and secure its borders because illegal immigration was placing an undue burden on the state. Supporters believed that Arizona needed to take action given that federal lawmakers had failed to protect Arizona's interests adequately.

Critics, which included civil rights groups, the Obama Administration, and the Justice Department, believed that the law was mean-spirited and racially tainted, citing both civil liberties concerns and Constitutional concerns. They argued passionately that the law would lead to "racial profiling" and create a "climate of fear" in Arizona. The Department of Justice expressed concern that Arizona was overreaching its authority because immigration policy is the Constitutional domain of the federal government.

Shortly before the law was to take effect, the federal District Court in Phoenix blocked the measure, and in April 2011, the 9th Circuit U.S. Court of Appeals let the decision stand. In April 2012, the U.S. Supreme Court heard oral arguments in *Arizona v. United States*. The Department of Justice challenged four provisions on the grounds of supremacy (i.e., the federal government has the Constitutional authority to regulate and enforce immigration policy, and states cannot undermine or intrude on federal powers). The Department argued that the federal government has the sole responsibility for maintaining immigration policy to prevent a patchwork of state immigration measures. The suit did not address concerns raised by civil rights groups that the Arizona measure might lead to racial profiling.

In June 2012, the U.S. Supreme Court ruled to uphold one of the central tenants of the law, which obligated local law enforcement to determine the immigration status of people they had a reasonable suspicion of being in the United States illegally. However, the court struck down the other three provisions. "Arizona may have understandable frustrations with the problems caused by illegal immigration, but the state may not pursue policies that undermine federal law" wrote Justice Kennedy for the majority. The Court adopted a vigilant stance with regard to the provision it upheld, indicating it would be willing to review the law should there be future civil liberties concerns.

EBBING IMMIGRATION TIDE IN ARIZONA

The U.S. Supreme Court decision helped clarify the state and federal roles in setting immigration policy and provided guidance for other states contemplating similar action. Although some of the key provisions of S.B. 1070 will never become law, its passage has likely had the impact intended by its framers. Illegal immigration is diminishing in Arizona. The number of illegal aliens in Arizona is at its lowest level since 2000. Interviews with immigrant families suggest that the cause is multifactorial and includes Arizona's sputtering economy. However, immigrant families also cite the stiff policies of local law enforcement and measures such as S.B. 1070 for creating a climate of fear in Arizona.

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Surgical Decompression After Spinal Cord Injury: The Earlier, the Better!

Tobias A. Mattei

The incidence of acute spinal cord injury (SCI) in the United States is approximately 10,000 new cases/year (which corresponds to around 720 new patients with permanent disability per 1 million population every year), resulting in an estimated annual economic burden of approximately $4 billion. It was estimated that in 2009 there were about 262,000 persons currently living in the United States with devastating neurologic deficits secondary to SCI (13).

Although experimental studies have shown that several drugs may possibly present neuroprotective effects (e.g., riluzole, minocycline, cyclosporine, indomethacin, glibenclamide, gabapentin, arginine, estrogen receptor agonists, adenosine receptor agonists, glutamate receptor blockers, and antioxidants) (10), up to now, the only U.S. Food and Drug Administration–approved pharmacologic treatment for SCI in the acute phase is methylprednisolone. It is important to highlight that even this pharmacological intervention has relied on very unstable support of the clinical evidence from one of the most controversial trials in the whole history of neurosurgery (12).

Because persistent compression and instability are two key contributors to secondary injury, at least theoretically early surgical decompression would offer both an immediate means of relieving physical pressure as well as further protection against subsequent injuries related to instability. In parallel to the current lack of efficient drug therapies for SCI, there has been significant preclinical evidence supporting the concept that early surgical decompression after SCI does result in better neurologic outcomes. According to experimental data, early decompression of the spinal cord has been proven to attenuate the deleterious effect of the so-called "secondary injury" by acting on several pathophysiologic mechanisms, such as ischemia, vasospasm, delayed axonal loss, apoptosis, ion-mediated cell damage, excitotoxicity, neuroinflammation, mitochondrial dysfunction, and oxidative cell damage (2).

For example, in an experimental model of SCI in dogs, it was shown that longer duration of spinal cord compression produced lesions of significantly greater volume with worse long-term functional outcomes. In such experiments, probably owing to the relatively rapid viscoelastic relaxation of the spinal cord during the early phase of sustained compression, longer periods of spinal cord displacement allowed propagation of the secondary injury process re-

sulting in lack of recovery of somatosensory evoked potentials, limited functional recovery, and more extensive tissue damage (3).

Another study showed not only that early spinal cord decompression (performed within 1 hour of evoked potential loss) resulted in significantly better electrophysiologic recovery, but also that the degree of early reperfusion hyperemia after decompression was inversely proportional to the duration of spinal cord compression and directly proportional to the electrophysiologic recovery (4). These results suggest that spinal regional vascular mechanisms are intimately linked to electrophysiologic recovery and that, after precise dynamic spinal cord loading to a point of functional conduction deficit, a critical time period exists when decompression can lead to effective recovery of electrophysiologic function.

Another experimental study attempted to evaluate the efficacy of anti-inflammatory therapy (using an anti-α4 monoclonal antibody that had previously been shown to attenuate leukocyte infiltration) in reducing secondary injury mechanisms after SCI (8). The results of this study demonstrated that although both early and delayed drug treatment reduced intraspinal inflammation and pain, motor function did not improve in the "delayed treatment" group, suggesting that the efficacy of anti-inflammatory measures to control secondary injury mechanisms depends on very early therapy delivery (<2 hours after SCI).

Nevertheless, until recently, the only class I evidence on the issue of timing of surgical decompression after SCI came from a historical randomized controlled trial (performed at one of the institutions with the largest volume of admissions for SCI in the world) that did not show significant neurologic benefit for surgical decompression after SCI performed <72 hours after injury compared with decompression after 5 days (14). Although no substantial scientific support existed for early decompression after SCI, several experts on the issue continued to defend and perform it (2).

Moreover, several other smaller prospective studies have failed to show any benefit in terms of neurologic outcomes of early decompression after SCI (14, 15). One of the great criticisms of such studies (besides their limitation to a single-center enrollment) was that early decompression was defined as a surgical procedure performed within 72 hours from the time of injury. However, based on the best available evidence at the present time, an expert consensus of the Spine Trauma Study Group has agreed that a 24-hour cutoff should be used to define early versus late decompression after SCI (5).

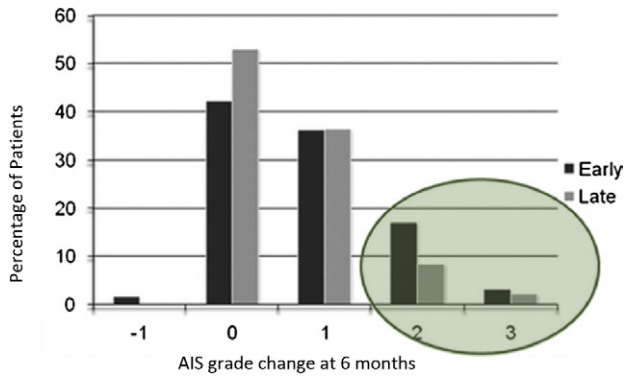


Figure 1. Overall American Spinal Injury Association Impairment Scale (AIS) grade improvement at 6 months: early (<24 hours) versus late (≥24 hours) surgery. (Modified from: Fehlings MG, Vaccaro A, Wilson JR, Singh A, W Cadotte D, Harrop JS, Aarabi B, Shaffrey C, Dvorak M, Fisher C, Arnold P, Massicotte EM, Lewis S, Rampersaud R: Early versus delayed decompression for traumatic cervical spinal cord injury: results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS). PLoS One 7:e32037, 2012 [6].)

Predictor Variable	Odds Ratio with 95% CI	p-value
Early vs. Late surgery ≥2 grade AIS improvement	2.83 (1.10,7.28)	P = 0.03
Early vs. Late surgery 1 grade AIS improvement	1.38 (0.74, 2.57)	P = 0.31

Figure 2. Results of a generalized ordinal logistic regression model assessing the effect of early versus late surgical decompression adjusted for preoperative neurologic status and steroid administration. (Modified from: Fehlings MG, Vaccaro A, Wilson JR, Singh A, W Cadotte D, Harrop JS, Aarabi B, Shaffrey C, Dvorak M, Fisher C, Arnold P, Massicotte EM, Lewis S, Rampersaud R: Early versus delayed decompression for traumatic cervical spinal cord injury: results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS). PLoS One 7:e32037, 2012 [6].)

A systematic review of the published literature from 1966–2000, combining a pooled data of 1687 eligible patients, concluded that decompression within 24 hours after SCI resulted in improved outcomes compared with either delayed surgery (>24 hours) or conservative treatment, although the analysis of homogeneity for this study showed that only the data regarding patients with incomplete SCI who had early surgery was reliable (9). Taking into account both experimental evidence from preclinical studies favoring early spinal decompression after SCI and the lack of clinical evidence supporting such conduct, the results of the recently published study STASCIS (Surgical Timing in Acute Spinal Cord Injury Study) have been enthusiastically welcomed by the spine surgery community.

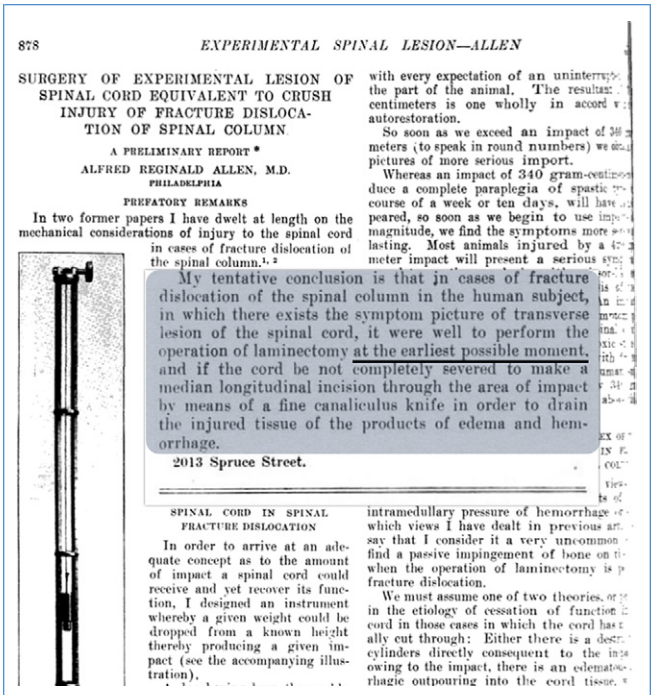
STASCIS was a multicenter prospective cohort study that proposed to compare the relative effectiveness of early (<24 hours after injury) versus late (≥24 hours after injury) surgery in patients with cervical SCI (6). The primary outcome was neurologic function 6 months after the injury. As secondary endpoints, the study assessed the impact of surgical timing on both in-hospital postoperative complication rates and mortality.

This study found that, of the 222 patients with follow-up data available at 6 months after injury, 19.8% of patients who underwent early surgery showed an improvement of two or more grades in the overall American Spinal Injury Association Impairment Scale (AIS) grade compared with only 8.8% in the late decompression group (odds ratio of 2.57) (**Figure 1**). In the multivariate analysis (adjusted for preoperative neurologic status and steroid administration), the odds of at least a two-grade AIS improvement were 2.83 times higher among patients who underwent early surgery compared with patients who underwent late surgery (**Figure 2**). The mortality rates were similar in both groups (one case in each group). Although complications occurred in 24.2% of early surgery patients and in 30.5% of late surgery patients, such difference was not statistically significant (P = 0.21).

Until STASCIS, preclinical studies supporting the role of early decompressive surgery after SCI in attenuating the deleterious effects of the secondary injury mechanisms (on both the anatomic integrity and the electrophysiologic parameters of the spinal cord) have provided progressive and solid experimental evidence to support neurosurgeons who unfortunately lacked clinical evidence for their conduct of early decompression after SCI. However, at the present moment, thanks to STASCIS results, there is significant clinical evidence supporting the benefits of early spinal decompression (<24 hours) after SCI in neurologic outcomes, although not in complication or mortality rates.

Even early pioneers, such as Allen (1), who through his initial experiments of SCI in dogs in 1911 first proposed the concept of "secondary injury" mechanisms, envisioned the importance of early spinal decompression after SCI. As stated in his paper (1), "My tentative conclusion is that in the cases of fracture dislocation of the spinal column in the human subject in which there exists the symptom picture of transverse lesion of the spinal cord, it were well to perform the operation of laminectomy at the earliest possible moment . . .," although not with the same clarity as those (like us) who came later, ". . . and if the cord be not completely severed, to make a median longitudinal incision through the area of impact by means of a fine canaliculus knife in order to drain the injured tissue of the products of edema and hemorrhage" (**Figure 3**).

In summary, the achievement of STASCIS deserves enthusiastic congratulations from all neurosurgeons who, similar to Allen, have long been convinced of the benefits of early decompression after SCI but still have not had clinical scientific support upon which to rely. Nevertheless, it is important to emphasize that we have not yet reached the summit of the scientific evidence on the issue. Actually, similar to the debate on several other neurosurgical issues (such as the classic discussion about the influence of the extent of resection on the outcomes of patients with low-grade gliomas) (11), as the panoramic view from the current standpoint seems so clear and convincing, it may not even be necessary to proceed further up, as already suggested (7). Yet it is worth remembering that, as STASCIS was a multicenter prospective cohort study (not a prospective randomized controlled trial), there is still no class I evidence supporting the benefits of early versus late surgical decompression after SCI both in terms of neurological outcomes and complications.



878 EXPERIMENTAL SPINAL LESION—ALLEN

SURGERY OF EXPERIMENTAL LESION OF SPINAL CORD EQUIVALENT TO CRUSH INJURY OF FRACTURE DISLOCATION OF SPINAL COLUMN

A PRELIMINARY REPORT *

ALFRED REGINALD ALLEN, M.D.
PHILADELPHIA

PREFATORY REMARKS

In two former papers I have dwelt at length on the mechanical considerations of injury to the spinal cord in cases of fracture dislocation of the spinal column.[1, 2]

My tentative conclusion is that in cases of fracture dislocation of the spinal column in the human subject, in which there exists the symptom picture of transverse lesion of the spinal cord, it were well to perform the operation of laminectomy at the earliest possible moment, and if the cord be not completely severed to make a median longitudinal incision through the area of impact by means of a fine canaliculus knife in order to drain the injured tissue of the products of edema and hemorrhage.

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SPINAL CORD IN SPINAL FRACTURE DISLOCATION

In order to arrive at an adequate concept as to the amount of impact a spinal cord could receive and yet recover its function, I designed an instrument whereby a given weight could be dropped from a known height thereby producing a given impact (see the accompanying illustration),

with every expectation of an uninterrupted course of a week or ten days, will have disappeared, so soon as we begin to use impacts of greater magnitude, we find the symptoms more severe and lasting. Most animals injured by a 40-centimeter impact will present a serious symptom-complex . . . duce a complete paraplegia of spastic type . . . course of a week or ten days, will have . . . peared, so soon as we begin to use impacts of greater magnitude, we find the symptoms more severe and lasting. Most animals injured by a 40-centimeter impact will present a serious symptom-complex . . . pictures of more serious import.

Whereas an impact of 340 gram-centimeters is one wholly in accord with . . . autorestoration.

So soon as we exceed an impact of 340 gram-meters (to speak in round numbers) we obtain . . . pictures of more serious import.

Whereas an impact of 340 gram-centimeters . . . duce a complete paraplegia of spastic type . . . course of a week or ten days, will have disappeared, so soon as we begin to use impacts of greater magnitude, we find the symptoms more severe and lasting. Most animals injured by a 40-centimeter impact will present a serious symptom-complex . . .

intramedullary pressure of hemorrhage . . . which views I have dealt in previous articles . . . say that I consider it a very uncommon . . . find a passive impingement of bone on the cord . . . when the operation of laminectomy is performed . . . fracture dislocation.

We must assume one of two theories, or . . . in the etiology of cessation of function in the cord in those cases in which the cord has not actually cut through: Either there is a destruction of cylinders directly consequent to the impact, or . . . owing to the impact, there is an edematous-hemorrhagic outpouring into the cord tissue. . . .

Figure 3. Historical article from one of the pioneers in SCI experimental studies: Alfred R. Allen, "Surgery of experimental lesion of spinal cord equivalent to crush injury of fracture dislocation of spinal column: a preliminary report" (JAMA 57:878-880, 1911). Front page of the original publication and highlights of the concluding comments where the author defends his firm belief in the benefits of early surgical decompression for SCI as well as a questionable "myelotomy" for relieving the compressive effects of the associated edema and hemorrhage on the spinal cord.

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Airport Screening and Spinal Implants

Kevin S. Cahill and Michael Y. Wang

Metal detectors are used in most airports throughout the world to screen passengers. The inconveniences associated with the additional screening that results from a triggered alarm on a metal detector may lead to travel delays and be a constant source of anxiety and annoyance in patients with metallic spinal implants. Many patients undergoing spine surgery voice questions and concerns about future interactions with metal detectors, and substantial preoperative and postoperative counseling may be devoted to addressing this concern. Data regarding detection of modern titanium spinal implants by metal detectors to guide surgeon-patient discussions have been limited. Grevitt and Chinwalla (1) addressed this deficiency in the April 2012 issue of *Spine*.

In their study, Grevitt and Chinwalla (1) evaluated the ability of handheld and archway metal detectors to detect modern spinal implants ex vivo (implants that were simply carried by a volunteer) and in vivo (using 40 postoperative patients with various spinal implant constructs). The archway detector used in this study was the CEIA Elliptic enhanced metal detector (Costruzioni Elettroniche Industriali Automatismi, Arezzo, Italy), which has been widely installed throughout Europe and U.S. airports. The handheld detector, a standard Scanna 16 metal detector (Scanna MSC, London, United Kingdom), was set to the highest sensitivity rating corresponding to the settings used in periods of increased terrorism threats. The implants used were predominately titanium-aluminum-vanadium with titanium-aluminum-niobium rods. Patients with cobalt-chromium-molybdenum disk replacements were also included.

The authors showed that the archway metal detector was unable to detect implants in any postoperative patient or ex vivo test, including patients with up to 13 segments of posterior instrumentation for scoliosis correction and patients with cobalt-chromium disk arthroplasties. However, the handheld detector was capable of detecting implants in predominately posterior spinal locations. In the thoracic and lumbar spine, the handheld detector was able to detect all posterior but no anterior instrumentation, whereas in the cervical spine, it was able to detect both posterior and anterior instrumentation (**Table 1**). The authors noted that there was no correlation with patient body mass index, total metal mass, or metal density per segment and detection rates.

The authors conclude that the archway metal detectors in use at many U.S. and European airports do not detect modern spinal implants regardless of the quantity or location of the implants. However, handheld detectors can detect posterior spinal implants. The authors note that this can be important information for counseling patients. They highlight the situation of a postoperative patient who triggers an alarm for a nonspinal reason and is subjected to a handheld metal detector inspection. In these patients, it may be important to have additional documentation and knowledge of the spinal implant. On a related note, it may also be important for patients to know that new full-body scanners in use at many U.S. airports are "backscatter" scanners that employ low-dose ionizing radiation. These machines cannot detect any implants that are more than a few millimeters below the skin surface. Spinal implants would also not be expected to be detected by these machines.

Table 1. Detection of Spinal Implants by Airport Metal Detectors

Location of Spinal Implant (Patients and Ex Vivo Experiments)	Detection by Archway Metal Detector	Detection by Handheld Metal Detector
Cervical		
Anterior	No	Yes
Posterior	No	Yes
Thoracic		
Anterior	No	No
Posterior	No	Yes
Lumbosacral		
Anterior	No	No
Posterior	No	Yes

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