

# Atraumatic Spinal Cord Injury in the Novice Surfer: A Comprehensive Review and Update

Christian Swinney BA; David Flick MD; and Moses Cheng DO

## Abstract

Novice surfers are at risk for a rare but potentially devastating form of atraumatic myelopathy. There are 16 published studies on this condition, including 66 cases. The most common suggested mechanism of injury is static hyperextension. However, active mechanisms, in contrast to static, have also been proposed and may be contributory. First time surfers, defined as those who have never been on a surfboard prior to the day of injury, are at particular risk. These individuals make up 89.5%-100% of the reported novice surfers found in the various reports. Multiple neurologic deficits occur and often include paraparesis, paraplegia, urinary retention, and hyperesthesia. While these deficits resolve in some cases, there are reports of multiple instances of permanent injury. Increased awareness of this condition is arguably the most effective preventative measure, as it may lead to avoidance of the predisposing postures. It may also lead to earlier diagnosis in the acute setting, which will become relevant as treatment modalities continue to be refined.

## Keywords

*Myelopathy, Surfing, Hawai'i, Atraumatic, Paraplegia*

## Introduction

Surfing, a popular recreational activity in the Pacific Region, is associated with a significant risk of injury. It has been linked to the development of multiple neurological insults, many of which have significant long term sequelae.<sup>1-12</sup> Review of the current body of literature shows damage can be sustained to multiple regions, including the brain, spinal cord, and external head/neck region. Of these injuries, those to the spinal cord may be particularly devastating, leading to significant morbidity and functional impairment.

The first major examination of nontraumatic surfing-related spinal cord injury was conducted in Hawai'i by Thompson in 2004. Thompson developed the term "surfer's myelopathy" to describe an atraumatic spinal injury in the novice surfer.<sup>2</sup> His five year retrospective study included nine patients who presented to a Hawai'i hospital with atraumatic back pain, following an initial surfing experience. Notable demographic features of these patients included that the majority were male (8/9), Japanese (8/9), and had no prior surfing experience (9/9). The most common presenting symptoms were paraparesis (8/9), urinary retention (8/9), anesthesia (3/9), and hyperesthesia (2/9). Outcomes in Thompson's original study varied. Three of the patients had a complete recovery, four had continued mild weakness without sensory deficits, three had residual urinary retention, and one remained paraplegic.

Thompson's original study is significant in that it illuminated a previously unreported condition and led to multiple subsequent case series and cases reports, which we have analyzed herein.

Including Thompson's original study, there are a total of 66 reported cases of surfer's myelopathy, spread across 16 publications.<sup>2,13-27</sup> Although there is some variation among these clinical cases, the patients tend to share similar mechanisms of injury, radiographic findings, and natural histories, suggesting a common disease process. The disease entity, which almost exclusively impacts novice surfers, is a result of radiographically identifiable ischemia to the spinal cord.<sup>11</sup> The associated morbidity is often substantial.<sup>13-27</sup>

While cases of surfer's myelopathy are widely reported in the scientific literature, there are a limited number of comprehensive reviews. Various mechanisms of injury have been proposed, but they are poorly understood and there is no consensus. This, in turn, has likely contributed to the relatively limited discussion of preventative measures. Given this dearth of evidence, further investigation into the mechanism of injury and preventative measures are warranted. Herein, we present a novel assessment of this disease process, which is highly relevant to the people of Hawai'i and the Pacific Islands. It is our genuine hope that an increased awareness of both the incidence and mechanism of surfer's myelopathy will enable surfing enthusiasts to provide more effective prevention education and physicians to provide more effective acute management.

## Methods

### Objective

The object of our study was to evaluate a potentially devastating disease process relevant to recreational surfers, especially those in Hawai'i and the Pacific Islands.

### Search Strategy

A comprehensive review of the literature was performed. The PubMed (MEDLINE), Google Scholar, and EMBASE databases were searched up to May of 2016. The first recorded reference was noted in January 2004. The search strategy utilized relevant keywords to find applicable articles. These included myelopathy, surfing, Hawai'i, atraumatic, and paraplegia. The titles of all articles within the period of eligibility were searched for the following terms: surfer's myelopathy, surfing, and atraumatic myelopathy.

### Selection of Studies and Data Extraction

Inclusion criteria were broad and any case reports or case series that specifically addressed the aforementioned condi-

tion, “surfer’s myelopathy,” were evaluated. General trends, including age of onset, presenting symptoms, treatments, and residual deficits, were recorded on a case-by-case basis. Articles originally written in English, as well as translated non-English articles, were considered.

### Data Analysis

Data was collected and analyzed using Microsoft Excel 2013. Our descriptive analysis reviewed the frequency of various features associated with the condition. Given the nature of this review, statistical significance was not deemed applicable and thus not evaluated.

### Results

A comprehensive search revealed 16 published papers detailing 66 separate cases (Table 1). A total of 42% of the reported cases occurred in Hawai‘i. Of the 16 studies, 4 were in the form of a case series, which ranged in size from 3 to 23 patients. The remaining studies were individual case reports. It should be noted that the discussion of surfer’s myelopathy in the literature is a relatively recent phenomenon, with a majority of cases (85%) reported after 2009. The primary risk factor for the development of surfer’s myelopathy was being a novice surfer, generally defined as someone whose initial surfing experience had been in the preceding month. All reviewed papers (16/16) alluded to this. The term novice was more specifically defined as a “first-time” surfer in some studies.<sup>13,18,21,27</sup> Of particular relevance is a large cases series from Queen’s Medical Center in Hawai‘i, which reported that 17 of 19 patients (89.5%) were true “first-time” surfers, with absolutely no prior experience.<sup>27</sup> Among the studies, the age at the time of injury ranged from 15 to 37. The chief presenting complaints varied among the studies and included various forms of pain, motor impairment, sensory impairment, and urinary dysfunction. A comprehensive list is as follows: lower back pain, paraparesis, urinary retention, paraplegia, hypoalgesia, and hyperesthesia. The most commonly proposed mechanism of injury was prolonged hyperextension, mentioned in 100% (66/66) of cases. Reported outcomes ranged from complete resolution of the presenting neurologic deficit, to no resolution with extended follow-up. Residual symptoms were common and no improvement was noted in multiple cases. Signs of thoracic spinal cord ischemia on MRI were commonly noted (Figure 1). Specific findings, which commonly included T2 MRI thoracic hyperintensities, were reported in patients presenting with suspected surfer’s myelopathy in some radiographic analyses.<sup>16</sup> Changes on T1 MRI imaging were not noted in any of the cases. Treatment regimens varied and were not always specified, but included combinations of steroids (methylprednisolone), intravenous immune globulin (IVIG), aggressive hydration, and CSF drainage.

### Discussion

The incidence of head, neck, and spine injuries among surfers is significant, occurring in up to 37% of this popula-

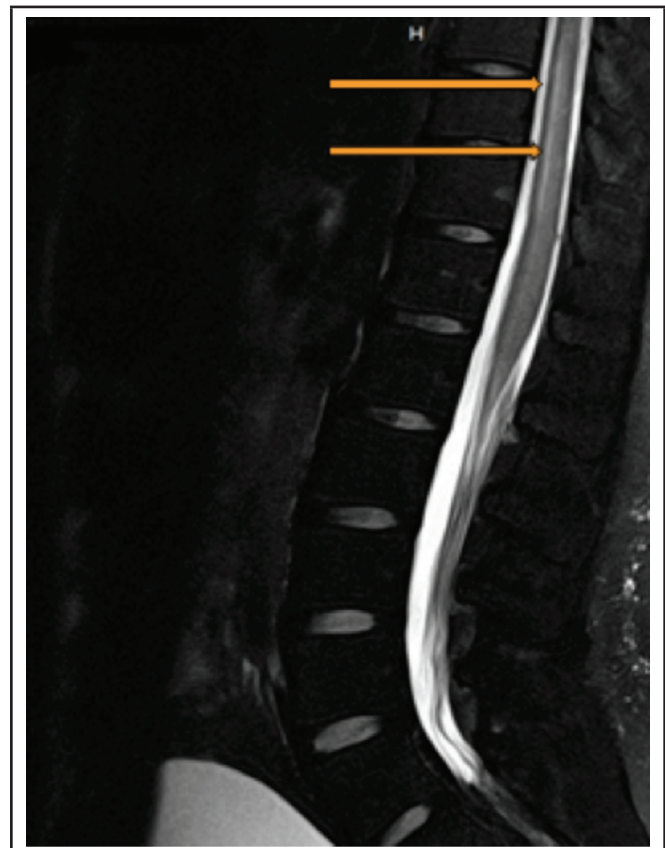


Figure 1. Gray Matter Hyperintensity in the Thoracic Cord

tion.<sup>1,3,5</sup> Classically, surfing related injuries are separated into 2 general categories, traumatic and atraumatic.<sup>3-9</sup> Common mechanisms for traumatic injuries include unintentional impact with the surfboard, other surfers, and the ocean floor.<sup>5-9</sup> While trends in traumatic injuries are well defined, less information exists on non-traumatic injuries.

A specific term, “surfer’s myelopathy,” is used by many in the medical community to describe spinal deficits resulting from surfing related injury. The term was first used by Thompson in 2004 to describe a series of atraumatic myelopathies noted in surfers in the Hawaiian Islands.<sup>2</sup> His original case series, which included 9 patients, was the first of multiple reports on this condition. Our review of the literature validates that atraumatic surfing-related spinal cord injuries, termed “surfer’s myelopathy,” are indeed a relatively common source of morbidity affecting novice surfers, with 66 cases described in the literature thus far. Given the predilection of this condition for the inexperienced surfer, awareness of the disease becomes particularly relevant in tourist destinations, such as Hawai‘i and the Pacific Islands, where many vacationers may seek to learn the sport, often for the first time. An understanding of the mechanism that leads to this condition is imperative for clinicians. The majority of cases involve the insidious onset of symptoms after a period of prolonged prone hyperextension, a static action. However, another distinct mechanism, which is active as opposed to static, has also been

Table 1. Reported Cases of "Surfer's Myelopathy"						
Year	Type	Patients	"First-Time" Clearly Specified	Reported Symptoms	Proposed Mechanisms	PMID <sup>a</sup>
2004	Case Series	9b		Low back pain, paraparesis, urinary retention, paraplegia, hyperesthesia		15303045
2007	Case Report	1		Low back pain, bilateral leg numbness, paresthesia	Prolonged hyperextension	17684897
2010	Case Report	1		Low back pain, paraplegia, paresthesia, anesthesia, bladder dysfunction	Prolonged hyperextension	20963461
2011	Case Report	1		Low back pain, paraparesis, hyperesthesia		21317134
2011	Case Report	1		Low back pain, weakness, sensory changes, urinary retention		21955419
2011	Case Report	1	Yes	Low back pain, paraplegia	Prolonged hyperextension, hyperextended valsalva	21196015
2011	Case Report	1		Low back pain, paraparesis, paraplegia	Prolonged hyperextension	21765307
2011	Case Report	1		Low back pain		21320847
2012	Case Report	1	Yes	Low back pain, paraparesis, hyperesthesia		22544059
2012	Case Series	19*	Yes	Low back pain, numbness, paralysis		23152585
2013	Case Report	1		Low back pain, paraplegia	Abnormal posturing	22019977
2013	Case Series	3		Low back pain, paraplegia, bladder dysfunction	Prolonged hyperextension, repeated flexion/extension of spinal column	22257974
2015	Case Report	1	Yes	Low back pain, bladder dysfunction, paraplegia, paresthesia, anesthesia		26394636
2015	Case Series	23		Low back pain, paraplegia, sensory abnormalities, urinary retention		23828111
2016	Case Report	1	Yes	Low back pain, weakness, paralysis, bladder dysfunction		27012110
2016	Case Report	1	Yes	Low back pain, paresthesia, paralysis, bladder dysfunction		27082966
Total		66	6			

<sup>a</sup>PMID is the unique identifier number used in PubMed.

\*Hawai'i-Based Study

reported. In the original case series by Thompson, there were two patients who reported symptom onset while attempting to stand up on the surfboard. Interestingly, this occurred in one patient while he was practicing his technique on the shore, not in the water. Other studies have suggested that repeated active flexion/extension, rather than prolonged static extension, may lead to ischemia and subsequent deficit.<sup>14,15</sup> Thus, there are at least two proposed mechanisms, which are fundamentally different, which may lead to the same clinical outcome.

In terms of a specific pathophysiological mechanism of these injuries, it has been postulated that ischemia to the spinal arteries may be contributory.<sup>11</sup> It is possible that holding a sustained hyperextended position may contribute to ischemia and subsequent infarction of watershed areas that share perfusion between the anterior and posterior spinal circulation. This mechanism seems particularly reasonable in the cohort of patients who report prolonged passive hyperextension without any acute active events. Other possible mechanisms of injury include avulsion of perforating vessels, vasospasm of the artery of Adamkiewicz, and fibrocartilagenous embolism.<sup>11</sup> These mechanisms seem to be more applicable to the few patients reporting acute onset of back pain during active motion. In terms of predisposing factors, Thompson suggests that the unconditioned back muscles of the novice surfer may pose a particular risk for back injury and subsequent infarction.<sup>2</sup> It has also been suggested that novice surfers spend more of their idle time in the prone hyperextended position, compared to their more experienced counterparts, who sit upright. This idle time makes up a notable proportion of a surfing experience. In fact, time motion analyses have revealed only 4%-5% of the total time of surfing involves wave riding.<sup>12</sup> The majority is spent paddling (50%) and idling (40%). Thus, this may contribute to increased risk in novice surfers.

Further exploration of the pathophysiological mechanisms and treatment modalities associated with this condition is warranted. No standard treatment has been proposed and outcomes have varied substantially. Therapeutic options have included aggressive hydration, high-dose steroids, induced systemic hypertension, and CSF drainage, but there is no data-based consensus at this time.

Various preventative measures may help decrease the morbidity associated with this condition. These include public service announcements, as well as other means of increasing awareness among physicians, novice athletes, and surfing schools. An appreciation of the role of prolonged hyperextension, the most agreed upon mechanism of injury in the development of this condition, may enable the physician to more effectively educate the patient on proper technique. This recommendation could be supplied to organizations that provide surfing instruction, which often provide novice surfers with equipment and guidance. This is particularly relevant in Hawai'i, where these companies are ubiquitous. These organizations could encourage novice surfers

to sit upright in the seated position while idling, as opposed to the prone hyperextended position. Increased awareness among physicians of the prevalence of this disease process may also lead to increased study and understanding of the presenting symptoms, natural history, and treatment options. This has the potential to translate into both more informed patient care, as well as additional research. There are various directions that additional research could take, including improved equipment/surfboard design and the impact of specific stretching/strengthening routines. Given the proposed impact of inexperience on the disease process, an observational study comparing novice and experienced surfers may also prove insightful. It should also be noted that not all studies reported concrete numbers when describing presenting symptoms, outcomes, and imaging results. This made it difficult to quantify their otherwise subject observations, a possible limitation of the present study.

It is quite possible that strengthening of the paraspinal musculature may decrease the risk of ischemia. This suggests that a preparatory exercise regime, based around core strengthening, should be considered prior to any initial attempts at surfing. Again, these recommendations could be provided by surfing instructors and schools, as well as to physicians. First time surfers should also be counseled to immediately stop surfing at the first sign of back pain. It is reasonable to assume that many of the affected individuals dismissed the initial lower back pain as musculoskeletal in origin, thereby unknowingly prolonging ischemia to the region. Lower back pain in the novice surfer is a potentially ominous warning sign that warrants cessation of activity.

## Conclusion

Novice surfers are at risk for a rare, but potentially devastating form of atraumatic myelopathy. The most commonly suggested mechanism is static hyperextension, but active mechanisms have also been proposed. Neurologic deficits may resolve, but have the potential to be permanent. Increased awareness of this condition is arguably the most effective preventative measure, as it may lead to avoidance of the predisposing postures. It may also lead to earlier diagnosis in the acute setting, which will become relevant as treatment modalities continue to be refined.

## Conflict of Interest

None of the authors identify a conflict of interest.

### Authors' Affiliations:

- University of Hawai'i, School of Medicine, Honolulu, HI (CS)  
- Tripler Army Medical Center, Department of Family Medicine, Honolulu, HI (DF, MC)

### Correspondence to:

Christian Swinney BA; John A. Burns School of Medicine, University of Hawai'i;  
Email: cswinney@hawaii.edu

## References

1. Swinney C. Assessing the Prevalence of Traumatic Head Injury amongst Recreational Surfers in the United States. *Hawaii J Med Public Health*. 2015;74(12):403-5.
2. Thompson TP, Pearce J, Chang G, et al. Surfer's Myelopathy. *Spine (Phila Pa 1976)*. 2004;29(16):E353-E356.
3. Alan RH, Eiseman B, Straehley C, et al. Surfing Injuries at Waikiki. *JAMA*. 1977;237(7):668-670.
4. Hartung GH, Goebert DA, Taniguchi RM, et al. Epidemiology of ocean sports-related injuries in Hawaii: 'Akahale O Ke Kai'. *Hawaii Med J*. 1990;49(2): 54-56.
5. Nathanson A., Haynes P, Galanis D. Surfing Injuries. *Am J Emerg Med*. 2002;20(3):155-160.
6. Nathanson A., Bird S, Dao L, et al. Competitive Surfing Injuries: A Prospective Study of Surfing-related Injuries Among Contest Surfers. *Am J Sports Med*. 2007;35(1):113-117.
7. Sunshine S. Surfing Injuries. *Curr Sports Med Rep*. 2003;2(3):136-141.
8. Taylor KS, Zoltan TB, Achar SA. Medical Illnesses and Injuries Encountered During Surfing. *Curr Sports Med Rep*. 2006;5(5):262-267.
9. Taylor DM, Bennett D, Carter M, Garewal D, Finch CF. Acute Injury and Chronic Disability Resulting from Surfboard Riding. *J Sci Med Sport*. 2004;7(4):429-437.
10. Cheshire WP, Santos CC, Massey EW, et al. Spinal Cord Infarction: Etiology and Outcome. *Neurology*. 1996;47(2):321-330.
11. Novy J, Carruzzo A, Maeder P, et al. Spinal Cord Ischemia: Clinical and Imaging Patterns, Pathogenesis, and Outcomes in 27 Patients. *Arch Neurol*. 2006;63(8):1113-1120.
12. Mendez-Villanueva A, Bishop D. Physiological Aspects of Surfboard Riding Performance. *Sports Med*. 2005;35(1): 55-70.
13. Freedman BA, Malone DG, Rasmussen PA, et al. Surfer's Myelopathy: A Rare Form of Spinal Cord Infarction in Novice Surfers: A Systematic Review. *Neurosurgery*. 2016;78(5):602-11.
14. Takakura T, Yokoyama O, Sakuma F, et al. Complete paraplegia resulting from surfer's myelopathy. *Am J Phys Med Rehabil*. 2013;92(9):833-7.
15. Chung HY, Sun SF, Wang JL, et al. Non-traumatic anterior spinal cord infarction in a novice surfer: a case report. *J Neurol Sci*. 2011;302(1-2):118-20.
16. Nakamoto BK, Siu AM, Hashiba KA, et al. Surfer's myelopathy: a radiologic study of 23 cases. *Am J Neuroradiol*. 2013;34(12):2393-8.
17. Lieske J, Cameron B, Drinkwine B, et al. Surfer's myelopathy-demonstrated by diffusion-weighted magnetic resonance imaging: a case report and literature review. *J Comput Assist Tomogr*. 2011;35(4):492-4.
18. Fessa CK, Lee BS. An Australian case of surfer's myelopathy. *Clin J Sport Med*. 2012;22(3):281-3.
19. Shuster A, Franchetto A. Surfer's myelopathy--an unusual cause of acute spinal cord ischemia: a case report and review of the literature. *Emerg Radiol*. 2011;18(1):57-60.
20. Sugiyama N, Yokoyama JI, Ikegami M, et al. A child case of surfer's myelopathy. *No To Hattatsu*. 2016;48(1):41-4.
21. Teixeira S, Moser F, Kotton RH. Imaging features and differentials in surfer's myelopathy: a case report. *Emerg Radiol*. 2016 Feb;23(1):89-92.
22. Aoki M, Moriizumi S, Toki M, et al. Rehabilitation and long-term course of nontraumatic myelopathy associated with surfing. *Am J Phys Med Rehabil*. 2013;92(9):828-32.
23. Karabegovic A, Strachan-Jackman S, Carr D. Surfer's myelopathy: case report and review. *CJEM*. 2011;13(5):357-60.
24. Dhaliwal PP, Cenic A, Eesa M, et al. An unusual case of myelopathy: surfer's myelopathy. *Can J Neurol Sci*. 2011;38(2):354-6.
25. Lin CY, Fu JH, Li SC. Surfer's myelopathy. *QJM*. 2012;105(4):373-4.
26. Avilés-Hernández I, García-Zozaya I, DeVillasante JM. Nontraumatic myelopathy associated with surfing. *J Spinal Cord Med*. 2007;30(3):288-93.
27. Chang CW, Donovan DJ, Liem LK, et al. Surfers' myelopathy: a case series of 19 novice surfers with nontraumatic myelopathy. *Neurology*. 2012;79(22):2171-6.