

# Curbing the Challenges in Recent Treatment Guideline for Early Management of Individuals with Traumatic Spinal Cord Injury: Recommendation for Therapeutic Hypothermia

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors SSE and CIU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript.*

*Authors SSE, KIO and COO managed the analyses of the study. Authors SSE, KIO and FOI managed the literature searches. All authors read and approved the final manuscript.*

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## **ABSTRACT**

**Background:** There has been little prognosis in improving function after a complete spinal lesion. The viewpoint that little can be done to improve motor function after complete SCI seems conceptually and scientifically part of the past. With advance in medicine, better neurological outcome is long expected.

**Objectives:** The purpose of this review is to explore the challenges in recent treatment guidelines' for early management of patient with TSCI and to draw recommendation for Therapeutic hypothermia.

**Methods:** We conducted a scoping study review comprising 28 studies (2010 to 2020) to identify and examine the research literature related to challenges' in recent treatment guidelines' for early management of patient with TSCI.

**Findings:** 28 studies were reviewed. Most cited challenges were surgical timing (26%), followed by controversy on the application of MPS (28.6%). In each of the studies, various challenges of acute stage interventions were outline with poor common standards and recommendations for clinical practices. Surgical decompression (16 papers) was the most cited intervention. Generally, result showed that despite the progress that has been made in the acute management of patients with SCI, neurological outcomes have not improved significantly in recent decades.

**Conclusion:** Key early interventions are increasingly being recognized; combined Neuroprotective and neuroregenerative care are probably more effective and they inspire current and future research. We concluded that an evidence based guidelines for TH would help reduce the doom experience around complete SCIs. Thus there is a need to better define the beneficial effect of TH on the injured SCI.

*Keywords: Traumatic spinal cord injury; emergency care; treatment guideline; therapeutic hypothermia.*

## ABBREVIATIONS

TSCI	: Traumatic Spinal Cord Injury
TH	: Therapeutic Hypothermia
MPS	: Methylprednisolone
SCIWORA	: Spinal cord injury without radiological abnormality
SCIWORET	: Spinal cord injury without radiological evidence of trauma

## 1. INTRODUCTION

According to the World Health Organisation (WHO, 2013), there is no reliable estimate of global prevalence of Spinal Cord Injury (SCI), but it is estimated that annual global incidence varies from 40 to 80 cases per million population, which means between 250,000 to 500,000 people sustain SCI every year. The prognosis of patients with neurological disorders in Africa is far from reproducible parameters. Oftentimes, these conditions produce devastating physical, social, and vocational impairment. Etiologically, more than 90% of SCI cases are traumatic and caused by incidences such as traffic accidents, violence, sports or falls. SCI has been associated with very high mortality rates. Yet today, only in developed countries, SCI can be viewed less as the end of a worthwhile or productive life and more as personal and social challenges that can be successfully overcome [1].

SCI is a medically complex and life-disrupting trauma, often tagged to be one of the greatest calamities that can befall man [2]. It is described as damage to the spinal cord, conus medullaris and cauda equina that causes temporary or permanent loss in its sensory, motor and/or autonomic function in the parts of the body served by the spinal cord below the level of the injury [3]. Damage to the spinal cord may be

traumatic or non-traumatic. Traumatic SCI can result from many different causes – including falls, road traffic injuries, occupational and sports injuries, and violence. Non-traumatic SCI, on the other hand, usually involves an underlying pathology – such as infectious disease, tumour, musculoskeletal disease such as osteoarthritis, and congenital problems such as spina bifida [1].

The extent and severity of sensory, motor and autonomic loss from SCI depends not only on the level of injury to the spinal cord, but also on whether the lesion is complete or incomplete and time of intervention [3]. According to the American Spinal Injury Associations (ASIA) classification of SCI, an SCI is considered complete if there is no sensory and motor function at S4–S5, while some sensory and or motor function is preserved below the level of injury in incomplete SCI [1]. While considerable function can be recovered if the injury is 'incomplete', there has been little prognosis in improving function after a motor and/or sensory complete lesion. Presently, literature holds that, those with a complete SCI are unlikely to regain function below the level of injury [4,5].

### 1.1 What Goes Wrong in a TSCI?

The pathophysiology of TSCI all begins with an impact on the spine that fractures or dislocates

vertebrae. The initial mechanical forces delivered to the spinal cord at the time of injury is referred to as primary injury where “displaced bone fragments, disc materials, and/or ligaments bruise or tear into the spinal cord tissue” [6]. Followed by associated spinal cord contusion or laceration, petechial hemorrhage formation, axonal shearing, and vascular disruption [7]. The most common form of primary injury is impact plus persistent compression, which typically occurs through burst fractures with bone fragments compressing the spinal cord or through fracture-dislocation injuries [7,8]. Regardless of the form of primary injury, these forces directly damage ascending and descending pathways in the spinal cord and disrupt blood vessels and cell membranes [9]. Causes spinal shock, systemic hypotension, vasospasm, vasoconstriction and vascular thrombosis, ischemia, cellular ionic imbalance, free radical formation, increased interstitial pressure, release of vaso-active protein, cellular membrane lipid peroxidation, excite toxic glutamine release and neurotransmitter accumulation [10,11]. Overall, the extent of the primary injury determines the severity and outcome of SCI [12,13].

## **2. CHALLENGES IN TSCI CLINICAL GUIDELINE**

Spinal cord injury need not be a death sentence. The perspective that slight chances of improvement in motor function after complete SCI seems conceptually and scientifically part of the past, not the present. But this requires effective emergency response and proper rehabilitation services, which are currently the focus of research.

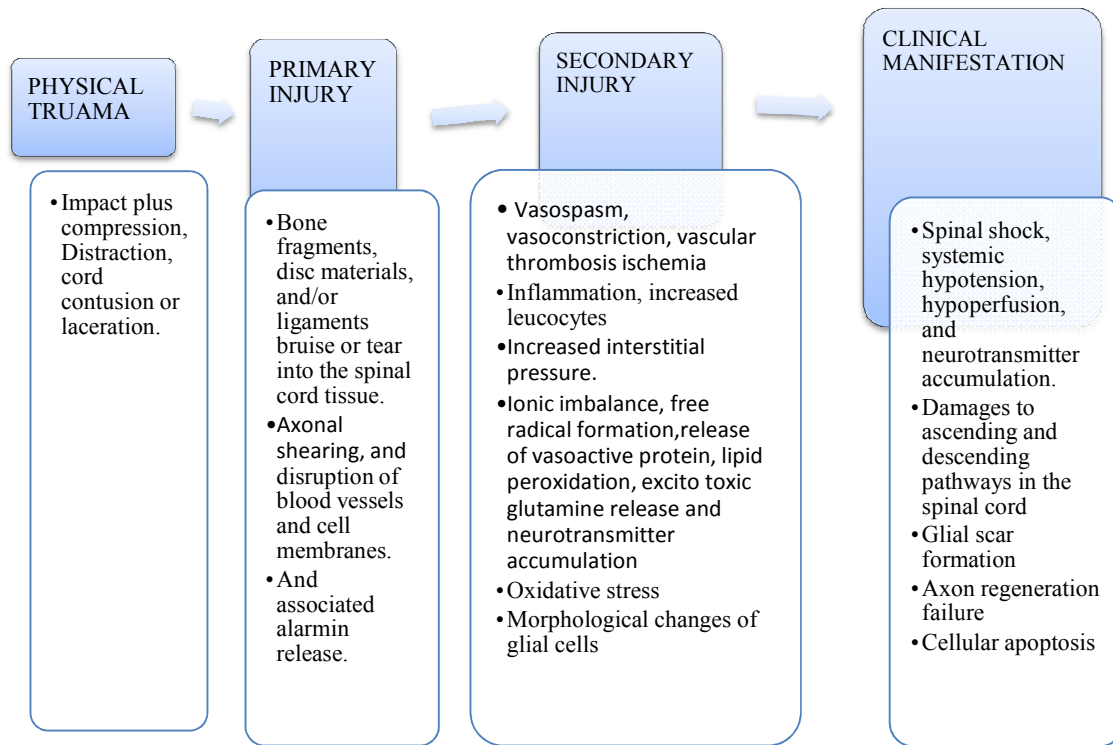
To date, the most effective clinical treatment to limit tissue damage following primary injury is early surgical decompression (< 24 h post-injury) of the injured spinal cord [12,13]. However, in several occasions, many factors pose challenges to the feasibility of having this surgical intervention within the safe period. There is few other advanced line of care following TSCIs but most of these lacks enough class1 evidence in the literature or are yet to be properly translated to clinical practice. Such treatment guidelines from advances in medicines include; Cryosurgery: Aimed at correcting the inflammatory effect, Spinal stimulation: aim at restoring motor functions, and cell mediated therapy.

Other classical lines of care after early surgical decompression have shown little or no clinical

benefit. For instance, the most emphasized routine spinal immobilization in trauma patients which was believed to be the best way to prevent further injury to the spinal cord following a traumatic injury [14], and, that it was in the best interests of all patients whose injuries had not yet been assessed. However, this recommendation is true for checking against more mechanical damages especially in an incomplete or a SCI without radiological abnormalities (SCIWORA) and in SCI with no radiological evidence of trauma (SCIWORET). In a potential complete SCI, this recommendation is without enough evidence [15]. It has been suggested that the risk of neurological injury due to inadequate immobilization may be over-estimated [16]. Excluding mechanical injury, there are well established mechanisms for spinal injury progression. This includes; (see Fig. 1.) haematoma, cord oedema, hypotension, inflammation and vascular changes such as reduced microcirculation [17,18]. Therefore, it is critical to understand the cellular and molecular mechanisms of SCI and develop new effective treatments for this devastating condition.

Thumbikat et al. [18] highlighted the cases of several patients, including a patient who had a fall on steps and fractured his cervical spine. The ambulance crew placed him in a hard collar and scoop stretcher while he was transported to the hospital. On admission, his powers were preserved and normal in all limbs. During 6-person inline transfer to another specialist unit, he suffered an abrupt shooting pain in one side of the body and there was an abrupt reduction in blood pressure. He became tetraplegic and later ended with a partial recovery. This scenario demonstrates that a standard spinal immobilization protocol can be quite harmful to some patients [18].

Literature has also ruled out the options of using Intravenous (IV) methylprednisolone [19]. A bottom-line finding is a timely, appropriate pre-hospital management, neuroprotective strategies, quick recognition of suspected spinal cord injury, rapid evaluation and initiation of injury management, prevention of associated complications and individualized patient-targeted rehabilitation programs provided by a specialized interdisciplinary team are crucial to optimize the outcome after SCI [20]. However, there is a gap in the role of physiotherapy care, as it is presently being limited to the rehabilitation phase in SCI with gap in its potential acute neural care.



**Fig.1. Primary and secondary injury mechanism after TSCI**

Physiotherapy principles will suitably initiate neuroprotective strategies through the use of therapeutic hypothermia. An acute TSCI, like every other acute injury to the body tissues [21,22], could benefit from localized therapeutic hypothermic care [23,24,25]. The final extent of the spinal cord damage results from primary and secondary mechanisms that start at the onset of the injury and goes on for days, and even weeks, after the event. The right treatment from the onset may help decrease the healing time and prevent further complications. The early stages of the secondary injury are thought to be critical areas where medical intervention can benefit the patient [26,27].

It is thus paramount, instead of trusting the recovery of neurological functions to fate in a postural reduction or immobilization, much emphasis should rather be placed on arresting the ongoing pathophysiological process. This work aims to recommend a localized therapeutic hypothermia as a potential focus in the treatment guideline for acute care in TSCI.

### 3. STUDY OBJECTIVE

The objectives of this scoping review are: [1] to collate and appraise all available published

literature, which understudies recent treatment guidelines' for managing patient with TSCI [2]. To elucidate the pathophysiology of TSCI and unravel the underlying cellular and molecular mechanisms of tissue degeneration and repair in the injured spinal cord [3]. To outline common standards and supporting evidence for the neurological care of patients within the first year after SCI [4]. To explore prevention strategies, and the evidence in literature on the effectiveness of the various treatment choices, including their challenges, and; [5] to draw out an evidence and recommendations for localized therapeutic hypothermia; as a key addition in the treatment guidelines following a TSCI.

### 4. REVIEW OF CURRENT TREATMENT GUIDELINE

The methodologically guidelines for scoping study, as proposed by Arksey and O'Malley [28] will be used for this review to conduct a comprehensive and systematic search of the literature and to draw out an evidence and recommend localized therapeutic hypothermia; to be considered as a key addition in the treatment guidelines following a TSCI. This review follows the six-stage scoping review framework outlined by Arksey and O'Malley [28].

#### **4.1 Stage One: Identify the Research Question**

A five-part research question will be in focus: World Health Organization [1] what is the pathophysiology of TSCI and the underlying cellular and molecular mechanisms of tissue degeneration and repair in the injured spinal cord? Azeez AL et al. [2] what are the common standards and supporting evidence for the neurological care of patients with TSCIs? Singh A et al. [3] what are the challenges in the recent early neurological care of patients with TSCIs? Waters RL et al. [4] how does interdisciplinary neurological team address the pathophysiology of TSCI? And [5] will a localized therapeutic hypothermia following a TSCI help in improving the clinical outcomes of TSCIs?

#### **4.2 Stage Two: Identify Relevant Studies**

With a comprehensive search of the literature, relevant peer reviewed journals articles published between (2010-2020) were sought from the following eight [8] electronic databases; AMED, Cochrane databases, PubMed, PubMed Central, MEDLINE, ProQuest, Embase, Web of Science Core Collection. The key search terms included: 'traumatic spinal cord injury AND emergency OR Acute OR early AND care OR management OR treatment OR intervention AND challenges OR controversies AND guideline OR recommendation'.

In addition, a thorough search of the reference lists of selected articles was undertaken and the use of Google Scholar to access any other primary sources and full text versions of articles was utilized. We exported all literature sources from each of the database searches into a references and bibliographic management software program.

#### **4.3 Stage Three: Study Selection**

The inclusion criteria are as follows; (1) articles written in English; (2) published original peer-reviewed journals; (3) those with an approved ethics statement; (4) studies which investigates guidelines in early neurological care for TSCIs; and (5) in a population sample of TSCIs only.

For the purpose of this study, exclusion criteria include; (1) Articles that were considered poorly conducted; (2) extremely small sample sizes; (3) articles examining the various interdisciplinary

care for TSCIs but without direct focus on neurological outcomes.

The second author reviewed each paper with the lead author to decide whether it should be included. Using the above key search terms, we identified 3462 articles across the eight databases. Of which, 28 were included in this review (see Fig. 2).

#### **4.4 Stage Four: Charting the Data**

The fourth stage involved developing a framework for data charting. A summarizing process, in a standardized manner, was executed as described by Arksey and O'Malley [28]. A data charting table was used for summarizing each primary reviewed article by; author, year, country of origin, study aim, early neurological care, challenges in the neurological care outlined, study design, study methods and sample size, an abridged summary of the findings and limitations for each study.

The second reviewer then validated the data by reviewing each selected article based on the inclusion/exclusion criteria; an agreement was reached on the information presented in Table 1.

#### **4.5 Stage Five: Collating, Summarizing and Reporting Results**

This fifth stage of the review involved collating the various interdisciplinary spinal neurological interventions, including their challenges into themes (Table 2). This is based on the development of the themes on a low inference simple qualitative descriptive approach recommended by Sandelowski and Leeman 2012 [7], and then uses the themes to summarize the challenges in early neurological care for TSCIs captured in the selected literature under review. Reporting involved recommending for an individualized physiotherapy administered therapeutic hypothermia following a TSCI as a key addition to guidelines for the early neurological care of TSCIs.

#### **4.6 Stage Six: Consultation Exercise**

The sixth and final stage of this review involved a consultation meeting with the healthcare team members involved in the care of TSCI. The 18-man consultation panel was made up with Two (2) consultant neurologists, one (1) nurse, one (1) laboratory scientist, one (1) statistician, two (2) informed TSCI patients, Nine (9)

physiotherapists and the three authors (physiotherapists). Discussions on further studies were made and agreement to exclude them from the scoping review was made.

## 5. RESULTS

Twenty-eight (28) studies (Table 1) were reviewed. Most [19] of the studies were systematic reviews of current literature. Four studies used prospective methods, 2 studies both used retrospective and reviews of guideline, and one used cross sectional survey method. In each of the studies, various acute stage interventions were reviewed to outline common standards and recommendations for clinical practices with highlights on their challenges. Various acute stage interventions cited include pre-hospital immobilization and transportation (7 papers), bed reduction (2 papers), hemodynamic stability: Use of vasopressors (7 papers), corticosteroids: MPS (10 papers), neuroprotective strategies: Fibroblast growth factor, minocycline, riluzole, cytokine granulocyte colony stimulating factor, TH (4 papers), neuroregenerative therapies: Embryonic stem cells, Induced pluripotent stem cells, olfactory ensheathing cells, Schwann cells, mesenchymal cells and activated autologous macrophages (2 papers), intubation (2 papers), Surgical decompression (16 papers), surgical fixation and fusion (9 papers), rehabilitation (5 papers), and radiological assessment-MRI (5 papers).

Of the 28 studies reviewed, surgical timing was the most cited challenges (N=12, 42.9%), followed by controversies on the use of MPS (N=8; 28.6%). TH was mentioned as an example of neuroprotective strategies in four of the papers reviewed. Surgical intervention is the most studied intervention. Most of the works were done in Canada; none was carried out in Africa. It was clear across the reviewed articles that no intervention has been successfully implemented to produce replicable neurological outcomes across various presentation of TSCI [13,26-58]. Several challenges and gaps in literatures have been cited to be associated with this lack of standardization of care, decreasing the heterogeneity of management strategies, and poor data for clinicians to make evidence-informed decisions. In the sections that follow, the different multidisciplinary interventions, as well as their themes in the various domains are presented accordingly.

### 5.1 Pre-hospital Immobilization and Transport

Immediately after TSCI what comes to mind is extrication and transportation to the nearest spinal centre. A long standing guideline had been spelt out on best practice for spinal immobilization and transportation. However, these guidelines are not without challenges. Some of the key challenges cited include; lack of class I or II evidence supporting the use of a rigid cervical collar. Rather, worse outcome is gotten in cases with penetrating trauma, because the process of immobilization could delay life-saving resuscitation (N=2, 7.1%). The Challenges with fast and efficient patient care for prompt transfer to a hospital (N=1, 3.6%), mitigates Theodore et al., 2013 [29] recommendation that the most rapid means available should be used to transport patient with an acute cervical TSCI to the nearest capable medical facility with the mode of transportation that is based on the patient's clinical circumstances, distance from target facility, immobilization and respiratory support available during transport. These challenges are worse in developing countries which are characterized with poor access to equipment, lack of knowledge, poor data, poor transportation, and delays to presentation within 8–24 hour (N=3, 10.7%). As such, disparities between the developing and developed worlds capacity to deliver emergency and acute care are most evident immediately following a TSCI [30].

A closely related intervention is postural or bed reduction, which is considered safe and essential in the management of SCI with loss of alignment, at least as an initial step in the overall care [31]. The Challenges cited on postural reduction includes; the risk of tissue necrosis which may occur from pressure of the rigid backboard and collars during prolonged transport, and/or short periods of rigid immobilization. Also, risks of aspiration, pressure sores and increased intracranial pressure (5, 17.9%). Besides, bed reduction is obsolete and now replaced with more aggressive medical and surgical interventions (N=1, 3.6%). No outcome data has sufficed as evidence-based improvement in SCI outcomes for all side of controversy [31]. However, in one of the study by Kornhall et al. [48], there was no reason to abandon the current practice of spinal immobilization in patients with potential SCI, but recommended maintaining a selective approach to the use of the various stabilization devices.

**Table 1. Details of primary studies identified and reviewed**

<b>S/n</b>	<b>Author, year</b>	<b>Country of origin</b>	<b>Study aim</b>	<b>Interventions</b>	<b>Challenges and benefits cited</b>	<b>Study design, methods &amp; sample size</b>	<b>Summary of the findings</b>
1	Thomas m. Kessler et al. 2018 [20]	Switzerland, Canada, Australia	To identify the relevant aspects of the early neurological care emphasizing common standards.	Pre-hospital transportation and immobilization (use of backboard, cervical collar), decompression, fixation/stabilization and fusion, early active rehabilitation, vassopressor, hemodynamic, MPS.	A. Inherent risks and complications in immobilization, such as high risk of aspiration, pressure sores and increased intracranial pressure. B. Poor transportation within 8–24 h C. There is no international consensus for the application of mps. D. Decompression timing	A systematic review of relevant literatures.	Early treatment, prevention of associated complications and individualized patient-targeted rehabilitation programs are crucial to optimize the outcome after sci.
2	J. K. Yue et al. (2017) [45]	USA	To evaluates existing guidelines and updates the evidence for prehospital transport, immobilization, initial resuscitation, critical care, hemodynamic stability, diagnostic imaging, surgical techniques, and timing appropriate	Prehospital transport, immobilization, initial resuscitation, critical care, hemodynamic stability, Diagnostic imaging, surgical techniques	A. Maintenance of mean arterial pressure of > 85 mm hg Optimize neurological outcome B. Risks of increased cardiogenic complication with vasopressors	A review of published guidelines.	Initial management should be systematic, with focus on spinal immobilization, timely transport, and optimizing perfusion to the spinal cord.

<b>S/n</b>	<b>Author, year</b>	<b>Country of origin</b>	<b>Study aim</b>	<b>Interventions</b>	<b>Challenges and benefits cited</b>	<b>Study design, methods &amp; sample size</b>	<b>Summary of the findings</b>
			for the patient with SCI who has multisystem trauma.				
3	Rouanetc et al. 2017 [17]	Brazil	To elucidate current concepts And treatment update in tscis	Surgical decompression, methylprednisolone( mps), Neuroprotective(hypothermia, fibroblast growth factor, minocycline, riluzole, cytokine granulocyte colony stimulating factor), Neuroregenerative therapies ( embryonic stem cells, Induced pluripotent stem cells, olfactory ensheathing cells, Schwann cells, mesenchymal cells, and activated autologous Macrophages)	Mps showed no long-term benefits. Besides, it increases gastrointestinal hemorrhage & has a trend to increase overall adverse events. B.challenges of ongoing recommendation for surgical decompression in the first 24 hours. C. Cellular transplantation remains an investigational and experimental therapy, with no formal recommendations yet.	A literature review, n= 4,346 articles screened.	Key early interventions are increasingly being recognized: combined neuroprotective and neuroregenerative care are probably more effective and they inspire current and future research.
4	Fehlings et al. 2017 [38]	Canada, USA, England	To develop recommendations on the timing of surgical decompression in patients with traumatic SCI and central cord syndrome.	Surgical decompression	There were no significant differences in Length of acute care/rehabilitation stay between treatment groups	A systematic review of literature.	We suggest that early surgery be considered as a treatment option in patients with traumatic central cord syndrome” and “we suggest that early surgery be offered as an



<b>S/n</b>	<b>Author, year</b>	<b>Country of origin</b>	<b>Study aim</b>	<b>Interventions</b>	<b>Challenges and benefits cited</b>	<b>Study design, methods &amp; sample size</b>	<b>Summary of the findings</b>
							option for acute sci.” Quality of evidence for both recommendations was considered low.
5	Fehlings et al. 2017 [40]	Canada, USA, England, Ireland, Japan, Australia	To develop guidelines that outline the appropriate type and timing of rehabilitation in patients with acute SCI.	Rehabilitation	A. A lack Of studies directly evaluating the impact of timing of treatment On the effectiveness of rehabilitation B. Access to Rehabilitation facilities; some centers will not have access to the equipment needed.	A systematic review of the literature	Rehabilitation be offered to Patients with acute SCI when they are medically stable and can tolerate required rehabilitation intensity
6	Fehlings et al. 2017 [34]	Canada	To identify effective methods to Manage SCIs and reduce the extent of future disability	Corticosteroids, surgical intervention, anticoagulation prophylaxis, MRI, and rehabilitation	A. There still controversy on benefit early versus late surgery: as spontaneous improvement could occur, and because decompression of a “fragile” spinal cord could result in neurological worsening. B. The evidence suggesting harmful side effects of mp is more consistent than any suggestion of clinical	Review of recent guidelines	There still remain controversial areas on available strategies for the treatment of SCI, including the use of corticosteroids, the optimal timing of surgical intervention, the type and timing of anticoagulation prophylaxis, the role of MRI, and

S/ n	Author, year	Country of origin	Study aim	Interventions	Challenges and benefits cited	Study design, methods & sample size	Summary of the findings
					<p>benefit.</p> <p>C. Prophylactic treatment in these patients is also associated with significant risks, including symptomatic hematoma formation, enlargement of a spinal cord contusion, worsening of neurologic deficits, bleeding, and mortality.</p> <p>D. Challenges with rehabilitation include a lack of standardization Of interventions, therapeutic doses and outcome measures, heterogeneous populations, superimposed spontaneous recovery, and problems with group assignment.</p> <p>E. Challenges with MRI includes; requires a patient to be supine for up to 30 minutes, may be risky in trauma in critical state, requires substantial resources to ensure 24-hour availability, and may delay surgical intervention.</p>		<p>the type and timing of rehabilitation.</p>

<b>S/n</b>	<b>Author, year</b>	<b>Country of origin</b>	<b>Study aim</b>	<b>Interventions</b>	<b>Challenges and benefits cited</b>	<b>Study design, methods &amp; sample size</b>	<b>Summary of the findings</b>
7	Fehlings et al. 2017 [46]	Canada, USA, Japan	To outline the appropriate use of methylprednisolone sodium succinate (MPSS) In patients with acute SCIs.	Methylprednisolone sodium succinate (MPSS)	Timing of MPSS infusion.	A systematic review of literature.	We suggest a 24-hour infusion of high-dose MPSS be offered to adult patients within 8 hours of acute SCI as a treatment option.
8	Fehlings et al. 2017 [37]	Canada, USA, Japan	To outline the role of MRI in clinical decision making and outcome prediction in patients with traumatic SCI	MRI	Timing of MRI.	A systematic review of literature.	We suggest that MRI be performed in adult patients with acute SCI prior to surgical intervention, to facilitate improved Clinical decision-making" (quality of evidence, very low)
9	Kreinst M et al. 2017 [47]	Germany	To analyze prehospital and emergency room care for patients with acute TSCI and to analyze whether recommendations given by the current guidelines are implemented	Immobilization, timely transport, early surgery	Surgical timing	Retrospective cohort study. N= 133	The current study shows that recommendations of the current literature and guidelines are mostly followed.

<b>S/n</b>	<b>Author, year</b>	<b>Country of origin</b>	<b>Study aim</b>	<b>Interventions</b>	<b>Challenges and benefits cited</b>	<b>Study design, methods &amp; sample size</b>	<b>Summary of the findings</b>
10	Kornhall et al. 2017 [48]	Norway	To provide a national guideline designed to facilitate the prehospital Management of adult trauma victims with potential sci.	Prehospital management (transport, immobilization), spinal stabilization.	A. Paucity of literature supporting spinal stabilization. B. It is logical that spinal stabilization in the critically injured patient may cause serious harm. C. Victims of isolated penetrating injury should not be immobilized. D. There is also evidence suggesting harm from rigid collars. E. Evidence supporting harm from hard surface stretcher. No evidence exploring spinal stability of common stretcher.	Systematic review of available literature and a standardised consensus process. N= 93	The faculty found no reason to abandon the current practice of spinal immobilisation in patients with potential SCI. However, we recommend Maintaining a selective approach to the use of the various stabilization devices.
11	N. Rath, B. Balain, 2017 [49]	UK	To highlights the main issues regarding surgical management of acute SCI patients.	Surgical decompression, fixation and stabilization,	A. Multiple factors can delay surgery B. Timing of surgery	A systematic review	It may be best to consider surgery within 24 hr in some patients, provided it can be safely done. Otherwise conservative management in a SCI remains the safe option.

<b>S/n</b>	<b>Author, year</b>	<b>Country of origin</b>	<b>Study aim</b>	<b>Interventions</b>	<b>Challenges and benefits cited</b>	<b>Study design, methods &amp; sample size</b>	<b>Summary of the findings</b>
12	Fransen BL et al. 2016 [50] <sup>0</sup>	Netherlands	To explore pre-hospital and acute management of TSCI in the Netherlands	Transportation, cord perfusion, MRI, MPS.	Variance in the delivery of pre-hospital and acute TSCI management	Questionnaire survey. N= 23	Survey results urge the need for Standardization
13	W. J. Readdy et al. 2015 [35]	USA	To elucidate the specific blood pressure management for acute traumatic central cord syndrome (ATCCS) and the implications of these interventions. Additionally, to fully explore the complications of specific vasopressors	Vasopressors(dopamine, phenylephrine), surgical timing.	Cardiogenic complications	A retrospective cohort analysis of 34 patients with ATCCS who received any vasopressor to maintain map goals for a mean of 101 hours.	Cardiogenic complications associated with vasopressor usage were notable in 68% and neurological status improved by a median of 1 ASIA grade in all patients.
14	Ropper AE, et al. 2015 [32]	USA	To review important aspects of the diagnosis and acute care of patients with TSCIs, emphasizing the recent evidence.	Complete spinal immobilization, radiological assessment, intubation, vassopressors, corticosteroids, surgical fixation and fusion, surgical decompression	A. There is no class i or ii evidence supporting the use of a rigid cervical collar rather worse outcome is gotten in cases with penetrating trauma. Because the process of immobilization delayed life-saving resuscitation. B. Cervical	A literature review	Despite the progress that has been made in the acute management of patients with SCI, neurological outcomes have not improved significantly in

S/n	Author, year	Country of origin	Study aim	Interventions	Challenges and benefits cited	Study design, methods & sample size	Summary of the findings
					Collars and backboards also pose risks such as Aspiration, pressure sores & increased intracranial pressure. C. Challenges in radiological study for awake, symptomatic and obtunded patients. D. No evidence supporting vassopressor, corticosteroids, rather corticosteroids is shown to be associated with pneumonia, sepsis, acute respiratory distress syndrome, GIT haemorrhage and death. E. Timing Of surgery; no class I evidence for early decompression		recent decades.
15	Evaniew et al. 2015 [51]	Canada	To determine whether mps improves motor recovery and is associated with increased risks For adverse events.	MPS	A. Showed no long-term benefits. Besides, it increases GIT bleeding B. Timing of mps infusion recommended to be within 8 hours	A systematic review and meta-analysis. N=21	These findings support current guidelines against routine use, but strong recommendations are not warranted because confidence in the

S/n	Author, year	Country of origin	Study aim	Interventions	Challenges and benefits cited	Study design, methods & sample size	Summary of the findings
16	Evaniew et al. 2015 [52]	Canada	To determine whether methylprednisolone improved motor recovery.	MPS	A. MPS did not improve motor score in patients with acute TSCIs when the influence of anatomical level and severity of injury were included in the analysis. B. there was a significantly higher rate of total complications	Prospective study. N=46	effect estimates is limited These findings support guideline recommendations against routine administration of methylprednisolone in acute TSCIs.
17	Dvorak et al. 2014 [53]	Canada	To determine the influence of time from injury to surgery on neurological recovery and length of stay.	Surgical care	Beneficial effect of early surgery on motor recovery was not seen in the patients With ASIA a complete SCI	An observational Canadian cohort study. N= 1410	This work provides evidence that for an incomplete acute TSCIs, surgery performed within 24 h improves motor neurological recovery.
18	R. R. Hansebout and C. R. Hansebout, 2014 [36]	Canada, Australia	To explore effectiveness of a combination of steroids, decompression surgery, and hypothermia to preserve viable spinal cord tissue and enhance	Combination of surgical decompression, glucocorticoid administration, and regional hypothermia	A. The optimal neuroprotective temperature after acute trauma has not yet been defined. B. Cooling equipment may be inaccessible	Prospective study. N=20	Given that the optimal neuroprotective temperature after acute trauma has not yet been defined, methods that allow for the early attainment of such a

S/n	Author, year	Country of origin	Study aim	Interventions	Challenges and benefits cited	Study design, methods & sample size	Summary of the findings
			functional recovery.				temperature locally should be further explored.
19	Theodore et al. 2013 [29]	UK	To update the medical evidence on the transport Of patients with acute SCI	Pre-hospital transportation and immobilization	A. Lack of standard transportation protocols for patients with cervical spine and sci. B. Transportation time- 2-h interval to spinal injury centers. C. Careful movement and the use of appropriate extrication Techniques are crucial in all mechanisms of injury with the potential to cause SCIs. D. Airplane air is less humid.	A review of literature. N= 16	The patient with an acute cervical SCI should be Carefully transported to the nearest capable medical facility. The mode of transportation should be based on the patient's clinical circumstances, distance from target facility, the most rapid means available. Immobilization of patients with acute cervical SCI is recommended. Respiratory support should be available during transport.
20	Jefferson R. Wilson , et al. 2013 [41]	Canada	To review relevant pathophysiology and recent	Neuroprotective therapies, Neuroregenerative, stabilization,	A.bed reduction is obsolete and now replaced with more aggressive medical	A review of literature. N= 45	Treating SCI is relevant not only to spine surgeons



S/n	Author, year	Country of origin	Study aim	Interventions	Challenges and benefits cited	Study design, methods & sample size	Summary of the findings
			evidence pertaining to the medical, surgical And cellular-based treatment of acute TSCIs	Decompression, Hemodynamic support, MPSS, therapeutic hypothermia, vasopressor,	and surgical interventions. B. MPS not a standard of care and may be associated with an increased risk of complications. C. The safety of neuroprotectiveand Neuroregenerativetherapie s, is under study in early phase clinical trials, but is currently purely an investigational therapy. C. Surgical timing d.Perioperative hemodynamic changes could Compromise cord perfusion E. TH showed neurologic recovery rate of 20%. Although there is currently Insufficient evidence to support the its use		and physiatrists, but also to the general clinician who will increasingly encounter such patients in the emergency department or family practice.
21	Fehlings MG, et al. 2012 [54]	Canada, USA	To evaluate the relative effectiveness of early versus late Decompressive surgery after	Surgical decompression	Controversy on what other factors could influence outcome.	A multicenter, international, prospective cohort study. N=313	Decompression prior to 24 hours after SCI is associated with improved neurologic

S/n	Author, year	Country of origin	Study aim	Interventions	Challenges and benefits cited	Study design, methods & sample size	Summary of the findings
			TSCIs .				outcome, defined as at least a 2 grade ASIA improvement at 6 months follow-up.
22	Ahmed M. Raslan and Andrew N. Nemecek, 2012 [31]	USA	To review the controversy surrounding reduction, prereduction MRI, timing of surgical intervention and the choice of surgical approach.	reduction, decompression, and stabilization, MRI	A. Controversy surrounding the timing of surgery remains unresolved. B. No outcome data has suffice as evidence-based improvement in SCI outcomes for all side of controversy.	A review of current literature	Presurgical reduction is considered safe and essential in the management of SCI with loss of alignment, at least as an initial step in the overall care.
23	Anthony S. Burns, and Colleen O'connell, 2012 [30]	Canada	To highlight differences in global epidemiology of SCI and the ongoing challenges in meeting the needs of individuals with SCI in the developing world, including post-disaster.	Immobilization, transportation, rehabilitation	Developing countries are characterized with poor access to equipment, lack of knowledge, poor data, delays to presentation are common.	A literature review	Disparities between the developing and developed Worlds capacity to deliver emergency and acute care Are most evident immediately following a SCI.
24	Felleiter et al. 2012 [55]	Switzerland	To examine the differences in the use of the Mps protocol for	MPS	No differences is observed in the neurological outcome between the different guideline of	A retrospective cohort study. N= 226.	The use of high-dose mps has reduced after the publication of new

<b>S/n</b>	<b>Author, year</b>	<b>Country of origin</b>	<b>Study aim</b>	<b>Interventions</b>	<b>Challenges and benefits cited</b>	<b>Study design, methods &amp; sample size</b>	<b>Summary of the findings</b>
			TSCIs before and after the publication of new guidelines in Switzerland.		increased and decreased mps use		guidelines. Despite these changes, no differences in the neurological outcome were detected between the observed patient populations.
25	Goulet et al. 2011 [39]	Canada	To answer 3 specific questions: (1) what is the recommended protocol for MRI in acute SCI? (2) does MRI affect the initial management? (3) does MRI predict a patient's long-term neurological outcome?	MRI	A. The logistics of patient transport and monitoring. B. May be risky in trauma patients in critical condition, c. May delay surgical intervention	A systematicall y review of literature. N= 113.	Based on the literature, the exact time to perform an MRI within the acute period cannot be determined
26	Furlan et al. 2011 [56]	Canada	To critically review the literature on the potential impact of timing of surgical decompression outcomes after	Surgical decompression	A number of studies indicated that patients who undergo early Surgery can have similar outcomes to patients who received a delayed surgery B. The optimal timing of	Reviews of pre-clinical and clinical evidence. N=41	Early surgical intervention should be considered in all patients from 8 to 24 hrs Following acute

S/n	Author, year	Country of origin	Study aim	Interventions	Challenges and benefits cited	Study design, methods & sample size	Summary of the findings
			TSCIs.		surgery, in patients with a central cord injury remains unclear.		TSCI
27	Ploumis et al. 2010 [57]	Greece, USA, Canada	To evaluate the evidence supporting a role for vasopressor support in the management of acute SCI and to provide updated recommendations for appropriate clinical application of this modality.	Vasopressor	There was no statistical difference in neurologic improvement.	A systematic review of clinical and preclinical literature. N=32	There is currently no gold standard on vasopressor support.
28	Laura Pimentel and Laura Diegelm, 2010 [58]	USA	To outline the evaluation and management of blunt cervical spine trauma by the emergency physician	Pre-hospital transportation and immobilization (use of backboard, cervical collar, spider straps, and Head blocks, kendrick extrication device), intubation, MRI, closed reduction, halo traction, Open reduction, or decompression,	A. should therapy proceed in the presence of spinal and neurogenic shock. B. Challenges with fast and efficient care for prompt transfer to a spinal center. C. How to secure to the backboard to minimize movement in case the patient vomits and needs to be rolled onto the side to prevent aspiration D. Studies are unclear regarding how long on the backboard as risk for developing complications.	Review of literature	Early intervention accomplishing closed reduction, halo traction, open reduction, or decompression provides the best patient outcomes.

<b>S/n</b>	<b>Author, year</b>	<b>Country of origin</b>	<b>Study aim</b>	<b>Interventions</b>	<b>Challenges and benefits cited</b>	<b>Study design, methods &amp; sample size</b>	<b>Summary of the findings</b>
					E. Caution is warranted when considering the use of phenylephrine its pure stimulation of a-receptors is associated With reflex bradycardia		

## 5.2 Corticosteroids

Methylprednisolone (MPS) use is generally a controversy across all the reviewed articles. Its most cited challenges are: Lack of supporting evidence, there is no international consensus for the application of MPS (N=8, 28.6%). Rather, MPS is shown to be associated with pneumonia, sepsis, acute respiratory distress syndrome, gastrointestinal haemorrhage and has a trend to increase overall Complication (N=6, 21.4%). And lastly, studies by Fehlings et al. [34] suggested a 24-hour infusion of high-dose MPS to be offered to adult patients within 8 hours of acute SCI as a treatment option. This highlighted the challenges on timing of MPS infusion within 8 hours and in the presence of other complications (N=2, 7.1%).

## 5.3 Hemodynamic Stability

Many patients exhibit neurogenic shock (hypotension and bradycardia) due to a sudden loss of sympathetic outflow and relative hypovolemia. This is common in patients' with acute cervical tetraplegia or high thoracic paraplegia. This can contribute to hypoperfusion of the spinal cord and further ischemic insult. Clinical guidelines on hemodynamic stability have routinely recommended vasopressors as key for maintaining the arterial pressure within 85 to 100 mmHg. However, its challenges include lack gold standard for usage (N=2, 7.1%), and there is risks of increased cardiogenic complications (N=3, 10.7%). In one of the study by Readdy et al. [35], cardiogenic complications associated with vasopressor usage were notable in 68% but Neurological status improved by a median of 1 ASIA grade in all patients.

Notwithstanding, despite the progress that has been made in the acute management of patients with SCI, neurological outcomes has not improved significantly in recent decades [32,33].

## 5.4 Neuroprotective Strategies

Key early interventions are increasingly being recognized: Combined Neuroprotective and neuroregenerative care are probably more effective and they inspire current and future research [19]. Some neuroprotective strategies cited include; Fibroblast growth factor, Minocycline, Riluzole, Cytokine granulocyte colony stimulating factor and Therapeutic Hypothermia. Challenges still abound on translating findings from this to clinical practice. Two of the studies reviewed expressed this

challenges stating that the safety of Neuroprotective and neuroregenerative therapies, is under study in early phase clinical trials, but is currently purely an investigational therapy (N=2,7.1%). TH; which is the motivation for this study, showed neurologic recovery rate of 20%. Although there is currently insufficient evidence to support its use (N=2, 7.1%). The optimal neuroprotective temperature after acute trauma has not yet been defined for TH (N=1, 3.6%). Moving forward, TH is worthy of more focus. Given that the optimal neuroprotective temperature after acute trauma has not yet been defined, Hansebout and Hansebout [36] recommend that methods that allow for the early attainment of such a temperature locally be further explored.

## 5.5 Neuroregenerative Therapies

This also promises to be another key early intervention. Some neuroregenerative therapies cited include; embryonic stem cells, induced pluripotent stem cells, olfactory ensheathing cells, Schwann cells, mesenchymal cells, and activated autologous Macrophages. However, cellular transplantation remains an investigational and experimental therapy, with no formal recommendations yet (N=1, 3.6%).

## 5.6 Radiological Assessment

The recommendations for MRI by Fehlings et al. [37] suggested that MRI be performed in adult patients with acute SCI prior to surgical intervention, to facilitate improved clinical decision-making. This recommendation was with very low quality of evidence, especially in consideration of the following cited challenges; radiological investigations requires a patient to be supine for up to 30 minutes, this may be risky in trauma patients in critical condition, requires substantial resources to ensure 24-hour availability, and may delay surgical intervention.(N=3, 10.7%). Challenges with the logistics of patient transport and monitoring (N=1, 3.6%). Based on the literature, the exact time to perform an MRI within the acute period has not been determined [39].

## 5.7 Surgical Interventions

In the reviewed articles, surgical decompression was the most cited intervention recommended for an acute TSCI (16 papers), followed by surgical fixation and fusion (9 papers), and intubation (2 papers). The challenge with surgical

decompression is often on the feasibility of carrying it out within the stipulated time (<24hrs from injury) (N=12, 42.9%). Meanwhile, early intervention accomplishing closed reduction, halo traction, open reduction, or decompression is recommended for the best neurological outcomes [39-43]. However, despite the progress that has been made in the acute management of patients with SCI, neurological outcomes have not improved significantly in recent decades [32]. Presently, the recommendations for early surgical intervention in clinical guidelines are mostly with low quality of evidence [38]. Other key challenge of surgical interventions that was cited is as follows: Incomplete resuscitation of patients prior to surgery may confound the influence of morbidity and mortality (N=2, 7.1%). There are still controversies on benefit of early versus late surgery: As spontaneous improvement could occur and because decompression of a fragile spinal cord could result in neurological worsening (N=7, 25%). Beneficial effect of early surgery on motor recovery was not seen in the patients with ASIA A complete SCI (N=1, 3.6%). The optimal timing of surgery, in patients with a central cord injury remains unclear as preoperative hemodynamic changes could compromise cord perfusion (N=1, 3.6%).

Studies on surgical fixation and fusion cited challenges which include that spinal stabilization in the critically injured patient may cause other serious harm (N=1, 3.6%), There is paucity of literature supporting spinal stabilization (N=1, 3.6%), as well as whether therapy should proceed in the presence of spinal and neurogenic shock (N=1, 3.6%); are all in controversy.

### 5.8 Rehabilitation

Kessler et al. [20] recommended offering rehabilitation to individuals with acute SCI when they are medically stable and can tolerate good rehabilitation intensity. There remain controversial areas on available strategies for the treatment of SCI, including the type and timing of rehabilitation [40]. Especially, the gaps between the capacity of developing and developed countries to deliver emergency and acute care instantly following a SCI is pronounced [30]. The recommendation for rehabilitation after patient is medically stable denies it its potential role in neuroprotective strategies, including use of TH. Early treatment, prevention of associated complications and individualized patient-targeted

rehabilitation programs are crucial to optimize the outcome after SCI [33]. The cited challenges for early rehabilitation include lack of standardization of interventions, therapeutic doses and outcome measures, heterogeneous populations, superimposed spontaneous recovery and problems with group assignment (N=1, 3.6%), As well as access to Rehabilitation facilities; as some centers may not have access to the equipment needed (N=2, 7.1). Lastly, there is lack of studies directly evaluating the impact of timing of treatment on the effectiveness of rehabilitation (N=1, 3.6%).

## 6. DISCUSSION

This review has sought to emphasize a treatment modality that targets the pathophysiological process of Traumatic Spinal Cord Injury (TSCI). Studies have shown that the secondary stage of SCI depicts a progressive damage with underlying cellular and molecular mechanisms of tissue degeneration and repair. Such pathological process as spinal shock, neurogenic shock, vasospasm, ischemia, infarction, oxidative stress, ionic imbalance, release of vaso-active protein, excitotoxic glutamine release, neurotransmitter accumulation, neuroinflammation, increased interstitial pressures, axon demyelination, glial scar formation, matrix remodelling, lipid peroxidation, and cell death has been disclosed to be major secondary presentations of TSCLs. These presentations occur within the acute phase, with the cell death and scar formation completed within the first few days [17,18]. Modalities to combat any of these presentations at the acute phase have potential to influence the final neurological outcome of the primary injury [17,18].

The result of this study shows different facets of challenges in current acute interventions and poor supporting evidence for the neurological care of patients with TSCLs. Firstly, there are limited treatment options for patients shortly after TSCI. And more unfortunately, most of the present choices of acute care are heavily in controversy as they often lead to more complications. Generally, no outcome data has sufficed as significant improvements in neurological outcomes for all side of controversy. Presently, early surgical decompression is the most cited and accepted treatment options recommended for the best neurological outcomes [39-43]. However, challenges on surgical decompression is often on the feasibility of carrying it out within the recommended time

(<24 hrs from injury). Secondly, despite the progress that has been made in surgical decompression, neurological outcomes have not improved significantly in recent decades [32]. The recommendations for early surgical intervention in clinical guidelines are mostly with low quality of evidence [38].

The argument in support of immobilisation is on SCIWORA and SCIWORET.

The Frankel E/ASIA E represents another importance of immobilization for incomplete SCI where patients may present with normal motor and sensory function but have a radiological evidence of SCI. It is in this case that immobilization helps to allow reduction of the spinal injuries and to avoid further injuries. Nevertheless, in cases of potential ASIA A/Frankel A SCI, there is no class I or II evidence supporting the practice of routine immobilization. Rather, the process of immobilization could delay life-saving and neuroprotective process. Similarly, many medications that had been employed to combat the presenting pathological process had shown no significant improvement in neurological outcomes: the corticosteroids, and the vassopressors, were employed to combat neuro-inflammation and neurogenic shock respectively. The major challenge of early rehabilitation is on timing determining the most appropriate time to begin rehabilitative protocols in the face of unstable vital signs, and poor clinical state [40].

The failure of improvement in SCI outcomes despite extensive efforts is frustrating. New focus of SCI intervention are on early intervention. Late interventions has been linked to poor neurological outcomes [17,18]. Besides, watching the patients without vital care to combat the ongoing pathological process at the early stage is as good as allowing nature or the normal body physiology to determine their fate. Thus, the practice of waiting for spinal shock to be over before commencing care is conceptually and scientifically part of the past. The findings of this study makes for a re-emphasis on early interventions; immediately from the accident scene, with the goal to revert the progressive damaging pathophysiological cascades (see Fig. 2). Early treatment, prevention of associated complications and individualized patient-targeted rehabilitation programs are crucial to optimize the outcome after SCI [33].

Key early interventions are increasingly being recognized: combined neuroprotective strategies

and neuroregenerative therapies are potentially more effective and they inspire current and future research [19]. However, presently, there are few recommendations for the safety of neuroprotective and neuroregenerative therapies in clinical guidelines. Their interventions are currently purely an investigational therapy [45].

Key objective of this study is to draw attention to possible opportunities that could be obtained in adding TH in the guidelines for the acute care of TSCI. TH has been cited as one of the key neuroprotective strategy that is presently a focus in preclinical studies [36,41]. TH is the treatment of certain pathological conditions by the use of low temperature. TH has been successfully used to achieve significant better neurological outcomes in such conditions as; anoxic brain injury and global brain ischemia seen in cardiac arrest patients and neonatal hypoxic-ischemic encephalopathy [42]. The neuroprotection effect offered by TH has been attributed to reducing metabolic demand by decreasing the rate of oxygen consumption, reducing ATP demand and halting early gene expression of excitatory neurotransmitters [42]. Thus, plays a central role in preventing neuronal cell death. TH also stabilizes the vascular integrity and reduces cerebral oedema by decreasing permeability to inflammatory cytokines and potential harmful substances such as free radicals and thrombin [42]. As elucidated above for the pathophysiology of TSCI, when a tissue is injured, blood vessels surrounding it are torn, and blood cells and fluids escape into the spaces among the tissues cells and such areas presents with inflammatory response. For TSCI, such swelling is countered by compression from the spinal bony vertebrae thus, producing a counter damaging effect.

TH applied in the form of cryotherapy produces deep cooling effect temperature will drop from skin to ~2-7 cm deep 10 minutes [43], decreases the flow of this fluid into the tissue and slows the release of chemicals that cause pain and inflammation [44]. The associate physiological benefit of TH would include; improve hemodynamic, reduce nerve ending response, decreased metabolism, reduced capillary hydrostatic pressure. Improve hemodynamic would be produced according to Lewis Hunting reaction. Hunting response is a reflex increase in vasodilatation that occurs in response to cold approximately 15 minutes from vasoconstriction following the application of cold. With a continued application, the vessels walls fluctuate



continuously from vasoconstriction to dilatation. Thus, would help correct neurogenic shock by increasing cord perfusion.

Secondly, for reduce nerve-ending response, TH would cause a reduced synaptic activity and increased threshold for nerve firing, thereby helping to correct vasospasm and discomforts from pain. Thirdly, on decreased metabolism; according to Vant Huff's law, "a fall in body temperature up to 1°C will lead to a decrease in the cellular metabolism by one eighth" [10]. This would prevent hypoxia, lipid peroxidation and associated inflammatory mediators and oxidative radicals. Also, for reduced capillary hydrostatic pressure; this would result from increased blood viscosity, reduced permeability and osmotic pressure, and preservation of the Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>+</sup> channels thereby helping reduce swelling. A reduced swelling would mean a reduction in cord compression. Finally, a combine effect of the above would help correct glial scar formation, neuronal cell death and result in a better neurological outcome (see Fig. 3).

Unlike the various facets of challenges with the other outlined early interventions for TSCI (Table 2), TH is much simpler and adaptable. It would be much easier; with TH, to promote

standardization of care, decrease the heterogeneity of management strategies, and would encourage clinicians to make evidence-informed decisions. This is because, the opportunities in TH would most perfectly mitigate the most glaring challenges of classical interventions; it would be much adapted to mitigate the challenges of timing as it could easily be administered by every member of the care team, thus, it can be administered from the prehospital stage of care alongside with transportation. Also, it can be administered simultaneously with other line of care and it has little or no cited pitfall and harmful effect; it can proceed in the presence of neurogenic shock, spinal shock, and in unconscious or critical state. Again, a development of promising acute intervention strategies from TH will not only be remedial but would be very feasible on clinical implementation, adaptability and; especially, in developing regions like Africa, where sophisticated equipment may not be easily accessible, a physiotherapy modality will be far reaching and potent for curbing the challenges' of TSCIs and other related complications. This can drive reduced disability levels with associated healthier population, reduced cost of care, and reduced morbidity as well as mortality that is common with SCIs.

**Table 2. Summary of themes identified**

<b>Interventions</b>	<b>Identified Themes of Challenges</b>	<b>N</b>	<b>%</b>
Prehospital immobilization and transport (7 papers)	Challenges with fast and efficient patient care for prompt transfer to a hospital.	1	3.6
	Tissue necrosis may occur from pressure of the rigid backboard and collars during prolonged transport, and/or short periods of rigid immobilization. Also, risks of aspiration, pressure sores & increased intracranial pressure	5	17.9
	There is no class I or II evidence supporting the use of a rigid cervical collar rather worse outcome is gotten in cases with penetrating trauma. Because the process of immobilization could delay life-saving resuscitation.	2	7.1
	Developing countries are characterized with poor access to equipment, lack of knowledge, poor data, poor transportation, and delays to presentation within 8–24 h are common.	3	10.7
Bed reduction (2 papers)	No outcome data has suffice as evidence-based improvement in SCI outcomes for all side of controversy.	1	3.6
	Bed reduction is obsolete and now replaced with more aggressive medical and surgical interventions.	1	3.6
Hemodynamic stability-use of Vassopressors(7 papers)	Risks of increased cardiogenic complications.	3	10.7
	No gold standard on use of Vassopressors.	2	7.1
Corticosteroids (methylprednisolone)	Rather it is shown to be associated with pneumonia, sepsis, acute respiratory distress syndrome, gastrointestinal	6	21.4

sodium succinate-(MPSS) (10 papers)	haemorrhage and has a trend to increase overall Complication.		
	No evidence supporting corticosteroids, and There is no international consensus for the application of MPS.	8	28.6
	Timing of MPSS infusion	2	7.1
Neuroprotective strategies (Fibroblast growth factor, Minocycline, Riluzole, Cytokine granulocyte colony stimulating factor) Therapeutic Hypothermia(TH),(4 papers)	The safety of Neuroprotective and neuroregenerative therapies, is under study in early phase clinical trials, but is currently purely an investigational therapy.	2	7.1
	TH showed neurologic recovery rate of 20%. Although there is currently insufficient evidence to support its use	2	7.1
	The optimal neuroprotective temperature after acute trauma has not yet been defined for TH	1	3.6
Neuroregenerative therapies ( embryonic stem cells, induced pluripotent stem cells, olfactory ensheathing cells, Schwann cells, mesenchymal cells, and activated autologous Macrophages)(2 papers)	Cellular transplantation remains an investigational and experimental therapy, with no formal recommendations yet.	1	3.6
Surgical decompression(16 papers)	Incomplete resuscitation of patients prior to surgery may confound the influence of morbidity and Mortality	2	7.1
	There still controversy on benefit of early versus late surgery: as spontaneous improvement could occur, and because decompression of a “fragile” spinal cord could result in neurological worsening.	7	25
	beneficial effect of early surgery on motor recovery was not seen in the patients with ASIA A complete SCI	1	3.6
	Surgical timing	12	42.9
	The optimal timing of surgery, in patients with a central cord injury remains unclear	1	3.6
	preoperative hemodynamic changes could compromise cord perfusion	1	3.6
	Controversy on what other factors could influence surgical outcome	2	7.1
surgical fixation and fusion(9 papers)	Surgical timing	4	14.2
	It is logical that spinal stabilization in the critically injured patient may cause serious harm.	1	3.6
	Paucity of literature supporting spinal stabilization.	1	3.6
	Should therapy proceed in the presence of spinal and neurogenic shock	1	3.6
Rehabilitation(5 papers)	a lack of standardization of interventions, therapeutic doses and outcome measures, heterogeneous populations, superimposed spontaneous recovery, and problems with group assignment.	1	3.6
	a lack of studies directly evaluating the impact of timing of treatment on the effectiveness of rehabilitation	1	3.6
	Access to Rehabilitation facilities; some centers will not have	2	7.1

	access to the equipment needed.		
Radiological assessment-MRI (5 papers)	Requires a patient to be supine for up to 30 minutes, may be risky in trauma patients in critical condition, requires substantial resources to ensure 24-hour availability, and may delay surgical intervention.	3	10.7
	Challenges with the logistics of patient transport and monitoring	1	3.6

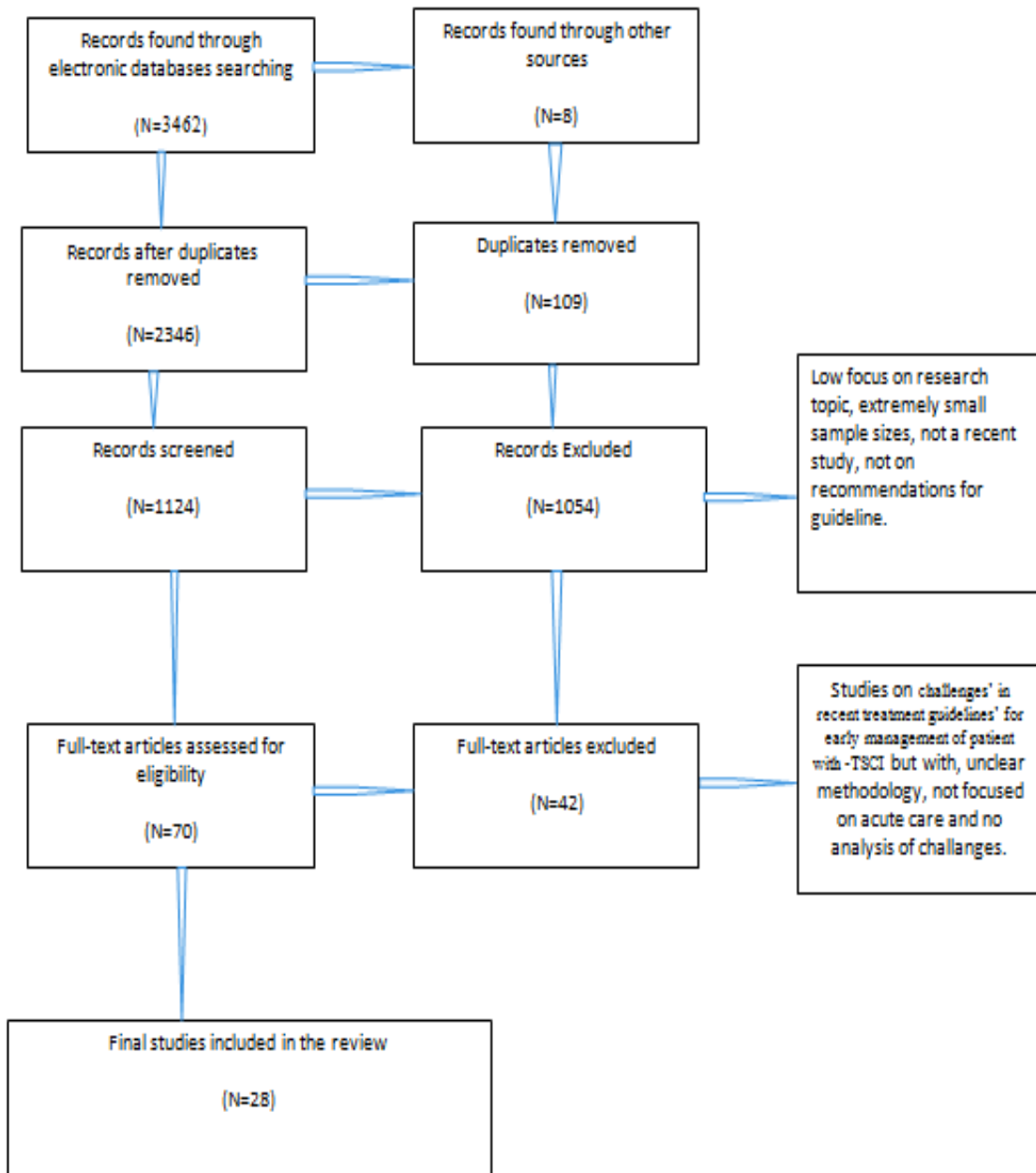


Fig. 2. PRISMA flow diagram of scoping literature search and selection

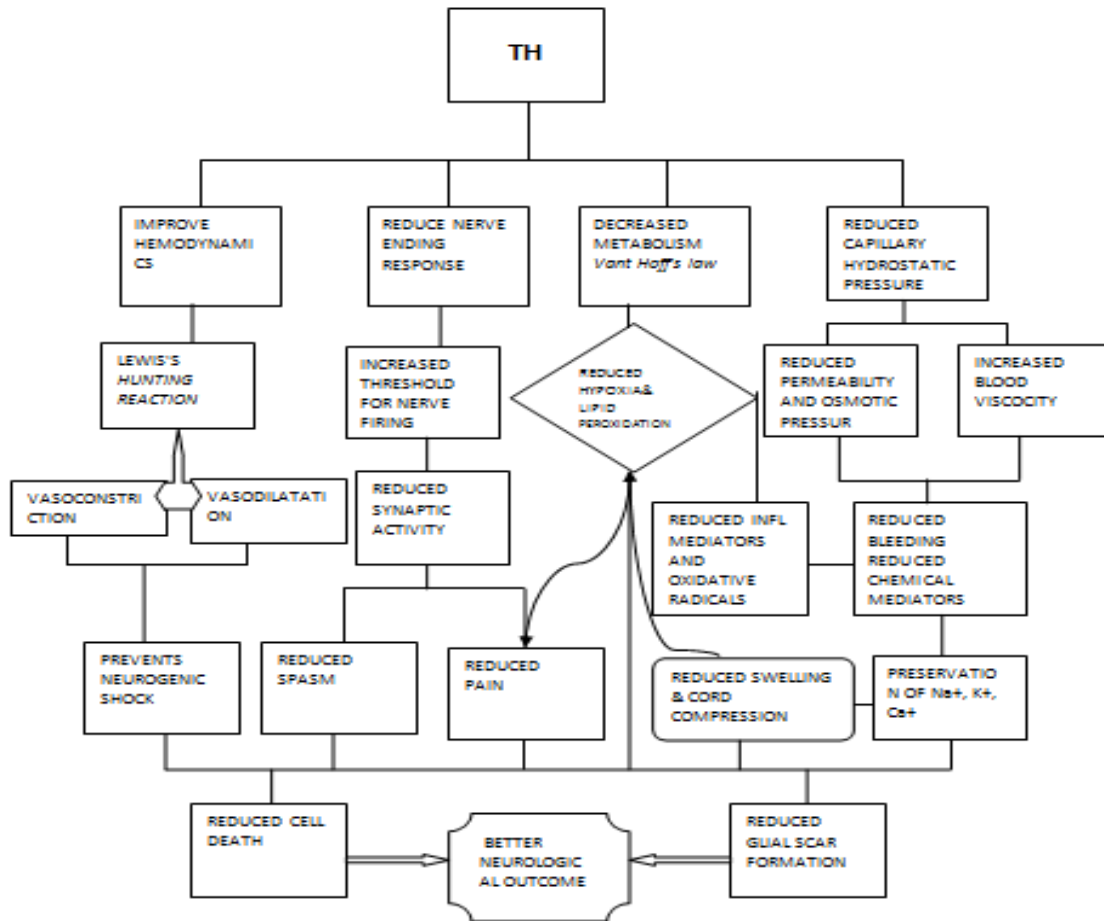


Fig. 3. Neuroprotective effects of TH

## 7. LIMITATIONS OF THE REVIEW

This review followed the vital scoping study framework proposed by Arksey and O'Malley [28]. Despite the rigorous process it adopted to engage with each of the six stages of the scoping review process, and efforts to ensure literatures in this sample is comprehensively reviewed. Despite this, there are some limitations attendant with the conduct of this review that need to be considered. The primary limitation was that the search strategy was limited to English-language studies only, and there may be other studies equally relevant to the area of challenges' in the early treatment guidelines for TSCI that we may not have found because it was not published in English. We also could not confirm a comprehensive list of possible lines of interventions; as such, it is possible there are emergency interventions that were not considered in this review.

## 8. IMPLICATIONS FOR FURTHER RESEARCH AND PRACTICE

Results of this review highlight the need for the acute treatment guideline of TSCI to be reviewed to increase focus on TH as neuroprotective strategies. The lack of evidence based guidance on the type, dose, timing, temperature; mode of applications and other related clinical parameters for TH necessitates future research to understudy this concept in pre-clinical and clinical trials. A prospective multi-centre longitudinal study is recommended to verify the possible neuroprotective effects of TH and its association with better neurological outcomes.

## 9. CONCLUSION

We collated and appraised all available published literature that investigates challenges in the early treatment guidelines for individuals

with TSCI to examine how these challenges is associated with the present poor evidence based treatment option to optimise neurological outcomes following a complete TSCI. We noted the pathophysiology of the associated complications of TSCIs and proposed TH as a key addition in the treatment guidelines for TSCIs. Early intervention has been a focus of treatment for enhancing neurological recovery in TSCIs. We conclude that evidence-based guidelines for TH would help reduce the doom experience around complete SCIs. Thus, there is a need to better define the beneficial effect of TH on the injured SCI, in particular as key part of neuroprotective strategies in acute care interventions for TSCIs.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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