risk of incorporating false-positive or false-negative results (Consortium for Spinal Cord Medicine, 2008).
	Strong	Based on the available evidence, clinicians (without conflicts of interest) consistently have a high degree of confidence that the desirable consequences (health benefits, decreased costs and burdens) outweigh the undesirable consequences (harms, costs, burdens) (DynaMed, 2018).
	Class I	Evidence from one or more-well designed, RCTs, including overviews of such trials (Congress of Neurological Surgeons, 2022).
	High	Further research is very unlikely to change our confidence in the estimate of effect (National Clinical Guideline Centre UK, 2016; Balshem et al., 2011; Guyatt et al., 2008).
	Class I	Prospective RCTs (Birrer et al., 2018).
	Level I	Incorporates Oxford Centre for Evidence-Based Medicine (OCEBM) levels of evidence 1a, 1b. Usually involves meta-analysis of trials (RCTs) OR a good-quality RCT OR "all or none" studies in which treatment is not an option (Elliott & Gomez, 2017) (Elliott & Gomez, 2017).
	IA, IB	Meta-analysis of RCTs or inception cohort studies OR at least 1 RCT or well-designed cohort study with

		group follow-up (Royal College of Physicians et al., 2008).
	Level 1	Representing research results addressing clinical outcomes and meeting an extensive set of quality criteria which minimizes bias (DynaMed, 2020).
Moderate	Level II	Lesser-quality RCTs (eg, <80% follow-up, no blinding, or improper randomization) OR prospective comparative study OR systematic review of Class II studies of Class I studies with inconsistent result OR case-control study OR retrospective comparative study OR systematic review of Class II studies (Walters, 2013).
	Level II	Evidence based on RCTs that are too small to provide level I evidence. These may show either positive trends that are not statistically significant or no trends and are associated with a high risk of false-negative results (Consortium for Spinal Cord Medicine, 2008).
	Class II	Evidence from one or more well-designed comparative clinical studies, such as non-randomized cohort studies, case-control studies, and other comparable studies, including less well-designed RCTs (Congress of Neurological Surgeons, 2022).
	Moderate	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate (National Clinical Guideline Centre UK, 2016; Balshem et al., 2011; Guyatt et al., 2008).
	Class II	Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies (Birrer et al., 2018).
	Level II	Incorporates OCEBM levels of evidence 2a, 2b and 2c. Includes low-quality RCTs (<80% follow-up) OR meta-analysis (with homogeneity) OR good-quality prospective cohort studies. May include a single group when individuals who develop the condition are compared with others from within the original cohort group. There can be parallel cohorts, where those with the condition in the first group are compared with those in the second group (Elliott & Gomez, 2017).
	Level IIA, IIB	At least 1 well designed controlled study without

		randomization or a meta-analysis of case control studies OR at least one study with quasi experimental design or case control study (Royal College of Physicians et al., 2008).
	Level 2	Representing research results addressing clinical outcomes, and using some method of scientific investigation, but not meeting the quality criteria to achieve Level 1 evidence labeling (DynaMed, 2020).
Low	Level III	Case series OR expert opinion (Walters, 2013).
	Grade 2+/-	Low level of evidence: further research is very likely to have an impact on confidence in the estimate of the effect and is likely to change the estimate of the effect itself (Roquilly et al., 2020).
	Level III	Randomized or nonrandomized observational or registry studies with limitations OR meta-analyses OR meta-analyses of such studies OR physiological or mechanistic studies, based on nonrandomized, controlled or cohort studies, case series, case-controlled studies, or cross-sectional studies (Consortium for Spinal Cord Medicine, 2008).
	Level IV	Evidence based on the opinion of respected authorities or of expert committees as indicated in published consensus conferences or guidelines (Consortium for Spinal Cord Medicine, 2008).
	Level V	Evidence that expresses the opinion of those individuals who have written and reviewed this guideline, based on experience, knowledge of the relevant literature, and discussions with peers (Consortium for Spinal Cord Medicine, 2008).
	Weak	Based on the available evidence, clinicians believe that desirable and undesirable consequences are finely balanced, or appreciable uncertainty exists about the magnitude of expected consequences (benefits and harms). Weak recommendations are used when clinicians disagree in judgments of relative benefit and harm or have limited confidence in their judgments. Weak recommendations are also used when the range of patient values and preferences suggests that informed patients are likely to make different choices (DynaMed, 2018).
	Level III	Evidence from case series, comparative studies with

		historical controls, case reports, and expert opinion, as well as significantly flawed RCTs (Congress of Neurological Surgeons, 2022).
	Low	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate (National Clinical Guideline Centre UK, 2016; Balshem et al., 2011; Guyatt et al., 2008).
	Very low	Many estimate of effect is very uncertain (National Clinical Guideline Centre UK, 2016; Balshem et al., 2011; Guyatt et al., 2008).
	Class III	Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion (Birrer et al., 2018).
	Level III	Incorporates OCEBM levels of evidence 3a, 3b, and 4. Includes good-quality retrospective case-control studies, where a group of patients who have a condition are matched appropriately with control individuals who do not have the condition OR good-quality case series, where a complete group of patients, all with the same condition, disease or therapeutic intervention, are described without a comparison control group (Elliott & Gomez, 2017).
	Level IV	Incorporates OCEBM levels of evidence 4. Includes expert opinion, where the opinion is based not on evidence but on "first principles" or bench research. Th Delphi process can be used to give expert opinion greater authority (Elliott & Gomez, 2017).
	Level III	At least 1 non-experimental study (eg descriptive study) (Royal College of Physicians et al., 2008).
	Level IV	Expert committee reports or reports by recognized authorities (Royal College of Physicians et al., 2008).
	Level 3	Representing reports that are not based on scientific analysis of clinical outcomes. Examples include case series, case reports, expert opinion, and conclusions extrapolated indirectly from scientific studies (DynaMed, 2020).
	Expert consensus	