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REVIEW

Is Surfer's myelopathy an acute hyperextension-induced myelopathy? A systematic synthesis of case studies and proposed diagnostic criteria

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Abstract

Background Surfer's myelopathy is a rare complication of spinal hyperextension originally described in novice surfers. However, reports from patients practicing different activities had risen.

Aim To systematically synthesize the epidemiological and clinical evidence on acute hyperextension-induced myelopathy ("Surfer's myelopathy") and propose new diagnostic criteria.

Methods We systematically searched four databases for all observational and case studies on the topic. We performed a narrative synthesis to propose diagnostic criteria and tested the criteria retrospectively on the included cases. A case report is also presented.

Results Forty-two articles reporting 104 cases (median age 19 years, slightly male predominance) were included. All cases reported a nontraumatic hyperextension event (58% after surfing). All of the cases presented pain of hyperacute onset. The most frequent clinical feature was bladder or bowel dysfunction (84%). The thoracic region was the most frequently affected (87%) with longitudinal involvement until the conus (67%). At discharge or follow-up, 52% partially recovered. We propose five diagnostic criteria with three levels of certainty (definite, probable, and possible): (1) nontraumatic spine hyperextension activity (in individuals with no pre-existent spinal disease); (2) hyperacute onset (with acute pain onset); (3) spinal cord injury clinic (motor, sensory, or autonomic deficit); (4) MRI findings with central spinal cord abnormalities (multiple segments); and (5) no other alternative diagnosis. We identified 88% definite and 12% probable/possible cases.

Conclusion The acute hyperextension-induced myelopathy could occur not only during surfing but also during other activities. Therefore, increased awareness and education among sports communities and general physicians are needed.

Keywords Surfer's myelopathy · Spinal cord ischemia · Spinal cord injury

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Introduction

The term surfer´s myelopathy (SM) was first coined by Thompson et al. [1], who reported a series of nine patients presenting with gradual onset of pain, paraparesis, loss of sensation in the lower extremities, and loss of sphincter control. It was originally described in young inexperienced surfers with an average age of 25.9 (range, 15–46) [1–5]. This condition is a rare nontraumatic spinal cord injury probably secondary to a related spinal infarction [1, 3, 6, 7]. Due to its rapid onset and progression, the hypothesis of spinal cord ischemia is reinforced [1, 4, 8, 9]. Spinal hyperextension had been postulated frequently as the initial event triggering the perfusion impairment [10]. Despite the dorsal and lumbar areas of the spine being less flexible, when novice surfers wait for a wave, they wrongfully tend to display a posture of mild dorsal hyperextension by laying prone on the board, which progresses to moderate or severe hyperextension after the wave hits. This exercise is usually repeated over a prolonged period of time and with a short recovery period between waves [2, 3]. Also, fibrocartilaginous embolism triggered by a "minor" spinal trauma as hyperextension was proposed as another potential etiology [11]; however, the cases reporting that evidence had a different clinical onset and triggering event [12, 13].

Findings on magnetic resonance imaging (MRI) could be normal even after 48 h after the insult, unlike ischemic myelopathies not related to surfing [14, 15]. However, occlusion has been reported in vessels such as the radicular and Adamkiewicz arteries [3, 4, 8, 16], and there are similarities on MRI findings between SM and spinal cord infarction [6, 15, 17, 18].

Differential diagnoses can include idiopathic acute spinal cord infarction, idiopathic transverse myelitis, longitudinally extensive transverse myelitis, central cord syndrome, aortic dissection, fibrocartilaginous and other types of embolism, spondylotic diseases, cocaine-induced, vasculitis and vascular malformations. [6, 14, 19]. However, the clinical presentation of SM involves previously healthy patients with the only antecedent of recent spine hyperextension.

Apart from surfing, similar cases have been reported in patients who participated in other activities such as gymnastics, swimming, golfing and others [3, 15, 17, 20–22]. In all of those patients, there was no evidence of a traumatic event, but the execution of a posture that involves hyperextension of the spine. Those communications raised the question whether this shared trigger could be fundamental for the definition of the disease and not the type of sport practiced. If so, the diagnosis of this entity and its awareness should be expanded to all areas of neurology and to sports professionals, since prevention (i.e., appropriate technique when receiving the waves, warm-up before gymnastics) and timely treatment [7, 22, 23] would reduce the genesis and impact of this disease on these otherwise healthy individuals.

We agreed that a more precise denomination for this condition would be acute hyperextension-induced myelopathy (AHIM). To justify this proposal, we aim to conduct a systematic review of patients who reported with potential SM with and without surfing history, to describe the clinical and epidemiological profile of the condition, to conduct a narrative synthesis of worldwide cases, and to propose practical diagnostic criteria that would represent the now onward called entity of acute hyperextension-induced myelopathy (AHIM). Additionally, we present an illustrative case from our hospital.

Methods

We aimed to identify all published documents related to the condition known as Surfer's myelopathy to date. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [24] reporting guidelines for the literature review and the CAse REports (CARE)[25] guidelines for the case report. The PRISMA checklist could be found in Supplementary Table 2. For the case reported, we received informed consent from the patient and the approval of the Institutional Review Board of the "Daniel Alcides Carrión" Hospital, Lima, Peru.

Systematic search

We conducted a comprehensive search in PubMed/Medline, Embase, Scopus, and Web of Science databases from inception to July 03, 2021. The search formula consisted of keywords for "surfer's myelopathy", "acute hyperextension myelopathy"; activities as "surf", "gymnastics", "sports"; and terms related to spinal injuries as "central cord syndrome", "paraparesis" or "myelopathy" (Supplementary Table 2). Additionally, we explored citations of previous reviews on the topic [3, 26] and included our case report.

Study selection

The inclusion criteria were: (1) observational studies, case series or case reports of surfer´s myelopathy with or without surfing and myelopathies due to hyperextension of acute onset in previously healthy individual; (2) reports that described socio-demographic and clinical data of the individual patients; (3) reports that described neuroimaging; and (4) full text available in English or Spanish languages.

EndNote X9 was used to remove duplicates using the reference tool "Find duplicates". Subsequently, two authors (LSA and RLE) independently selected the reports and extracted the data in Microsoft Excel 2019. In case of inconsistencies, a third author decided whether to include the article (CAD).

Quality assessment

We used the tool proposed by Murad et al. [27]. This tool evaluated the methodological quality of case reports/series assessing eight questions about four domains. Since our systematic review does not focus on cases of adverse events, we selected only six questions for our assessment: (1) selection (a, Does the patient(s) represent(s) the whole experience of the investigator (center) or is the selection method unclear to the extent that other patients with similar presentation may not have been reported?); (2) ascertainment (b, Was the exposure adequately ascertained? c, Was the outcome adequately ascertained?); (3) causality (d, Were other alternative causes that may explain the observation ruled out? e, Was follow-up long enough for prognosis outcomes to occur? (we accepted a threshold of 6 months post-discharge as appropriate); and (4) reporting (f. Is the case(s) described with sufficient details to allow other investigators to replicate the research or to allow practitioners make inferences related to their own practice?). As suggested by the authors of the tool, we summed up the scores of the binary responses in an aggregate score (6 points at maximum). We defined equal or less than three as low -uality study.

Data extraction and narrative synthesis

The data were extracted independently by two authors (LSA and RLE). We extracted the following information: name of the first author, year of publication, sex, age, clinical presentation, ASIA Impairment Scale (AIS), neuroimaging description, onset of symptoms, treatment, and recovery. We described the categorical variables using frequencies and percentages. For numerical variables we used medians and interquartile ranges. We also analyzed the association between AIS score A and no recovery using Chi-square test ($p < 0.05$). For that analysis we used the software Stata 14.

We performed a narrative approach for synthesizing the included studies. Narrative synthesis is an approach for systematic reviews and synthesis from multiple studies that depends primarily on using words and text to explain and summarize the findings. We used a four-stage process based on previous guidelines [28]: (1) developing a theory of how/why the association could be justified (pathophysiological and clinical plausibility); (2) developing a preliminary list of synthesis categories (contextual factors related to the exposure, time interval between exposure and event, AHIM clinical manifestations, neuroimaging and CSF findings, treatment response, and prognosis data); (3) exploring the relationships between and within included cases and present them by a summary table; and (4) proposing diagnosis criteria based on the most important and frequent characteristics identified in the synthesis categories. We defined a three-level certainty category (definite, probable, and possible) by consensus. Finally, we performed an exploratory retrospective validation of our diagnosis criteria calculating the frequency of our diagnosis criteria in the included cases.

Results

Case report

A 28-year-old male driver, with no remarkable medical history except for asthma, consulted the emergency room for acute low back pain, urinary retention, and lower limb weakness. 12 h before admission, during his first surfing lesson, he experienced sudden onset of low back pain that progressed to the lower extremities, along with weakness and numbness that made him unable to swim.

Upon physical examination in the emergency department, sensory loss was detected below the thoracic level 12 (T12) and bilateral paresis in both lower limbs with a Medical Research Council score of 1/5. The initial diagnosis was acute nontraumatic spinal cord injury; an MRI was performed. The sagittal MRI demonstrated an isointense lesion on T1-weighted imaging and a high-signal lesion on T2-weighted imaging of the spinal cord adjacent to the lumbar vertebral level 1 (L1 vertebra) down to the conus medullaris (Fig. 1). Since our patient was a beginner surfer whose signs and symptoms started acutely following a hyperextension posture, we oriented our diagnostic approach to AHIM. The patient was ultimately diagnosed with severe acute paraparesis secondary to spinal cord infarction. Other causes of acute myelopathy such as infections and demyelinating diseases were ruled out.

After an empiric course of intravenous (IV) methylprednisolone (1000 mg every 24 h for 5 days), followed by prednisone (50 mg every 24 h as part of the tapering off strategy) and physical therapy, the initial flaccid paraparesis improved. The patient then scored 4/5 in his neurologic evaluation of his lower limbs at discharge. Urinary and bowel dysfunction also improved and 6 months after discharge, the patient was fully recovered and performed his usual activities without any sequelae.

Systematic review

The search strategy identified 349 documents; from those, 188 were duplicates. We found an additional record from the

Fig. 1 MRI of the thoracolumbar spine (T2-weighted images) taken on the admission day. **A** Complete spinal cord cross section. Decrease in height and signal intensity on L4–L5 IV discs. L5–S1 degenerative features. L4–L5 protrusion. Lean muscle mass increase at the paraspinal muscles at L4–L5. **B** Thoracic-MRI axial plane**. C** Sagittal plane. Increased signal at the level of the medullary cone in L2. Decrease in height and signal intensity on L4–L5 IV discs. Disc protrusion in L4–L5. Lean muscle mass increase at the level of the paraspinal muscles at the level L4–L5

manual search [29] and included the present case reported. A total of 163 records were screened by title and abstract and 70 were selected for full-text assessment.

After reviewing the full text, we excluded 27 studies. One study (Nakamoto et al. [15]) reported cases from the same community hospitals in Hawaii, having the exact periods and characteristics of the patients in another study (Chang et al. [2]). We chose the latter because it provided details about the individual patients. The list of excluded studies and reasons for exclusion could be found in Supplementary Table 3. Thus, a total of 42 documents were included representing 104 patients (Fig. 2) [1–3, 5–10, 14, 16–18, 20–23, 29–52].

Quality of the included studies

The average score of the quality scale was 4.6 (3–6), meaning moderate to high quality. The follow-up and ascertainment domains were the sections with more missing information. The complete assessment of the included studies is reported in Supplementary Table 4.

Narrative synthesis

A total of 104 patients with potential AHIM were selected. The detailed description of the cases is reported in Supplementary Table 5. The median age was 19 years (range 3.5–56) with 52% of male patients ($n=54$). Surfing was the main sport activity reported ($n=60$; 58%), followed by gymnastics ($n=5$) [10, 18, 20, 41, 53]. Other sports reported included swimming [17], pole vaulting [21], and golf [50]. Common activities of daily living that could involve spinal hyperextension were reported as triggers too, like playing with other kids [10], doing sit-ups [54] driving a car [30], working in constructions [5], or having sexual intercourse [52]. Thirty patients reported that symptoms appeared during the triggering activity; 27 reported symptoms during the first hour after the finalization of the activity; and, 9 patients reported symptoms hours after (range 2–3 h). Therefore, the onset was reported as hyperacute (an hour or less from activity discontinuation) in 57 patients (55%). Some patients reported a sensory level or presented paresthesia ($n=28$; 27%). Only 4% of the patients presented tetraplegia ($n=3$;

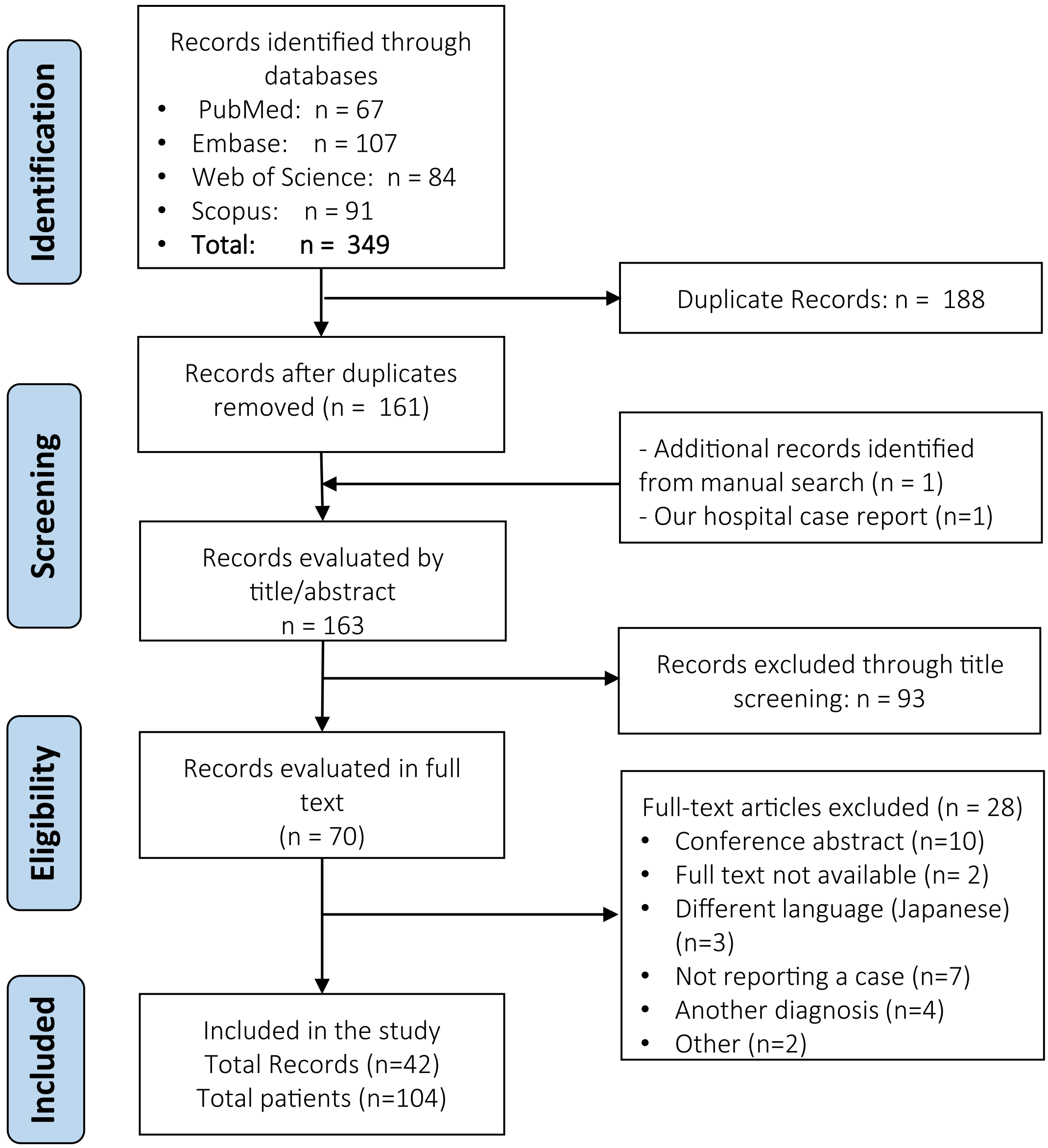

Fig. 2 PRISMA flowchart

3%); most of the cases reported paraplegia ($n=60$; 58%) and back pain ($n=87$; 84%). Besides, the most common manifestation was loss of bladder or bowel control ($n=91$; 88%). The most frequent regions involved were the thoracic ($n=90$; 87%) and lumbar ($n=73$; 70%), followed by lesions from the thoracic area to the conus medullaris ($n=70$; 67%), with more than one area involved in some patients.

The AIS score A appeared as the most common reported grade at admission ($n=36$, 35%). 27 patients (26%) were reported to be without improvement at discharge or after, and only 15 patients (14%) were fully recovered. We found significant association between AIS score A and no improvement ($p=0.022$). The most common therapeutic choices were steroids and physical therapy [48% ($n=50$) and 25% ($n=26$), respectively]. A summary of the most relevant findings is presented in Table 1.

Proposed diagnostic criteria

Despite the different reports, there is no established criteria for AHIM. Consequently, we propose five criteria to help diagnose AHIM based on the currently available information included in our systematic review: (1) recent history of performing an activity that caused a nontraumatic hyperextension of the back or spine (in individuals with no pre-existent spinal disease); (2) hyperacute onset, with a presentation of no more than 4 h after criteria No. 1; (3) presence of symptoms of spinal cord injury with with acute onset of

Table 1 Patient characteristics reported in the literature

Characteristics	n (%)
Sex	
Male	54 (52%)
Female	50 (48%)
Age (median, range)	19 (3.5–56)
Activity	
Surf	60 (57.7%)
Other sports	8 (7.7%)
Activities of daily living	5 (4.8%)
Not specified	31 (29.8%)
Time onset from activity cessation	
During activity	30 (28.9%)
Around 1 h	27 (26%)
Two hours or more	9 (8.6%)
Not reported	38 (36.5%)
Clinical presentation[a]	
Paraparesis	25 (24%)
Paraplegia	60 (58%)
Tetraplegia	3 (3%)
Bladder/bowel dysfunction	91 (88%)
Back pain	87 (84%)
Paresthesia	28 (27%)
Neuroimaging signal hyperintensities[a]	
Cervical	5 (5%)
Thoracic	90 (87%)
Lumbar	73 (70%)
Thoracic to conus	70 (67%)
Not reported	11 (11%)
ASIA score at admission	
A	36 (34.6%)
B	19 (18.3%)
C	8 (7.7%)
D	7 (6.7%)
Not reported	34 (32.7%)
Treatment[a]	
Steroids	50 (48%)
Physical therapy	26 (25%)
Antiaggregant/anticoagulants	5 (5%)
Others	10 (10%)
Not reported	45 (43%)
Recovery at discharge	
No improvement	27 (26%)
Partial improvement	39 (38%)
Total recovery	15 (14%)
Not reported	23 (22%)

[a] = more than one possibility was possible per patient

pain; (4) MRI finding involving the central cord including hyperintense diffuse T2-weighted signal abnormalities with a longitudinally extensive pattern (e.g., prolongation from central spinal cord to the conus), and (5) no other alternative diagnosis. Further details are outlined in Table 2.

Retrospectively, when applying the criteria proposed for the included cases, the frequency of the diagnosis was as follows: definite, 92 (88%); probable, 2 (2%); and possible AHIM, 10 (10%). However, one case series did not specify properly the time of onset of symptoms, but stated that "the latent period ranged from 30 min to 8 h."[49]

Discussion

In this study, we synthesized 104 AHIM cases. All cases reported a nontraumatic hyperextension event (58% after surfing). All of them presented hyperacute onset of pain within the first 4 h after activity discontinuation. The most frequent clinical feature was bladder or bowel dysfunction (88%). The thoracic region was the most frequently affected area (87%) with longitudinal involvement until the conus (67%). At discharge or following, 26% had at least partial recovery. Based on our narrative synthesis, we propose five diagnostic criteria with three levels of certainty (definite, probable, and possible): (1) antecedent of a nontraumatic spine hyperextension activity (in individuals with no pre-existent spinal disease); (2) hyperacute onset; (3) spinal cord injury symptoms; (4) MRI findings with central spinal cord abnormalities (multiple segments); and (5) no other alternative diagnosis. When we retrospectively applied the criteria on the included cases, we identified 88% definite and 12% probable/possible cases. This suggests our criteria could have high accuracy, comparable to other proposal using similar methodology [55]. However, a validation cohort of patients with alternative intrinsic myelopathy etiologies is needed to evaluate the diagnostic profile of our criteria.

Pathogenesis and pathophysiology

It is proposed that after hyperextension of the spine, the diameter of the vertebral vessel (i.e., the artery of Adamkiewicz) is occluded producing ischemia which could be transient or progress to infarction [3]. Despite knowing that the dorsal and lumbar areas of the spine are poorly flexible, when novice surfers wait for a wave, they classically display a posture of mild dorsal hyperextension (laying prone on the surface of the board with the chest up) that could progress to moderate or severe hyperextension after the wave hit (depending on its magnitude and intensity) in an attempt to achieve the standing position. This exercise is usually repeated over a prolonged period of time and with a short recovery period between waves [2, 3]. On the other hand, Reisner et al. [11] proposed fibrocartilaginous embolism into the vertebral arterial circulation after what they considered as "minor" trauma as a potential cause. Even though they

Table 2 Proposed acute hyperextension-induced ischemic myelopathy (AHIIM) diagnostic criteria

Criteria
1. Activity that caused nontraumatic hyperextension of the back or spine[a]
2. Hyperacute onset:
Motor or sensory deficit in 4 h or less after hyperextension activity
3. Sign and symptoms of spinal cord injury:
Acute onset of pain (even before the deficit)
Motor, sensory, or autonomic neurological deficit of the region spinal affected[b]
4. Magnetic resonance imaging involving the central cord with:
Hyperintense diffuse T2 lesion in the central spinal cord that may prolongate to the conus[c] or infraction-like spinal or
"Pencil-like" or "owl/snake eye" longitudinally extensive hyperintense T2-weighted signal abnormalities
5. No other alternative diagnosis
Type of AHM
Definite AHM (all criteria)
Probable AHM (at least 1, 2, and 3)
Possible AHM (at least 1 and 3)

[a]Usually presented in previously healthy individuals (who have no pre-existent spinal disease or vascular risk factors)

[b]Progressive neurological deficits (variable motor and/or sensory involvement) usually consist of loss of bladder and bowel control, acute onset of low back pain, and varying degrees of paraparesis to more severe paraplegia or tetraplegia, also new or progressive paresthesia or worse onset of paresis

[c]MR imaging usually shows extensive T2-weighted signal enhancement in the thoracic spine region (T5–T10), with extension to the lumbar or conus medullaris. Also, it could involve primarily gray matter with entire cross section of spinal cord

reported unpublished evidence of radiological evidence of disc fissures, the case reports cited had a different clinical onset as well as triggering event [12, 13].

Clinical and imaging findings

We reported an unusual case of AHM in a young adult without previous neurological conditions who hyperextended his back during his first surf lesson. These characteristics are very similar to the majority of reported cases of AHIM, involving predominately young adult men practicing surf (Table 1). Despite being initially reported in adults, in recent years, AHIM cases are now being reported in teenagers and children. The youngest case was a 3-year-old child [49]. All cases are described as nontraumatic.

AHIM can occur in patients who perform activities involving spinal hyperextension [1]. We found that the most reported cases carried out activities that generated back extension movements such as surfing; however, other activities such as swimming and gymnastics have also been identified in patients diagnosed with AHIM [17, 18, 20]. Our case presented this criterion since he hyperextended his back during his surf lesson. We must emphasize that every physical activity that could result in back hyperextension may result in stretching of the spinal cord, which is postulated as the underlying trigger mechanism for this myelopathy [8, 17, 20]. Therefore, sports trainers (especially for surfing) should be aware of this risk in students who are beginners, as they are reported to be the most affected [3, 7] and may later experience permanent sequelae [1].

Symptoms appeared quickly after activity had taken place in most cases, including our case report, between the 4 h of exercise onset. The brief period could support the ischemic etiology hypothesis [1, 4, 8, 9, 14, 16, 23, 34] and reject a possible inflammatory origin [8, 36, 40]. Spinal cord injury common clinical manifestations are pain and loss of sensory or motor function. When it is severe, it affects bowel, bladder, breathing, heart rate as well as blood pressure control [56]. Similarly, back pain which could involve lower areas and neurological impairment (motor, sensitive and vegetative) is present in spinal cord infarction of other causes such as the ones produced after aortic reparation surgery. Nevertheless, those patients are usually older, have a previous surgical antecedent, other vascular or vertebral comorbidities or a previous traumatic event [57].

In the AHIM included cases, we identified a spinal cord injury clinic characterized by a motor deficit (paraplegia in the lower limbs or quadriplegia), sensory deficit (sensory level paresthesia or pain), and autonomic deficit (bladder or intestinal dysfunction) [1, 3, 18]. Similarly, our clinical case presented with acute paraplegia, paraparesis, sensory level T12, and bladder dysfunction.

Laboratory studies such as complete blood count (CBC) and creatine kinase (CK) are usually normal in spinal cord syndrome with an ischemic cause [5, 18, 36, 40], as in our case. Cerebrospinal fluid (CSF) can help rule out other causes such as infections or inflammatory diseases.

MRIs can also help to identify the location of the lesion, to see if it tends to involve several continuous spinal levels. In AHIM, the lesion distribution tends to be medial and central. Also, it could involve primarily gray matter with the entire cross section of spinal cord [18].

The MRI findings are variable in AHIM. Ten cases [22, 49], did not provide any information about imaging, although their diagnosis was spinal infarction; another one did not provide further details about the imaging [39]. Two other studies specified infarction-like MRIs [7, 17]. In addition, Nakamoto et al. analyzed the MRIs of 23 cases, and most of them had a pencil-like-shaped T2-weighted hyperintense signal from the midthoracic region to the conus [15]. This is similar to our case, but the region showing a hyperintense signal was the lumbar region. The typical imaging of infarction is a T2 hyperintensity in vascular-specific territory, most commonly an anterior "pencil-like" lesion on sagittal sequences and "owl/snake eye" pattern of signal abnormality on axial sequences; these are most likely due to ischemia [3, 15, 58]. Other findings were hyperintense or an infarction-like spinal cord MRI. In other types of spinal cord infarction, MRI could reveal adjacent vascular malformations [59], the presence of a concomitant vertebral infarction (which could suggest atherosclerotic disorders) or vertebral abnormalities (compressive myelitis by spondylotic disease) [60], and intervertebral disc degeneration of fissures which could suggest fibrocartilaginous embolism [13]. Additionally, spinal cord infarction after aortic reparation could present similar MRI images in T2-weighted images showing "pencil-like" hyperintensities or "snake eyes" most commonly in the territory of the Adamkiewicz artery [61].

Treatment and prognosis

Intravenous corticosteroids were the preferred treatment, although not supported by previous evidence. Its use was associated to at least one grade AIS score improvement in 55% of cases [3]. There is still not convention for management of acute spinal cord injury, and only supportive management is recommended. The American Academy of Neurological Surgeons discourages the use of methylprednisolone for the treatment of acute spinal cord injury [62], although several case studies reported its use to treat AHIM with adequate response. Still randomized control trials are needed to evaluate and understand the role of corticoids and other potential treatments in the management of AHIM. Previous studies found a correlation between AIS scores A and B with poor prognosis or no improvement [2, 15]. In this case's synthesis, we found a significant association between AIS score A and no improvement [3, 8, 10, 34, 42, 49], which is concordant with previous literature. Regarding prognosis, only 52% of cases reported a complete or moderate recovery at discharge. However, the lack of longer follow-up hampered the interpretation of these outcomes. Similarly, patients suffering from spinal cord infarction of other etiologies were reported to recover some function over the months or years with proper rehabilitation [57]. Although prospective cohorts will be the ideal design to assess the disease's prognosis, due to the rarity of the event, a retrospective analysis of AHIM patients from hospitals where the cases were reported could be a more feasible alternative.

Limitation and recommendations

This study provided a comprehensive synthesis of the AHIM evidence with a rigorous methodological approach. However, it presented some limitations. First, in our case report, we could not complement the imaging study with angioresonance (due to limited resources) to better specify the anatomical location of the injury. Second, our proposed criteria are preliminary and based mainly on the clinical data from AHIM case reports; thus, several missing data are expected. Also, we performed only an exploratory retrospective validation of the diagnosis criteria; therefore, future prospective cohort studies including an SCI control cohort will be necessary to quantitatively evaluate the validity of our criteria.

Conclusions

Acute hyperextension myelopathy could occur not only during surfing, but also during other activities; thus, the surfer's myelopathy denomination should be discouraged. AHIM management is often challenging due to its lack of effective diagnostic and treatment. For this reason, we propose practical diagnostic criteria to improve AHIM detection. Since there is no consensus for AHIM treatment yet, increased awareness is needed among general physicians to consider this differential diagnosis when assessing anamnesis and develop their clinical approach. Besides, awareness and education are essential among sports communities to provide and demand proper ergonomic techniques when attempting recreational or professional sports activities that involve spine hyperextension.

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Author contributions A-DC, L-SA, R-LE, and NM designed the case report; M-MC and N-FA provided the method to develop the systematic review; L-SA, R-LE, and N-FA independently screened titles and abstracts for relevance, assessed full texts for inclusion, and carried out data extraction; M-MC, A-DC, and P-BK conducted the formal analysis; A-DC, R-LE, L-SA, M-MC, N-FA, and P-BK drafted the manuscript; A-DC, V-RV, AW, ESS, MN, and R-SR provided clinical corrections; A-DC, P-BK, V-RV, and MT revised the manuscript and did systematic review; MT, ESS, N-FA, and P-BK helped in the translation, editing, and proofing of the manuscript and contributed to the method report and systematic review. All authors provided critical revisions to the manuscript.

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Code availability Non applicable.

Declarations

Conflicts of interest The authors declare no conflicts of interest.

Ethics approval For reporting the clinical case, the authors receive approval from the Institutional Review Board of "Daniel Alcides Carrión" Hospital, Lima, Peru.

Consent to participate The index patient provided his informed consent to participate in the case report.

Consent for publication The patient provided consent for publication of the case report.

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