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Original article

Spinal cord injuries in the absence of post-traumatic radiographic anomalies (SCIWORA): the traumatic moment between patient anterior state and efficient/ concurrent causes of injury

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Abstract. *Background and aim:* Spinal Cord Injury without Radiographic Abnormality (SCIWORA) represents acute traumatic myelopathy in the absence of instrumental evidence of fractures and/or dislocations of the cervical vertebrae. *Methods:* In this article we present 4 cases of SCIWORA that came to our observation and the medico-legal implications associated with them. *Results:* In defining the compensation in the context of a private accident policy for traumatic pathologies of the spinal cord, an in-depth medical-legal assessment is essential, based on an accurate examination of the health documentation including the instrumental investigations performed, the anamnesis and an accurate evaluation of the trauma dynamic. The paraphysiological deterioration of organ-tissue structures, identifiable in the concept of "natural variability of biological risk", should be included in the same definition of insured risk by age group, with the consequence that physical conditions that fall within the physiological or paraphysiological definitions, although potentially contributing to injury, do not necessarily exclude compensation. *Conclusions*: A different concept dominates the variability of the compensation according to a paraphysiological pre-existing condition. The two arguments therefore call for thorough consideration of both the paraphysiological contributing causes of injury and/or impairment as necessarily subject to a preliminary study, which through the clinical and instrumental investigation method, will define the perimeter of functionality. (www.actabiomedica.it)

Key words: SCIWORA, Spinal Cord Injury, contributing causes of injury, natural variability, forensic evaluation

Introduction

Spinal Cord Injury Without Radiographic Abnormality (SCIWORA) means acute traumatic myelopathy in the absence of instrumental evidence of fractures and / or dislocations of the cervical vertebrae. Such an acronym was first introduced in 1982 by Pang and Wilberger (1), who described an acute traumatic injury of the spinal cord, occurring in children, which appeared immediately post-traumatic or 4-5 days later, highlighting traumatic events as an injurious mechanism with proven damaging suitability, such as falls from a height, high-energy road accidents. Such forms of trauma were believed to be the causes of the development of medullary edema, spinal cord contusions, partial or complete spinal cord injuries (all

findings were clearly detected instrumentally) with integrity of the osteoarticular anatomy of the cervical spine. A reduction of the initial acute symptoms was reported over a long period of time, with residual neuromotor and neurosensory deficits in the limbs of variable entity but persisting over time. The restitutio ad integrum was verified only in 25% of the cases examined. Over the years, publications about SCIWORA in adults have increased significantly (2-4).

Two recent Italian studies by Bonfanti et al (5) in 2018 and Michelini et al (6) reported cases of SCIWORA in adults. The incidence of SCIWORA in the reported series ranges between 13 and 19% in children and between 10 and 12% in adults, respectively (7, 8). The physiopathology of SCIWORA in adults is very different from that among the pediatric population (8, 9). Most of the cases described were caused by high-energy trauma with hyperextension, hyperflexion, distraction of the cervical spine, generally resulting from collisions with motor vehicles, falls, sports injuries with cranial trauma and direct front facials trauma. Such types of trauma cause an acute myelopathy produced by a reversible dynamic stenosis of the spine, mainly at the level of the middle-lower segments. The 3 to 5-day latency before the complete manifestation of spinal damage, which occurred in some cases of SCIWORA in childhood and adulthood, is explained by the double insult: after the primary impact injury, a secondary insult to the spinal cord parenchyma is caused by complex reactions at the cellular level that produce cell damage mediated by free radicals, lipid peroxidation and activation of membrane lipases. As a result, a cascade of secondary inflammatory reactions, oedema and ischemia can occur, resulting in further parenchymal damage of the spinal cord and ensuing deterioration of clinical conditions (9).

MRI helps the identification of spinal cord injuries such as concussion, oedema, contusion, and partial section (10). MRI is considered the instrumental investigation tool determining the differential diagnosis between extramedullary lesions (disc herniation, canal stenosis, lesion of the posterior ligament complex and intracranial hematoma) and intramedullary lesions (oedema, contusion, haemorrhage) (11).

The clinical reviews show that medullary oedema has the best prognosis and bleeding has the worst.

A 1989 study by Matsuura et al (12) measured the cross-sectional area and sagittal and transverse diameters of the cervical spinal canal in 42 patients with traumatic spinal cord injury and in 100 non-traumatized control subjects, concluding that the total volume of space in the spinal canal is not a critical factor favouring the lesion, but the shape is.

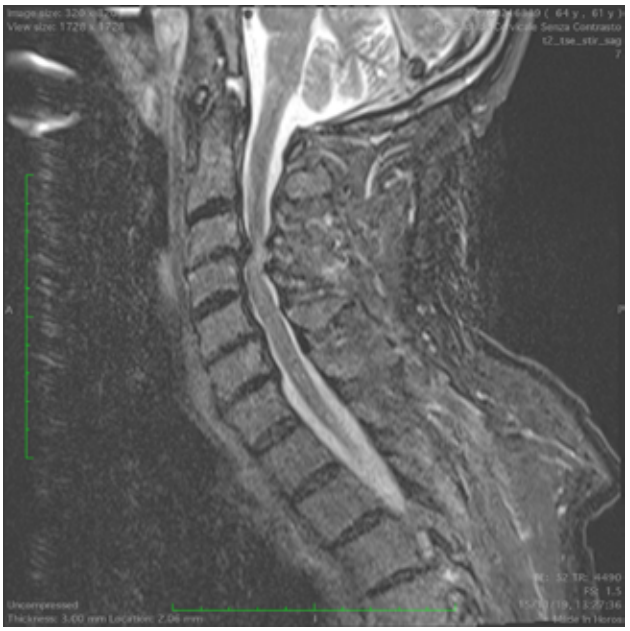
A review of a case series of 101 subjects with CSCI (traumatic cervical spinal cord injury) without fractures or dislocations proposed by Takao et al. (13), highlighted no relationship between pre-existing cervical spinal canal stenosis (CSCS) and neurological outcomes after traumatic CSCI. Again Takao et al, in a 2013 study (14) concluded that the relative risk of the incidence of traumatic CSCS in patients with CSCS was 124.5 times higher respect patients without CSCS, but that only 0.017% of subjects with CSCS may be able to avoid the development of traumatic CSCI if undergoing decompression surgery prior to the trauma.

Case studies

In the 2019-2021 period, four cases of SCIWORA in adult subjects came under our direct observation:

B.A. 61-year-old car accident (motorbike hit by car and fallen to the ground), immediate appearance of tetraparesis from post-traumatic spinal cord contusion C3-C4-C5-C6 in degenerative stenosis of the cervical spinal canal without fractures, dislocations, vertebral instability, hernias discs (figure 1 and 2); initial conservative treatment was opted for, followed by FKT. Due to the COVID-19 pandemic and restrictions thereof, the progress of the patient's clinical condition following discharge was monitored by means of a remote assistance service, through direct and continuous communication between the patient and health professionals, so as to allow suitable personalized treatment. the intensification of the follow-up and the continuity of care of the traumatized person (15, 16).

Once the sequelae were stabilized, the outcomes of chronic tetraparesis were ascertained, and then assessed under the accident policy with a disability rate of around 85%.



Figures 1-2. stenosis of the vertebral canal in the tract from C3 to C6 on a degenerative basis. Note area of bone marrow distress, evidenced by the hyperintensity of the signal in the intramedullary area, more accentuated in the C3-C4 area. At the passage C3-C4 we appreciate the arthritic disc bar with coarse somato-marginal osteophytic beaks where posteriorly imprints and displaces the medulla posteriorly. Similar findings to C4-C5, C5-C6 and C6-C7.

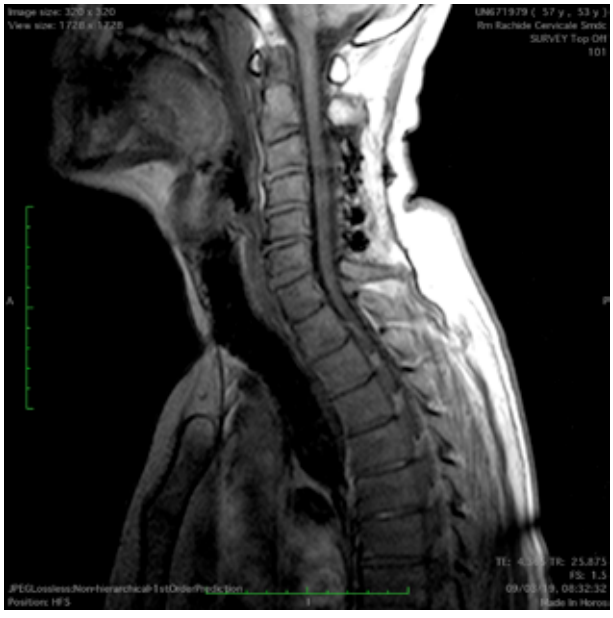


Figure 3. Signs of cervical cord contusion C4-C5-C6 without fractures and dislocations.

A.S. 62 years old, skiing injury at high speed, following a sudden fall forward with direct trauma to the anterior craniofacial and hyperextension of the cervical spine, with immediate onset of weakness, hypoesthesia, paraesthesia in the upper limbs; CT scan found a C4-C5-C6 cervical medullary contusion without fractures and dislocations, in a cervicoarthrosis picture; a conservative treatment was performed with cortisone and a Philadelphia-type collar, which resulted in the partial resolution of weakness and a significant attenuation of the alterations in tactile sensitivity; on the other hand, paresthesia in the forearm and hand and modest motor impediment in the digital grip remained, impairments assessed in the context of private accident insurance with a percentage of disability equal to 7% with reference to the ANIA tables and 10% in relation to the tables INAIL 1124/65 (figure 1 and 2).

C.A., 53-years-old, road accident (in motion collision with car and subsequently to the ground), immediate appearance of tetraparesis in the instrumental framework (CT and MRI), absence of traumatic osteoarticular injuries, with the exception of oedema of the longitudinal ligament anterior to the cervical tract, with MRI finding of oedema and medullary contusion C4-C5-C6, pre-existing cervicoarthrosis with modest stenosis of the vertebral canal (figure 5-6) asymptomatic and unknown.

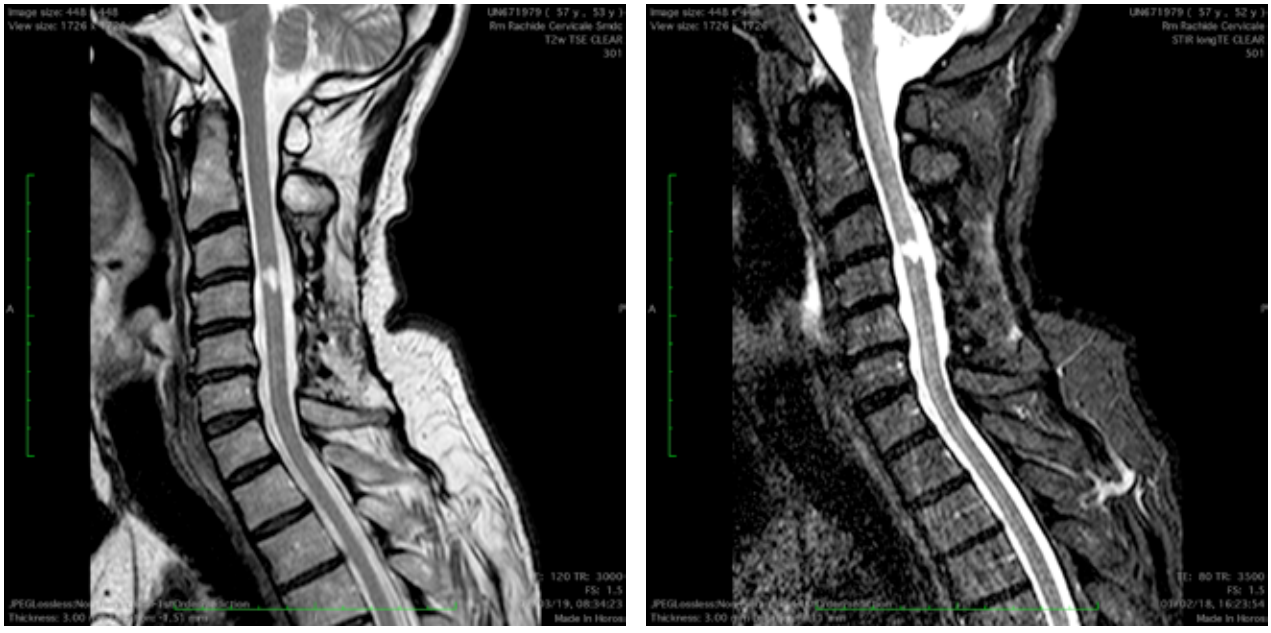
Clinical recovery occurred with residual sensory and motor tetraparesis, assessed with a percentage of permanent disability equal to 100% in private accident insurance. This assessment was not recognized by the insurance company, as it was deemed a contributing factor to the pre-existing pathological condition, even if asymptomatic and unrecognized.

Figure 4. Reduction of interbody fusion spaces C3-C4, C5-C6 and C6-C7 with marginal osteophyte apposition.

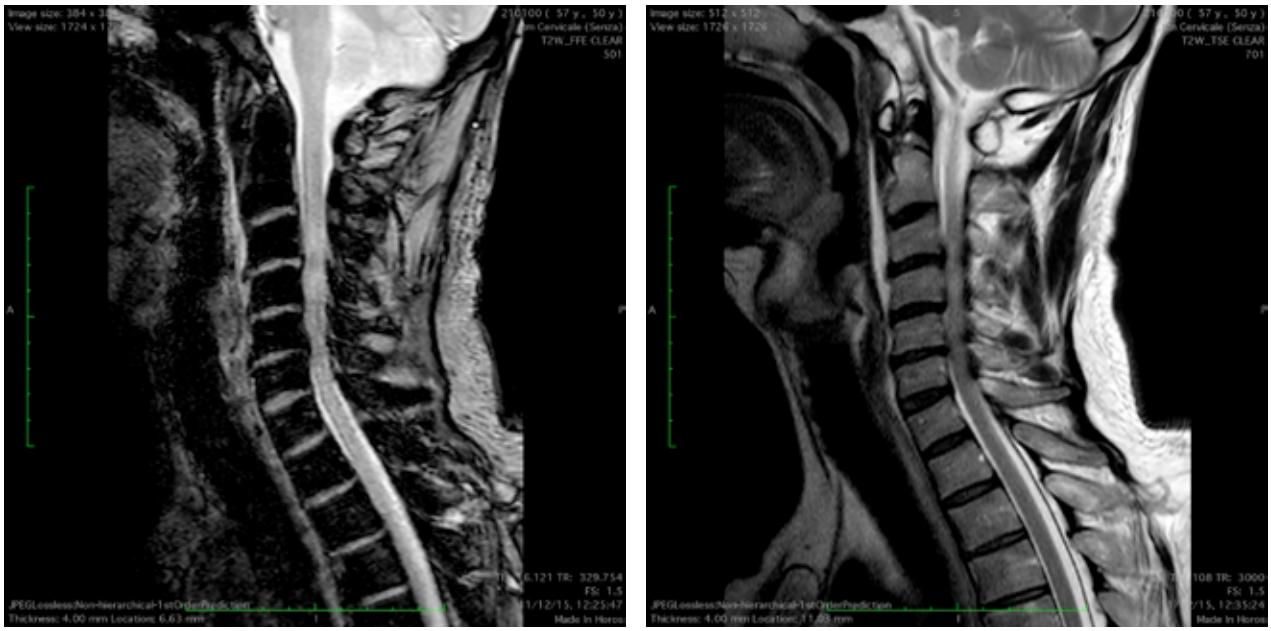
During the judicial proceedings, the court-appointed forensic doctor found an adequate traumatic mechanism of the accident that caused the vertebro-medullary injuries. The localization and type of vertebro-medullary lesions were traced back to a stress of the cervical spine in hyperextension, in a manner completely consistent with the "backlash" which occurred with the reflex contraction of the extensor muscles of the neck, associated with the exhaustion of the inertial movement of the neck, head and consequent transmission of the deceleration force to the cervical spine, resulting in the recognition of full traumatic-genetic suitability and satisfaction of the causal link.

This means that the clear disproportion existing between the traumatic stress and the paraphysiological state of the cervical spine structures would have produced the same effects even in a healthy subject (17), thus respecting the terms of the policy.

S.R., aged 40, accidental fall from a stretcher during a stay in the emergency room following a



Figures 5-6. picture of degenerative spondyloarthrosis with stenosis of the canal at the level of the tract C3-C6 (in particular C5-C6). Subtle marrow signal alterations are detectable at the C3-C4, C4-C5 and C5-C6 levels, associated with a swollen medullary appearance. Edematous change in the soft tissues adjacent to the anterior longitudinal ligament.



Figures 7-8. signs of cervico-arthrosis C3-C6 with osteo-disc protrusions with dural imprint, evident signs of suffering of the marrow in C3-C6.

comitial episode, with initial onset of tetraparesis; cranio-encephalic CT identified disc protrusion C5-C6 that imprint of the dural membrane but absence of fractures, hematomas and / or contusive phenomena.

Cervical MRI documented a condition of cervico-arthrosis C3-C6 with osteo-disc protrusions with dural imprint, initial signs of suffering of the medulla in C3-C6 (fig. 7-8). After 48 hours he showed worsening of the tetraparesis. He was therefore subjected to C3-C6 decompressive laminectomy surgery, with only partial improvement of the tetraparesis picture. At the end of the long rehabilitation period, a residual state of tetraparesis of a mild degree was found in the upper limbs and of a mild-moderate degree in the lower limbs, however with recovery of autonomous walking.

The patient was ascribed a 35% degree of permanent disability with reference to the INAIL tables (18), thus admitting the causal link between injury and spinal cord injury. Taking on the risk in an epileptic subject had already been reportedly regulated by the company, through a special agreement.

Discussion

The review of currently available research findings and the analysis of the proposed cases show that traumatic injuries of the cervical spinal cord have been ascertained following traumatic events with a contusive/distracting background of proven injurious suitability, without bone fractures, dislocation or other damage to the osteoarticular structures of the cervical spine, pathological situations classified with the acronym SCIWORA.

Typically, for the purpose of assessing damage compensation, traumatic spinal cord injuries of the cervical spine are considered secondary to fractures, dislocations, fracture-dislocations, traumatic disc injuries and vertebral instability.

Within the sphere of spinal medical-legal traumatology, SCIWORA should certainly be included and analysed, given how its anatomical-pathological and clinical have been scientifically documented (19-22).

The causal relationship between injury and traumatic event in healthy subjects, without clearly disabling preexisting conditions affecting the cervical spine, can be established through the analysis of clinical, radiographic, CT and MRI data which show acute spinal cord damage, although in the absence of osteoarticular lesions, as an indisputable clinical reality.

Obviously, a trivial blunt-distortion trauma of the cervical spine has not yet been reported as a cause of SCIWORA (23). In fact, statistical data indicate that SCIWORA is caused in all cases by violent trauma

from road accidents, falls from above, sports injuries. Most cases are due to hyperextension injuries of the spine, as seen in rear motor vehicle collisions or direct anterior craniofacial trauma (24). Prognostic and therapeutic (25) measures need to be put in place in a timely fashion, including the already mentioned MRI (26), in order to shield professionals from possible negligence-based claims (27-29).

The evaluation of any anterior pathological state of the cervical spine is very important. In the case of pre-existing pathologies, the problems of a medico-legal nature are more complex (30, 31). For example, in a subject already suffering from primitive cervical myelopathy, even asymptomatic, there is an impairing concomitant with the pathological state derived as a result of the trauma. The finding of a high-energy traumatic picture, even if applied to a rachis already affected by primary myelopathy, can produce damage at this level. Between the two extremes mentioned, SCIWORA in a healthy subject and SCIWORA in a patient with pre-existing, non-symptomatic but clinically documented myelopathy, there is a broad array of intermediate cases which are worthy of analysis.

Asymptomatic spinal stenosis pre-existing to the trauma cannot be deemed a certain contributing or predisposing cause of SCIWORA.

There is no confirmed association between spinal canal imaging features and severity or recovery from Cervical Spinal Cord injury (CSCI) after minor trauma.

In SCIWORA with spinal cord injury, it usually appears immediately or very shortly after a violent traumatic event, whereas in the case of spinal canal stenosis syndrome with spinal cord damage, the clinical and instrumental signs manifest themselves slowly and progressively, at least in the initial stages, for endogenous pathological phenomena, prior to trauma.

Aspects such as accidentality, detrimental efficacy, timing, and criteria confirming the causal relationship in private accidents, all seem to manifest themselves in SCIWORA cases.

SCIWORA is to be qualified as a scientifically defined condition, and a direct, objectively demonstrable consequence of an accident eligible for compensation under private accident insurance.

The same impairing features of SCIWORA differ from those of a common myelopathy and cannot be confused with these.

The pre-existing pathological state in SCIWORA cases, with the limits already outlined herein, cannot be viewed as a contributing cause.

In the case of SCIWORA, in order for spinal cord damage to occur, the simultaneous action of anomalies of the osteo-discal and cervical vertebral articular canal and exogenous trauma is not necessary, only the injurious suitability of the traumatic action being sufficient.

To date, the state of scientific knowledge points to SCIWORA as the only consequence of the violent and external cause that alone is enough to produce the damage. As for damage assessment in private accidents, when determining the degree of permanent disability remaining after the end of the traumatic illness in SCIWORA cases, if this has affected an already impaired spine, the values to be applied (i.e. those shown in the policy table) must be "decreased taking into account the degree of pre-existing disability", or the rule provided for in private insurance against accidents must be applied for cases in which the state of impairment is the result of a causal concurrence between the direct effects of the event and other pre-existing conditions.

In the cases herein examined, in fact, the biomechanical suitability of the visual impairment was considered enough to cause spinal cord injury of the SCIWORA type, thus showing a phenomenological continuum between the reported lesion and objectivable anatomical-functional repercussions.

Conclusion

The causal link between SCIWORA and the traumatic incident can be ruled out only if there is certainty of an asymptomatic primary cervical myelopathy or a pre-existing invalidating pauci-symptomatic state. Such a concept derives from the fact that SCIWORA's features coincide with those of pre-existing myelopathy. Alterations in the size and shape of the cervical vertebral canal do not act as a contributing cause of injury. In the case of pre-existing mild and/or moderate degenerative osteoarticular alterations, even

if due to a non-specific and non-serious reduction of the diameters of the vertebral canal without objective compressive effect, SCIWORA will be indemnified for the impairing component attributable to it.

It is worth bearing in mind that from the medico-legal standpoint, and with particular reference to the field of private accident insurance, the deterioration of the organ-tissue structures, natural and non-pathological, falls within the same definition of risk (32). As for the physical conditions that pertain to the physiological or paraphysiological sphere, although they can potentially play a role in causing the injury, they do not exclude per se compensation for the damage ascribable to the traumatic incident.

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