Traumatic spinal cord injury (SCI) is a devastating disease process with significant morbidity and mortality. For those patients who survive the injury, approximately 32.5% are left with complete paraplegia or tetraplegia. These neurological deficits not only incur significant costs, but also dramatically impair patients’ ability to work and reduce their life expectancy. For patients with incomplete motor loss (66.8%), the average yearly expenses directly attributed to their injury are $375,196 for the first year and $45,572 thereafter. As the level of impairment increases, the cost increases, with high cervical tetraplegia incurring $1,149,629 in year 1 and $199,637 annually after that. In addition, acute SCI (aSCI) patients have an employment rate in their first year postinjury of 18% compared to 67% preinjury, and this only improves to an average of 32%–40 years postinjury. The compounding effect of increased expenses and the inability to work can leave patients financially compromised. Furthermore, aSCI patients have shorter life expectancies, with incomplete motor loss patients living an average of 34.8 years, high cervical tetraplegic patients 20.6 years, and ventilator-dependent patients 8.6 years postinjury.1 Therefore, a focus on interventions that optimize patient outcomes is critical to improving SCI management.

The timing of intervention and its impact on patient outcomes is one aspect of aSCI management that has been discussed extensively.2,3 In 1911, the novel theory that decompressing the spinal cord early would allow blood products and necrotic debris to extravasate before the onset of secondary injury was proposed.4 World War I and World War II then expanded interest in aSCI research.5 In 1965, the early hypothermic treatment of SCIs was challenged by the feasibility of the US trauma infrastructure to provide care for these patients.6

ABBR EV IAT IONS  
AIS = American Spinal Injury Association Impairment Scale; aSCI = acute SCI; aSDH = acute subdural hematoma; ATCCS = acute traumatic central cord syndrome; CNS = Congress of Neurological Surgeons; SCI = spinal cord injury.

SA M P LE  
OBJECTIVE Current guidelines do not specify timing for management of acute spinal cord injury (aSCI) due to lack of high-quality evidence supporting specific intervals for intervention. Randomized prospective trials may be unethical. Nonetheless, physicians have been sued for delays in diagnosis and intervention.

METHODS The authors reviewed both the medical literature supporting the guidelines and the legal cases reported in the Westlaw and Lexis Advance databases from 1972 to 2018 resulting in awards or settlements, to identify whether surgeons are vulnerable to litigation despite the existence of guidelines not mandating specific timing of care.

RESULTS Timing of intervention was related to claims in 59 (36%) of 163 cases involving SCI. All 22 trauma cases identified cited timing of intervention, sometimes related to delayed diagnosis, as a reason for the lawsuit. The mean award of 10 cases in which the plaintiffs’ awards were disclosed was $4,294,384. In the majority of cases, award amounts were not disclosed.

CONCLUSIONS Because conduct of a prospective, randomized trial to investigate surgical timing of intervention for aSCI may not be achievable, evidence-based guidelines will be unlikely to mandate specific timing. Nonetheless, surgeons who unreasonably delay intervention for aSCI may be at risk for litigation due to treatment delay. This is increasingly likely in an environment where “complete” SCI is difficult to verify. SCI may at some point be recognized as a surgical emergency, as brain injury generally is, despite a lack of prospective randomized trials supporting this implementation, challenging the feasibility of the US trauma infrastructure to provide care for these patients.
mal subjects demonstrated significant recovery of sensory and motor function. Other studies evaluated the use of steroids within 3 hours of aSCI; however, due to research ethics laws established via the Nuremberg Code in 1948, no prospective study could be effectively or ethically replicated in human trials. Isadore Tarlov, in 1972, wrote that “precious time should not be lost . . . to immediately de- compress the spinal cord.” In 1990, Bracken and Collins demonstrated a small therapeutic benefit in patients with SCI who received supraphysiological doses of methylprednisolone within 8 hours of injury, facilitating further discussion around the idea of early management.

A role for early surgical decompression in aSCI is suggested by pathophysiology. Histologically, the acute phase of SCI is characterized by inflammation and ischemia, while the subacute/chronic phase demonstrates cytotoxicity, scarring, and vascular compromise. It is plausible that early surgical decompression could mitigate secondary injury, leading to improved clinical outcomes, although approximately half of patients do not receive surgery within 24 hours of SCI. Despite the discordance between clinical preference and practice, some literature suggests that early surgical decompression can improve functional neurological recovery. The prospective STASCIS (Surgical Timing in Acute Spinal Cord Injury Study) trial found earlier intervention (< 24 hours) was associated with an American Spinal Injury Association Impairment Scale (AIS) grade improvement of more than 2 in patients with cervical aSCI without an increased risk of operative complications. A Canadian prospective study found that early surgical intervention (< 24 hours) for aSCI significantly improved AIS motor score by more than 2 grades when compared to delayed intervention. Early surgical intervention (8–24 hours after injury) has also demonstrated safety, feasibility, and the potential to improve functional recovery while lowering the cost of long-term care.

The establishment of surgical guidelines for neurological pathologies in the US is guided by associations, including the Congress of Neurological Surgeons (CNS) and AO Spine. Both have published several evidence-based guidelines on the topic that are the result of a rigorous, multidisciplinary review of the literature by experts in the field. Currently, they do not recommend definitive guidelines regarding the timing of aSCI intervention due to insufficient quality of evidence and the paucity of prospective studies. However, guidelines on neurosurgical conditions such as epidural and subdural hematomas are supported with retrospective studies alone as prospective trials are potentially unethical. For example, immediate surgical intervention is recommended for the management of some acute subdural hematomas (aSDHs). These guidelines reflect the outcomes of several retrospective studies demonstrating improved mortality rates for early (< 2 hours) surgical management of aSDH.

SCI is one of the most prevalent pathologies litigated for malpractice in the US due to the multifaceted and heterogeneous nature of SCI and risk of complications. Between 2010 and 2014, the average settlement from SCI malpractice cases was $2.3 million, with case proceedings taking 4.5 years for completion when ruling in favor of the defendants. From a systematic analysis of 569 cases related to SCI malpractice, cases citing diagnostic and operative delay were more likely to rule in favor of the plaintiff. Additionally, physicians were more likely to lose their case and plaintiffs to receive larger awards when patients sustained catastrophic outcomes. In this review we evaluate whether current guidelines concerning the timing of aSCI surgical management render spinal surgeons vulnerable to risk of litigation. In addition, we discuss the feasibility of caring for these patients in the current healthcare system.

**Methods**

**Surgical Guideline Selection**

Eligible guidelines focused on the treatment of neurological conditions in the US. Guidelines without a spinal cord pathology ruling and those pertaining exclusively to atraumatic or chronic pathologies, such as oncological masses and demyelinating disorders, were excluded. Recommendations relevant to both pediatric and adult populations were allowed. Guidelines published solely in a language other than English or derived from a governing body without jurisdiction in the US were not eligible. This search identified two premier guideline sources: CNS and AO Spine.

**Surgical Guideline Search**

A systematic review of the selected guideline sources was then performed chapter by chapter, or publication by publication, for the keywords “acute Spinal Cord Injury and/or aSCI,” “Surgery and/or Intervention,” and “early and/or timing.” Peer-reviewed publications cited in the selected guidelines via these screening criteria were accessed for review. Those that mentioned timing were then retained for analysis.

Features extracted from the publications included publication year, study design, pathology investigated, number of subjects, the interval for timing criteria, key results, and the class of evidence the conclusions provided. Support for early intervention included outcomes such as improved AIS grade, decreased mortality, fewer complications, and shorter length of stay. Class of evidence was determined utilizing a methodology recommended by the CNS.

**Malpractice Case Extraction**

The malpractice lawsuits examined in our review were retrieved from searches in the Lexis Advance and Westlaw databases. While both databases are useful tools for accessing legal cases in the US, they are not comprehensive and thus may not be fully representative of the spectrum of similar cases.

In Lexis Advance, three searches were performed. First, a Boolean search in the “All Healthcare Law Cases” database was run using the operative terms “summary ("spinal cord injury") or core-terms ("spinal cord injury").” mean the phrase “spinal cord injury” must appear in the summary or core-terms segments of lawsuits. Second, a further full-text Boolean search was run using the function “medical malpractice”/p “spinal cord injury”/p (diagnos! or misdiagnos!), meaning the phrase “medical malpractice” and the phrase “spinal cord injury” must appear in the same paragraph. In addition, the paragraph
must also contain words with the root diagnos! or misdiagno$. Note that “/p” signifies the same paragraph and the exclamation point is a root extender. Third, a final Lexis Advance blanket search was made in the “All Healthcare Law Jury Verdicts & Settlements” database using the operation “spinal cord injury” & “medical malpractice,” which is a full-text search for documents containing the phrase “spinal cord injury” and the phrase “medical malpractice” in the same document.

In Westlaw, a first Boolean search in the “Health Law Cases” database was performed using the operation SY,DI(“medical malpractice” & “spinal cord injury”). This is a field search, meaning the phrase “spinal cord injury” must appear in either the synopsis field (abbreviated SY) or digest field (abbreviated DI) to satisfy the search. A second Boolean search was performed using the operation “medical malpractice”/p “spinal cord injury”/p (diagnos! or misdiagno$), which is a full-text search that finds the phrase “medical malpractice” and the phrase “spinal cord injury” appearing in the same paragraph. In addition, the paragraph must also contain words with the root diagnos! or misdiagno$! A final Westlaw full-text search in the “Health Law Jury Verdicts & Settlements” database was performed using the operation “spinal cord injury” and “medical malpractice,” which looked for the phrase “spinal cord injury” and the phrase “medical malpractice” used in the same document.

Results

Guideline Characteristics

Our query identified six CNS “Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injuries 2013” (chapters 10–13, 17–18) that met our inclusion criteria (Fig. 1). The analyzed chapters referenced 199 peer-reviewed publications and 10 directly investigated the timing of surgical intervention and its impact on aSCI recovery. They were published between 1991 and 2011, ranging from single case reports to prospective observational trials, and were all evidence class III. A complete output of extracted features for these publications is displayed in Table 1.

Similarly, we identified 8 of the 47 publications cited in the AO Spine’s “A Clinical Practice Guideline for the Management of Patients With Acute Spinal Cord Injury and Central Cord Syndrome: Recommendations on the Timing (≤24 hours vs >24 hours) of Decompressive Surgery,” which met our inclusion criteria (Fig. 1). Publications were published between 1954 and 2015 and included case reports, retrospective reviews, prospective observational trials, and a single randomized controlled study. The evidence class for all publications was also class III.

Legal Database Output

Our queries identified 221 cases in Westlaw and 140 cases in Lexis Advance. Of those, 198 cases were found to be duplicates or contained incomplete information, and thus were excluded. The remaining 163 cases were retained for evaluation (Fig. 2). Cases were filed between 1972 and 2018 and the most common state was California (23%), followed by Florida (6%) and Massachusetts (6%). The timing of care was noted in the available filing documents in 36% of all cases identified. Figureative representation of the distribution of case categories is shown in Fig. 3.

Categorization based on 5 key features of the malpractice argument demonstrated 70 surgical cases, 5 degenerative cases, 30 diagnostic cases, 22 traumatic cases, and 36 other cases. Cases focused on surgical error, degenerative disease, and “other” were filed between 1989 and 2018.
| Authors & Year | Study Design | Pathology | Pts (hrs) | Support Early Intervention | Key Results |
|---------------|-------------|-----------|-----------|-----------------|-------------|
| Cowan & McGillicuddy, 200824 | Case report | Traumatic cervical SCI | 1 | <4 | Yes | Rapid closed reduction may facilitate near-total recovery from traumatic SCI |
| Guest et al., 200225 | Retrospective review | ATCCS | 50 | <24 | Yes | Early decompression was significantly correlated to post–spinal injury motor score improvement in pts w/ disc herniation & fracture dislocations, but not those w/ spinal stenosis |
| Lenehan et al., 201026 | Prospective observational study | ATCCS | 73 | <24 | Yes | Pts who underwent early surgical decompression had significantly better AIS & FIM scores at both 6 & 12 mos postinjury |
| Wolf et al., 199127 | Retrospective review | Bilat cervical facet dislocation | 52 | <24 | Yes | Early reduction & internal stabilization, open & closed, can facilitate recovery even in pts w/ neurologic compromise at admission |
| Anderson et al., 200428 | Retrospective review | Traumatic cervical facet dislocation | 45 | NR | No | Time to reduction, unlike age & initial motor score, did not demonstrate a significant independent relationship to neurologic outcome w/in 5 yrs of injury |
| Arabi et al., 201129 | Retrospective review | ATCCS | 42 | <48 | No | Time to decompression did not demonstrate a significant difference in AIS score improvement or neuropathic pain at 1-yr postinjury |
| Chen et al., 199730 | Retrospective review | ATCCS | 49 | <96 | No | No significant difference was found btwn those operated on w/in or after 4 days for AIS motor score or Walking Index for Spinal Cord Injury 6 mos postinjury |
| Stevens et al., 201031 | Retrospective review | ATCCS | 126 | <24 | No | No statistically significant difference in neurologic outcome was identified using Frankel grades btwn surgical subgroups based on timing of surgery |
| Vale et al., 199732 | Prospective observational study | Traumatic cervical & thoracic SCI (complete & incomplete) | 77 | <24 | No | No relation btwn AIS improvement & timing of surgical intervention; all undergoing delayed intervention (24–72 hrs) had complete cord transection, spinal instability w/o cord compression, or life-threatening associated organ system injuries |
| AO Spine 2017 guidelines | | | | | |
| Bourassa-Moreau et al., 201333 | Retrospective review | Traumatic cervical & thoracolumbar SCI | 431 | <24 | Yes | Earlier surgical intervention demonstrated a reduction in the global rate of complications as well as rates of pneumonia & pressure ulcers when compared to later counterparts |
| Dvorak et al., 201534 | Prospective observational study | Traumatic cervical, thoracic, & lumbosacral SCI | NR | <24 | Yes | Pts w/ incomplete AIS injuries (B, C, D) located btwn C2 & L2 demonstrated an additional 6.3 motor point improvement when operated on w/in 24 hrs compared to those after 24 hrs |
| Fehlings et al., 201235 | Prospective observational study | Traumatic cervical SCI | 222 | <24 | Yes | Pts treated w/ early surgical intervention showed a higher propensity for AIS improvements ≥2 grades than those operated on after 24 hrs |
| Lenehan et al., 201036 | Prospective observational study | ATCCS | 73 | <24 | Yes | Pts who underwent early surgical decompression had significantly better AIS & FIM scores at both 6 & 12 mos postinjury |
| Mac-Thiong et al., 201237 | Retrospective review | Traumatic cervical, thoracic, & lumbosacral SCI | 477 | <24 | Yes | Hospital resource utilization & length of stay for the acute hospitalization after SCI was reduced for those pts undergoing surgery w/in 24 hrs of injury |
TABLE 1. Studies supporting current guidelines

| Authors & Year | Study Design | Pathology | Pts | Timing (hrs) | Support Early Intervention | Key Results |
|---------------|-------------|-----------|-----|-------------|---------------------------|-------------|
| AO Spine 2017 guidelines (continued) | Wilson et al., 2012<sup>15</sup> | Prospective observational study | Traumatic cervical & thoracolumbar SCI | 82 | <24 | Yes | Pts operated on early in this study had a significantly better rate of achieving ≥2 AIS grade improvement at discharge from rehab; additionally, when adjusted for preop neurological status, there was a positive effect estimate for early surgery that was significant. |
| | Rahimi-Movaghar et al., 2014<sup>36</sup> | Randomized controlled trial | Traumatic cervical & thoracolumbar SCI | 35 | <24 | No | Pts who underwent early surgical decompression for T1–L1 traumatic SCI demonstrated no significant improvement in AIS motor score when compared to their later counterparts. |
| | Schneider et al., 1954<sup>37</sup> | Case report | Traumatic cervical SCI | 6 | NR | No | This historical case report found a worsened neurological outcome & increased morbidity in subjects operated on early, in the setting of central cord syndrome. |

FIM = Functional Independence Measure; NR = not reported; Pts = patients.

1977 and 2018, and 1986 and 2018, respectively. Examples of “other” cases include mistreatment of the elderly by nursing home staff resulting in SCI, pregnancy complications in the setting of SCI, and rehabilitation staff errors. The remaining two categories, diagnosis and trauma, were of particular relevance to the aim of this study. Diagnostic malpractice cases accounted for 19% of all cases identified. Cases were filed between 1977 and 2016 and most commonly in California (20%), Massachusetts (10%), and New York (10%). Notably, 83% of filing occurred between 1998 and 2018, with California (27%), New York (14%), and Florida (9%) being the most common states. One hundred percent of the cases in this group mentioned timing. Additionally, the mean award for settlements to the defendant was $750,000 to $10,000,000, with a mean award of $1,250,000 to $10,000,000. The remaining 17% of cases were of “other” nature and included misdiagnosis and delay in treatment.

FIG. 2. Legal database flowchart depicting the malpractice case selection and categorization for analysis.
$4,294,384 (Table 2). Of note, a majority of settlements were not publicly available as they were settled out of court or currently ongoing.

**Discussion**

The optimal timing of surgical intervention for aSCI is frequently debated. While more than 80% of neurological and orthopedic spine surgeons favor early surgical decompression, national guidelines do not endorse a specific window of timing for intervention. Two US-based neurosurgical aSCI guidelines, CNS’s 2013 guidelines and AO Spine’s 2017 guidelines, have determined that the current body of data favoring early surgical decompression for aSCI treatment is insufficient given the lack of randomized prospective controlled trials and quality of supporting evidence.

**CNS Guidelines**

Discussion of surgical intervention timing in the 2013 CNS guidelines primarily occurred in Chapter 17: “Management of Acute Traumatic Central Cord Syndrome (ATCCS).” The authors argued that the heterogeneity of ATCCS presented barriers to the investigation of the role that early surgical intervention plays in improving postoperative outcomes. A key study referenced by CNS authors was a retrospective study of ATCCS subjects, which suggested no benefit of early surgical intervention. The AIS grade scores of these patients were collected over a 5-year period and compared using a statistical model based on the date to measure correlation between variables and motor score improvement. While the authors were able to isolate single variable effects on postoperative outcomes using this model, the study’s subject cohort was notably heterogenous. The authors address this as a limitation of their study. As such, it may be difficult to ascertain a demonstrated benefit of early surgical intervention using this statistical model. Notably, a recent meta-analysis evaluating 10 studies demonstrated benefit for ATCCS secondary to vertebral fracture, dislocation, traumatic disc herniation, or instability after early decompression. Nonetheless, the current evidence is primarily retrospective and observational. The argument has been made that prospective randomized studies are needed to evaluate the impact of surgical timing on postoperative outcomes.

---

**FIG. 3.** Pie chart for SCI malpractice cases. Categorization based on the key features of the negligence accusations: surgical, diagnostic, trauma, degenerative, and other. Secondary pie charts depict the portion of cases in each category that were related to the timing of care. CA = California; TX = Texas.
### TABLE 2. Malpractice case examples with award settlements

| Case Details                                                                                       | Argument                                                                                           | State   | Award            |
|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|---------|------------------|
| Plaintiff was seen for new-onset pain in their right upper extremity. The defendant diagnosed the plaintiff w/ radiculopathy & recommended an anterior cervical discectomy. The surgery was performed & immediately postoperatively the pt noted complete loss of sensation from the midchest down. Surgical revision did not occur until 6 hrs after the discovery of the new sensory loss. The plaintiff was left w/ chronic neurologic deficits. | The delay in interven- tion resulted in irreversible spinal cord damage                              | Ohio    | $10,615,000      |
| Plaintiff, who had preexisting cerebral palsy, was admitted to the hospital with new-onset left-sided weakness. The defendants involved in the plaintiff’s case did not diagnose him w/ ruptured discs from C3 to C5 until 11 days after presentation. At that point, permanent damage had occurred to the cervical spinal cord. The incident occurred over a holiday, when the defendants had reduced hrs & failed to diagnose & treat the plaintiff's condition despite the documented neurological deterioration in the electronic medical record. The plaintiff was left quadriplegic. | The delay in diagnosis & intervention resulted in irreversible spinal cord damage                   | California | $8,148,137  |
| Plaintiff underwent an initiation ceremony for a Masonic society during which he was blindfolded & bounced by several members on a canvas blanket. During the ceremony the plaintiff landed on his head, suffering a cervical spine injury. Paramedics on scene misdiagnosed the plaintiff as having a psychological episode & thus he was not put in cervical precautions. Upon arrival at the hospital, the plaintiff did not receive spinal imaging or neurosurgery consultation. Two days postinjury, the plaintiff’s nurse noted progressive weakness in the upper extremities. At that time, repeat imaging was performed & demonstrated edema of the spinal cord. The plaintiff was left quadriplegic. | The failed prehospital precautions, radiographic examination, neurosurgical consultation, & intervention resulted in irreversible spinal cord damage | Florida | $8,000,000      |
| Plaintiff, a 26-year-old man, presented to the office of his primary care physician, defendant, complaining of unremitting back pain. At that time the plaintiff was being treated for a Staphylococcus infection & the defendant believed he may have developed an epidural spinal abscess. The defendant ordered blood tests, prescribed an antiinflammatory, & directed the plaintiff to seek medical attention in the emergency room if pain worsened or he developed neurologic symptoms. Later that day, the plaintiff’s pain worsened & he was evaluated in the emergency room. An MRI confirmed the presence of an epidural abscess that was treated surgically. The following day, the defendant visited the plaintiff & discovered he was paralyzed from the waist down. The plaintiff never regained function of his lower extremities, bowel, or bladder. | The delay in confirma- tory diagnosis & adequate intervention resulted in irreversible spinal cord damage | California | $4,724,719      |
| The plaintiff underwent a scheduled anterior discectomy & cervical fusion to treat a ruptured disc at C3–4 at a VA hospital by defendant 1, the attending neurosurgeon, & defendant 2, the resident surgeon. During the operation Surgifoam was utilized to mitigate bleeding & the surgical site was closed. Postoperatively, the plaintiff endorsed loss of motor & sensory function below the neck. Follow-up MRI revealed spinal cord compression secondary to Surgifoam. Defendant 1 was informed of the plaintiff’s condition & advised defendant 2 that the sensory & motor function would return in time. Defendant 1 did not evaluate the plaintiff for 7 days postoperatively despite no return of function. The plaintiff was left quadriplegic. | The delay in examina- tion & failure to reoperate resulted in irreversible spinal cord damage          | California | $4,341,919      |
| Plaintiff was involved in an MVC & was arrested after fleeing the scene. During apprehension, the plaintiff was restrained & had his face pressed against the officer’s vehicle. Upon arrival at the hospital, radiographic examinations identified cervical spine injury warranting an Aspen collar for 6–8 wks. During the plaintiff’s hospitalization they sustained an alcohol withdrawal seizure, fell, & sustained further cervical injury. Four days after the seizure, the plaintiff complained of motor & sensory loss in his upper extremities. The defendants determined he could be discharged once able to ambulate. The following day, the plaintiff was found to be paralyzed from the neck down. Surgical decompression was performed at that time. The plaintiff was left quadriplegic. | The delay in diagnosis & surgical interven- tion resulted in irreversible spinal cord damage       | California | $3,450,000      |
| The plaintiff, a 42-year-old man, was participating in an off-road vehicle excursion, hit uneven ground, & landed forcefully on the seat. Subsequently, he began experiencing low-back pain as well as numbness in his bilat lower extremities. Pt was admitted to the hospital with a probable spinal column fracture & neurosurgery was consulted. The defendant, a neurosurgeon, was required to see the pt within 20 mins of consultation. However, the defendant did not see the pt until the following day. The plaintiff underwent surgical decompression 2 days postinjury. Despite intervention, the plaintiff was left paraplegic. | The delay in examina- tion & surgical intervention resulted in irreversible spinal cord damage | California | $3,000,000      |

CONTINUED ON PAGE 8 »
early spine surgery, its incipient risks, the heterogeneity of neuropathology, and the research protection acts in place, randomized controlled trials are difficult to achieve. As such, current guidelines must rely on class III evidence.

**AO Spine Guidelines**

AO Spine guideline authors also acknowledge early surgical intervention for patients with aSCI or ATCCS as a treatment option. They too found that no study has rigorously examined the benefits of early (<24 hour) surgical decompression for aSCI and that the role of early surgical intervention is unclear.23 de novo assessment of the studies found variable methodology and outcome measurement, which limited the author’s ability to make recommendations.24 AO Spine guideline authors also acknowledge early surgical intervention for patients with aSCI or ATCCS as a treatment option. They too found that no study has rigorously examined the benefits of early (<24 hour) surgical decompression for aSCI and that the role of early surgical intervention is unclear.23 de novo assessment of the studies found variable methodology and outcome measurement, which limited the author’s ability to make recommendations.24

**TABLE 2. Malpractice case examples with award settlements**

| Case Details | Argument | State | Award |
|--------------|----------|-------|-------|
| Plaintiff presented to the hospital with new-onset pain & paresthesias in his bilateral upper extremities. At that time, he was evaluated by defendant 1, who suspected carpal tunnel syndrome as the underlying pathology & ordered an EMG. Defendant 2 reviewed the EMG results & notified defendant 1 of the abnormalities found & suggested additional testing in addition to a neurosurgical consult. Defendant 1 did not pursue further evaluation, did not inform the plaintiff of defendant 2’s recommendations, & discharged them. Six mos later the plaintiff re-presented w/ progressive symptoms including difficulty extending his left upper extremity & bilateral lower extremities. Defendant 3 did not recommend a neurosurgical consult & discharged the plaintiff. An evaluation done 10 mos after onset of symptoms included a neurosurgical consult & MRI, which revealed disc herniation at C3–6. At that time, the plaintiff was diagnosed w/ hyperreflexia w/ clonus in the lower extremities requiring surgical intervention. The plaintiff was left w/ multiple chronic neurologic deficits. | The repetitive delay in diagnosis & surgical intervention resulted in irreversible spinal cord damage | Pennsylvania | $298,979 |
| The plaintiff was involved in an MVC & was ejected from the vehicle. Upon arrival at the hospital, the plaintiff endorsed the loss of motor function in his legs. The emergency medicine physician examined the plaintiff & found paralysis of the left lower extremity. A portable cervical spine radiograph was ordered, which demonstrated no fracture or abnormality. The on-call neurosurgeon, defendant, was consulted but was unable to be reached for over an hr & ultimately refused to come to the hospital in the middle of the night. The defendant did order additional imaging of the spine & asked to be kept informed of any findings. Additional radiographs were negative for acute pathology. Despite voicing distrust in the findings & that they felt there was an undiagnosed fracture, the defendant again refused to come to the hospital. At 4:00 AM the defendant came in & evaluated the plaintiff but did not document the neurological assessment in the EMR. By 7:30 AM the plaintiff had developed numerous motor & sensory deficits. | The delay in examination & failure to intervene resulted in irreversible spinal cord damage | Louisiana | $240,084 |
| Plaintiff, a 36-year-old woman, was involved in a horseback riding accident during which she was thrown & landed on her back. Upon arrival at the hospital, radiographic examinations revealed a T5–6 burst fracture w/ increasing kyphotic deformity. The defendant, an orthopedic surgeon on-call, recommended surgery. However, this was not performed until 18 days postinjury. The surgery was performed & the same day reoperation was required to replace misplaced rods from T1 to T12. The plaintiff was left w/ incomplete paraplegia. | The delay in operation, in the setting of increasing kyphotic deformity, resulted in irreversible spinal cord damage | California | $125,000 |

EMG = electromyogram; EMR = electronic medical record; MVC = motor vehicle crash.

Litigation Risk

Not only is the timing of intervention for aSCI a factor...
that impacts a patient’s functional outcome, but it is also a critical component to some of the reported malpractice cases. By definition, medical malpractice is when a hospital or healthcare provider causes injury to a patient, through either negligence or omission. The claim must prove a violation of the standard of care, that an injury was caused by negligence, and that the injury resulted in damages. If a decision to delay surgery is deemed to not meet the standard of care, it seems plausible that delaying intervention could leave some surgeons vulnerable to malpractice suits. Given the debilitating lifelong consequences of aSCI, arguing that the actions, or lack thereof, of the medical staff may have resulted in disability, loss of income, unusual pain, suffering and hardship, or therefrom, of the medical staff may have resulted in disability, loss of income, unusual pain, suffering and hardship, or significant medical expenditure is possible. Additionally, given the emerging evidence reviewed above, it seems plausible that delaying intervention could leave some surgeons vulnerable to malpractice suits. Given the debilitating lifelong consequences of aSCI, arguing that the actions, or lack thereof, of the medical staff may have resulted in disability, loss of income, unusual pain, suffering and hardship, or significant medical expenditure is possible. Additionally, given the lack of clarity surrounding the timing of surgical intervention for aSCI, it is no surprise that all cases identified in our query for management of trauma included the interval of time to treatment in their filing. While explicit guidelines surrounding this topic will not protect medical professionals from civil lawsuits, they may contribute significantly in negligence lawsuits as the standard of care.

Evolving Understanding of SCI

The likelihood of increased lawsuits related to surgical timing will increase as our understanding and management capabilities for severe traumatic injuries continue to improve. Restoration of volitional movement with epidural spinal cord stimulation in patients who were previously thought to have “complete” SCI has resulted in an evolving understanding of what constitutes an irreversible injury. As biomarkers are identified elucidating the pathophysiology of SCI enabling differentiation between patients with capacity for recovery and those who are less likely to improve, there will be increased need for infrastructure to support early intervention.

Feasibility of Early Intervention and System Capacity Challenges

Infrastructural components required to execute timely surgery include the availability of qualified surgeons and nurses, as well as the consolidation of proper equipment and instrumentation. Level 1 and 2 trauma centers are the primary treatment facilities for aSCI, but 16% of the US population does not live within an hour of such centers. A minority of trauma centers have specific spine call schedules for neurosurgeons, raising the possibility that some neurosurgeons taking trauma call may not perform complex spine surgery. The economics of healthcare may even dissuade complex spine surgeons from taking trauma call as it would interfere with their ability to provide elective care. A potential concern raised by this review is that if SCI is ultimately treated the way brain injury is, as “a surgical emergency,” the number of surgeons who are willing to take trauma call may further decrease. The performance of long, stressful, and technically challenging cases in the middle of the night or at off-hours with suboptimal staffing will further challenge a workforce already highly susceptible to burnout. Systematic solutions, such as the outsourcing of complex spine trauma cases to dedicated spine surgeons or spine centers, may be necessary to manage these patients.

Conclusions

The guidelines for aSCI management do not mandate a timeline for surgical interventions because there have been relatively few randomized prospective trials addressing the issue. The conduct of such trials may be unethical, as they would be for the management of similar acute brain injuries. Nonetheless, patients have successfully litigated against physicians for delays in management of aSCI. The purpose of this study was to evaluate the gap between guideline recommendations and reported legal judgments to better understand if current guidelines might expose surgeons to litigation risk. Our results suggest that, when safe and possible, surgeons may want to intervene as quickly after the injury as is feasible. As understanding of SCI continues to evolve, and there is increased recognition that few injuries are “complete” or “irreversible,” such lawsuits may become more common and more successful. Infrastructural and systemic changes are needed to enable surgeons to be able to provide timely care.

Acknowledgments

We would like to thank Vicente E. Garces at the University of Minnesota Law Library and Brendan Johnson for their contributions to data collection.

References

1. DeVivo MJ. Causes and costs of spinal cord injury in the United States. Spinal Cord. 1997;35(12):809–813.
2. Wilson JR, Tetreault LA, Kwon BK, et al. Timing of decompression in patients with acute spinal cord injury: a systematic review. Global Spine J. 2017;7(3 Suppl):95S–115S.
3. Badhiwala JH, Ahuja CS, Fehlings MG. Time is spine: a review of translational advances in spinal cord injury. J Neurosurg Spine. 2019;30(1):1–18.
4. Allen AR. Surgery of experimental lesion of spinal cord equivalent to crush injury of fracture dislocation of spinal column: a preliminary report. JAMA. 1911;57(11):878–880.
5. Lifshitz J, Colohan A. A brief history of therapy for traumatic spinal cord injury. Neurosurg Focus. 2004;16(1):E5.
6. Albin MS, White RJ, Locke GE. Treatment of spinal cord trauma by selective hypothermic perfusion. Surg Forum. 1965;16:423–424.
7. Ducker TB, Hamit HF. Experimental treatments of acute spinal cord injury. J Neurosurg. 1969;30(6):693–697.
8. Shuster E. Fifty years later: the significance of the Nuremberg Code. N Engl J Med. 1997;337(20):1436–1440.
9. Tarlov I. Acute spinal cord compression paralysis. J Neurosurg. 1972;36(1):10–20.
10. Bracken MB, Shepard MJ, Collins WF, et al. A randomized, controlled trial of methylprednisolone or naloxone in the treatment of acute spinal-cord injury. Results of the Second National Acute Spinal Cord Injury Study. N Engl J Med. 1990;322(20):1405–1411.
11. Fehlings MG. Traumatic spinal cord injury’s secondary injury cascade. Spine Universe. Accessed September 15, 2020. https://www.spineuniverse.com/conditions/spinal-cord-injury/traumatic-spinal-cord-injuries-secondary-injury-cascade
12. Fehlings MG, Rabin D, Sears W, et al. Current practice in the timing of surgical intervention in spinal cord injury. Spine (Phila Pa 1976). 2010;35(21 Suppl):S166–S173.

13. Ter Wengel PV, Feller RE, Stadhouder A, et al. Timing of surgery in traumatic spinal cord injury: a national, multidisciplinary survey. Eur Spine J. 2018;27(8):1831–1838.

14. Fehlings MG, Vaccaro A, Wilson JR, et al. Early versus delayed decompression for traumatic cervical spinal cord injury: results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS). PLoS One. 2012;7(2):e32037.

15. Wilson JR, Singh A, Craven C, et al. Early versus late surgery for traumatic spinal cord injury: the results of a prospective Canadian cohort study. Spinal Cord. 2012;50(11):840–843.

16. Furlan JC, Noonan V, Cadotte DW, Fehlings MG. Timing of decompressive surgery of spinal cord after traumatic spinal cord injury: an evidence-based examination of pre-clinical and clinical studies. J Neurotrauma. 2011;28(8):1371–1399.

17. Bullock MR, Chesnut R, Ghajar J, et al. Surgical management of acute subdural hematoma. Neurosurgery. 2006;58(3 Suppl):S16–S24.

18. Dyda L. 7 trends in spine surgery malpractice cases—75% found in favor of surgeons. Becker’s Spine Review. July 5, 2017. Accessed September 15, 2020. https://www.beckerspine.com/spine/item/37340-7-trends-in-spine-surgery-malpractice-cases-75-found-in-favor-of-surgeons.html

19. Daniels AH, Ruttiman R, Eltorai AEM, et al. Malpractice litigation following spine surgery. J Neurosurg Spine. 2017;27(4):470–475.

20. Kirshblum S, Waring W III. Updates for the International Standards for Neurological Classification of Spinal Cord Injury. Phys Med Rehabil Clin N Am. 2014;25(3):505–517, vii.

21. Congress of Neurological Surgeons. Guideline Development Methodology. Accessed September 15, 2020. https://www.cns.org/guidelines/guideline-development-methodology

22. Guidelines for the management of acute cervical spine and spinal cord injuries. Neurosurgery. 2013;72(Suppl 3):1–259.

23. Fehlings MG, Tetreault LA, Wilson JR, et al. A clinical practice guideline for the management of patients with acute spinal cord injury and central cord syndrome: recommendations on the timing (≤24 hours versus >24 hours) of decompressive surgery. Global Spine J. 2017;7(3 Suppl):195S–202S.

24. Cowan JA Jr, McGillicuddy JE. Images in clinical medicine. Reversal of traumatic quadriplegia after closed reduction. N Engl J Med. 2008;359(20):2154.

25. Guest J, Eleraky MA, Apostolides PJ, et al. Traumatic central cord syndrome: results of surgical management. J Neurosurg. 2002;97(1 Suppl):25–32.

26. Lenehan B, Fisher CG, Vaccaro A, et al. The urgency of surgical intervention in the setting of traumatic central cord syndrome. J Neurosurg Spine. 2010;35(21 Suppl):S180–S186.

27. Wolf A, Levi L, Mirvis S, et al. Operative management of bilateral facet dislocation. J Neurosurg. 1991;75(6):883–890.

28. Anderson DG, Voets C, Ropiak R, et al. Analysis of patient variables affecting neurologic outcome after traumatic cervical facet dislocation. Spine J. 2004;4(5):506–512.

29. Aarabi B, Alexander M, Mirvis SE, et al. Predictors of outcome in acute traumatic central cord syndrome due to spinal stenosis. J Neurosurg Spine. 2011;14(1):122–130.

30. Chen TY, Lee ST, Lui TN, et al. Efficacy of surgical treatment in traumatic central cord syndrome. Surg Neurol. 1997;48(5):435–441.

31. Stevens EA, Marsh R, Wilson JA, et al. A review of surgical intervention in the setting of traumatic central cord syndrome. Spine J. 2010;10(10):874–880.

32. Vale FL, Burns J, Jackson AB, Hadley MN. Combined medical and surgical treatment after acute spinal cord injury: results of a prospective pilot study to assess the merits of aggressive medical resuscitation and blood pressure management. J Neurosurg. 1997;87(2):239–246.

33. Bourassa-Moreau É, Mac-Thiong JM, Ehrmann Feldman D, et al. Complications in acute phase hospitalization of traumatic spinal cord injury: does surgical timing matter? J Trauma Acute Care Surg. 2013;74(3):849–854.

34. Dvorak MF, Noonan VK, Fallah N, et al. The influence of time from injury to surgery on motor recovery and length of hospital stay in acute traumatic spinal cord injury: an observational Canadian cohort study. J Neurotrauma. 2015;32(9):645–654.

35. Mac-Thiong JM, Feldman DE, Thompson C, et al. Does timing of surgery affect hospitalization costs and length of stay for acute care following a traumatic spinal cord injury? J Neurotrauma. 2012;29(8):2816–2822.

36. Rahimi-Movaghar V, Naikan A, Haghmehgadhar A, et al. Early versus late surgical decompression for traumatic thoracic/thoracolumbar (T1-L1) spinal cord injured patients. Primary results of a randomized controlled trial at one year follow-up. Neurosciences (Riyadh). 2014;19(3):183–191.

37. Schneider RC, Cherry G, Pantek H. The syndrome of acute central cervical spinal cord injury: with special reference to the mechanisms involved in hyperextension injuries of cervical spine. J Neurosurg. 1954;11(6):546–577.

38. Aarabi B, Hadley MN, Dhall SS, et al. Management of acute traumatic central cord syndrome (ATCCS). Neurosurgery. 2013;72(Suppl 2):195–204.

39. Yelamarthy PKK, Chhabra HS, Vaccaro A, et al. Management and prognosis of acute traumatic cervical central cord syndrome: systematic review and Spinal Cord Society–Spine Trauma Study Group position statement. Eur Spine J. 2019;28(10):2390–2407.

40. Yousuffiard M, Rahimi-Movaghar V, Baikpour M, et al. Early versus late spinal decompression surgery in treatment of traumatic spinal cord injuries; a systematic review and meta-analysis. Emergency (Tehran). 2017;5(1):e37.

41. El Tecle NE, Dahdaleh NS, Bydon M, et al. The natural history of complete spinal cord injury; a pooled analysis of 1162 patients and a meta-analysis of modern data. J Neurosurg Spine. 2018;28(4):436–443.

42. Danzon PM. Medical Malpractice: Theory, Evidence, and Public Policy. Harvard University Press; 1985.

43. Darrow D, Balser D, Netoff TI, et al. Epidural spinal cord stimulation facilitates immediate restoration of dormant motor and autonomic supraspinal pathways after chronic neurologically complete spinal cord injury. J Neurotrauma. 2019;36(15):2325–2336.

44. Pino JP, Hoover C, Venkatesh S, et al. Long-term spinal cord stimulation after chronic complete spinal cord injury enables volitional movement in the absence of stimulation. Front Syst Neurosci. 2020;14:35.

45. Gill ML, Grahn PJ, Calvert JS, et al. Neurormodulation of lumbosacral spinal networks enables independent stepping after complete paraplegia. Nat Med. 2018;24(11):1677–1682.

46. Atkinson DA, Sayenko DG, D’Amico JM, et al. Interlimb conditioning of lumbosacral spinally evoked motor responses after spinal cord injury. Clin Neurophysiol. 2020;131(7):1519–1532.

47. Arpin DJ, Ugiliweneza B, Forrest G, et al. Optimizing neuromuscular electrical stimulation pulse width and amplitude to promote central activation in individuals with severe spinal cord injury. Front Physiol. 2019;10:1310.

48. Branas CC, MacKenzie EJ, Williams JC, et al. Access to trauma centers in the United States. JAMA. 2005;293(21):2626–2633.

49. Calero-Martinez SA, Matula C, Peraud A, et al. Development and assessment of competency-based neurotrauma course curriculum for international neurosurgery residents and neurosurgeons. Neurosurg Focus. 2020;48(3):E13.
50. Kalkanis SN, Shaffrey CI, Rao G, et al. Letter to the Editor. Education and evidence-based medicine in neurosurgery. *J Neurosurg Spine*. 2020;33(1):126–128.

**Disclosures**

Dr. Samadani reports receiving lecture fees from Abbott Laboratories, the American Association of Neuroscience Nurses, Cottage Health, Google Inc., Integra Corp., Medtronic Corp., National Neurotrauma Society, the National Football League, USA Football, and the Minnesota, Texas, Louisiana, and Wisconsin Coaches Associations; receiving grant support from the Minnesota Department of Education (Traumatic Brain and Spinal Cord Injury), Veterans Administration, Abbott Laboratories, Medtronic, and Integra; having equity in Oculogica; and serving as an unaffiliated neurotrauma consultant to the National Football League for 5 games during each of the 2015–2018 football seasons.

**Author Contributions**

Conception and design: Samadani, Rafter, Shen. Acquisition of data: Samadani, Rafter, Vasdev, Hurrelbrink, Gormley, Shen. Analysis and interpretation of data: Samadani, Rafter, Vasdev, Hurrelbrink, Shen. Drafting the article: Rafter, Vasdev, Hurrelbrink, Gormley. Critically revising the article: Samadani, Rafter, Shen. Reviewed submitted version of manuscript: Rafter, Chettupally, Shen. Approved the final version of the manuscript on behalf of all authors: Samadani. Administrative/technical/material support: Rafter, Chettupally. Study supervision: Samadani, Rafter, Shen.

**Supplemental Information**

**Previous Presentations**

 Portions of this study were presented in poster form at the Annual Meeting of the Congress of Neurological Surgeons in San Francisco, California, on October 21, 2019.

**Correspondence**

Uzma Samadani: University of Minnesota, Minneapolis, MN. usamadan@umn.edu.