

Original Article

Spinal cord infarction: prognosis and recovery in a series of 36 patients

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Objective: To study the clinical evolution and the functional outcome of patients suffering from spinal cord infarction who were treated at the Spinal Cord Injuries Unit. To try to determine the factors that could have influence in their functional outcome.

Setting: In a Spinal Cord Injuries Unit, regionally-based, and which forms part of a general hospital with a high level of specialization.

Method: Retrospective study of the medical records of patients suffering from vascular spinal cord ischemia, as acute anterior spinal artery syndrome or associated with aortic surgery or rupture. Cases that were due to compressive, tumoral or inflammatory pathologies were excluded. Assessment of the neurological syndrome followed the ASIA/IMSOP criteria. Age, sex, history and magnetic resonance imaging (MRI) findings were analyzed. Assessment of functional outcome was made regarding ambulatory ability or wheelchair use, and bladder/sphincter control.

Results: Thirty-six cases were selected, the commonest group being spinal cord ischemia due to idiopathic causes (36.1%). Following these, there were cases associated with aortic surgery (25%), systemic arteriosclerosis (19.4%) and acute deficit of perfusion (11.1%). The average age of the patients was 59.3 years, with a mortality of 22.2% during the hospital stay. Regarding the functional outcomes at the moment of discharge, it must be pointed out that 57.1% of the patients were wheelchair users, 25% were ambulatory, using technical aids, and 17.9% were fully ambulatory. The group who could perform some kind of walking was significantly younger than the group of wheelchair users (48.17 vs 61.38 years). Additionally, it became evident that those patients who did not show voluntary muscle contraction at the time of admission (ASIA groups A and B) presented a higher risk of being wheelchair users.

Conclusion: Acute spinal cord ischemia syndrome has a severe prognosis with permanent and disabling sequelae. Initial neurological assessment following ASIA/IMSOP classification proves to be the best predictor of prognosis, and the patient's advanced age constitutes a negative factor for functional recovery.

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Introduction

Acute Spinal Cord Ischemia Syndrome (ASCIS), also referred to as Spinal Cord Infarction when it reaches its utmost severity, is a relatively infrequent disease within the vascular pathology of the central nervous system. Sandson & Friedman¹ point out that its incidence was 1.2% of all admissions related to vascular pathology of the nervous system in a Department of Neurology.

ASCIS prognosis has not been completely determined since, given its low frequency, the published

series are of few cases.^{2,3} On the other hand, in many series, the cases of idiopathic and vascular spinal cord ischemia have been added to compressive myelopathies and syndromes associated to vascular malformations or tumors; therefore the physiopathology of these syndromes might have various mechanisms.⁴ Likewise, various factors such as a patient's previous disease, age and condition might influence their clinical evolution and functional outcome. Because of this, we have tried to select patients among our cases, excluding those associated with intra- or extra-spinal cord compressive pathology, so that vascular spinal cord ischemia would be the main pathogenic mechanism of the spinal cord injury.

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This study has been carried out in a Spinal Cord Injuries Unit, regionally-based, and which forms part of a general hospital with a high level of specialization, where patients suffering from ASCIS with severe neurological deficit are referred for assessment and rehabilitation treatment. This study aims to review the clinical outcome of Acute Spinal Cord Ischemia Syndrome, in a way to account for the factors that can influence its functional prognosis avoiding, therefore, the discussion of its pathophysiology.

Method

A retrospective study has been carried out on the records of those patients suffering from spinal cord injuries of vascular origin that have been followed in the last 10 years at the Spinal Cord Injuries Unit in our hospital. Those cases whose clinical picture was compatible with the anterior spinal artery syndrome were selected: a sudden, progressive and acute paralysis, with loss of pain and temperature perception, and bowel and bladder control.^{2,4,5} Patients suffering a spinal cord syndrome after aortic surgery, aortic rupture, or severe acute systemic perfusion deficit were also included, following the description stated by several authors.⁵⁻¹⁴

Associated vascular factors were investigated (radiological atheromatous disease, aortic pathology, chronic hypertension and other previous vascular disease), and a battery of tests was made in order to diagnose other spinal cord pathology: magnetic resonance imaging (MRI),¹⁵⁻¹⁹ biochemical and immunologic studies in cerebrospinal fluid (CSF) and blood,^{20,21} and spinal angiography when available. Those cases that presented a spinal cord syndrome associated with vascular malformations, spinal tumors, inflammatory myelopathies and spinal cord compression of any etiology were excluded.

Thirty-six patients met a clinical picture of acute spinal cord ischemia. Several variables were studied, such as: age, sex, personal history and the probable etiology of the spinal cord ischemia, distinguishing between aortic pathologies with or without surgery, arteriosclerosis and hypotension or severe spinal cord perfusion deficits. Cases where no vascular risk factor could be demonstrated were qualified as idiopathic. For the characterization of the neurological syndrome, the criteria of the International Standards for Neurological and Functional Classification of Spinal Cord Injury²² were followed; spinal cord level and initial and final degrees of impairment were studied. The data from magnetic resonance imaging done during the first weeks of their evolution were examined, as well as images obtained by means of spinal cord angiography, if this was done.

With regard to the functionality reached for mobility, three categories have been distinguished: fully ambulatory, ambulatory with technical aids (walker or crutches), and wheelchair users. The following groups were made with respect to the

bladder/sphincter function: those with voluntary control, those needing to perform intermittent bladder catheterization, and those with an indwelling catheter. Differences between subpopulations for normally distributed continuous variables were compared using the Student *t*-test. Continuous data, not normally distributed, and ordinal data were analyzed using the Mann-Whitney *U*-test, and the Pearson's Chi-Square test for categorical data. Statistical significance was assumed if $P \leq 0.05$. A logistic regression analysis was performed using those variables that showed significant differences on univariate comparison. For multivariate logistic regression model, ASIA impairment was reduced to three groups: A + B, C and D; the etiology was reduced in idiopathic and non-idiopathic. Then, functional outcome was dichotomized in wheelchair users and those able to walk, in order to identify the variables that influenced a worst functional result.

Results

Of the 36 cases analyzed, 24 were males and 12 were females. The mean age was 59.3 years (S.D. ± 15.11 ; men 62.38 years old, women 53.25 years old). In terms of etiology (Figure 1), the highest percentage was that for those who were categorised as idiopathic patients – those for whom no associated pathology or vascular risk factors were detected – with 36.1%. The rest of the patients showed infarctions associated with several factors: 25% with surgery on the aorta, 8.3% aortic pathology without surgery, 19.4% associated with arteriosclerosis or embolism, and 11.1% acute systemic perfusion deficit such as cardiac arrest or hypovolemic shock.

The spinal cord injury was produced at the cervical level in only one of the cases, in another 20 cases (55.6%) at a thoracic level, and in 15 of the cases (41.7%) at the thoracolumbar level.

In the first neurological assessment carried out, the ASIA classification corresponded to grade A in 19.4%

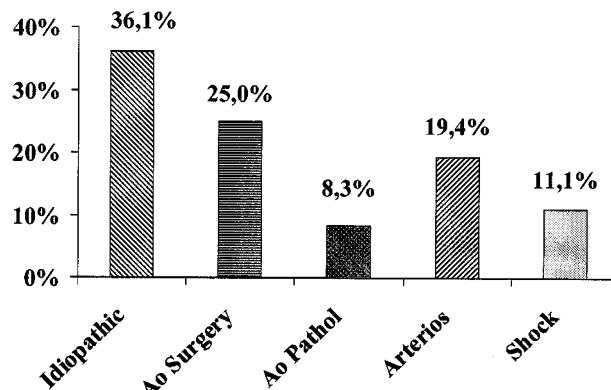


Figure 1 Etiology (Ao Surgery: Surgery on the aorta; Ao Pathol: Pathology of the aorta not surgical; Arterios: Arteriosclerosis; Shock: Acute perfusion deficit)

of the cases, B in 27.8%, C in 30.6%, and D in 19.4% (Figure 2). In one patient, initial ASIA impairment could not be defined. Table 1 shows the initial and final degrees of impairment for patients who survived. Eight patients died during their hospital stay which corresponds to 22.2% of the sample. The mean time of follow-up was 19.9 months (S.D. \pm 30.16) for survivors.

In 26 cases, study of the spinal cord by means of MRI was made during the acute period of the disease, taken the first 4 weeks of evolution. Seventy-three per cent showed pathological changes corresponding to spinal cord ischemia, with a typical cord enlargement pattern on T1 and a linear increased signal intensity on T2-weighted spinal cord images.^{17,18} It must be pointed out that some MRIs with normal spinal cord signals were found in several studies carried out during the first hours of the clinical evolution, showing a pathological signal in a second study performed later.

After 1 month's evolution, an MRI study was carried out as a control in eight patients: 50% continued showing pathological spinal cord images, whereas in the other 50% a normal spinal cord signal was appreciated. Spinal cord angiography was carried out in nine patients, and no alteration was found in eight cases; a probable thrombosis of a lumbar radicular artery was observed in one case, which was non-correlated with the clinical manifestation of the case.

Functional outcomes

The functionality reached at the time of discharge from the Spinal Cord Injuries Unit can be summed up as follows (Figure 3): 57.1% of the patients were wheel-

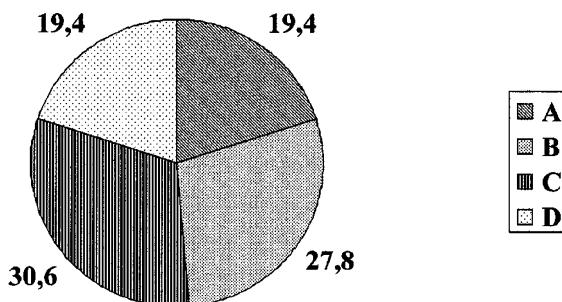


Figure 2 Initial degree in ASIA impairment scale

Table 1 Evolution of ASIA impairment scale

Initial ASIA score	A	ASIA score at discharge	B	C	D
A	3			1	
B			5	1	1
C				4	6
D					7

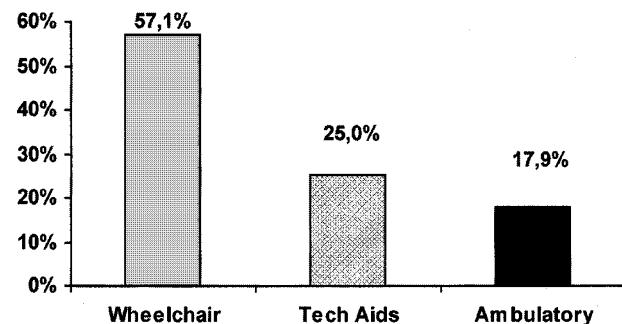


Figure 3 Functional outcome in terms of walking ability

chair users, 25% were ambulatory with technical aids, and 17.9% of the patients were fully ambulatory.

Regarding bladder/sphincter function, 60.7% of the patients needed an indwelling bladder catheter (28.6%) or intermittent catheterization (32.1%) for the handling of their neurogenic bladder at the time of discharge from hospital. An association was found between the need of bladder catheterization – either intermittent or permanent – and functional level reached ($P=0.001$): patients non-ambulatory tend to need bladder catheterization, which indicates a more severe neurogenic bladder disturbance.

Influential factors

When comparing the patients who reached walking ability to wheelchair users, a significant difference in mean age was found ($P=0.034$): the mean age of the group requiring a wheelchair was 61.38 years, while the mean age of patients with walking ability was 48.17 years. Also, when comparing the functional outcome according to initial ASIA degrees of impairment, significant differences can be appreciated in the Chi-square test ($P=0.033$). Only one patient from the initial ASIA A or B groups managed to walk with technical aids (9%), whereas 29.41% of the patients with initial ASIA C or D achieved free walking and 32.25% managed to walk with technical aids. No differences were found among functional groups in non-parametric testing carried out to study the relationship with the existence of personal histories, MRI data, neurological level, sex or etiology of the ischemic syndrome.

When a logistic regression was performed, the groups of patients with no active motor contraction at admission (ASIA groups A and B) were united to adjust the multivariate regression, obtaining a significant difference in relation to the functional outcome ($P=0.017$): patients in A+B group had an increased risk of being wheelchair users [O.R. = 27.9; 95% CI (1.80–434.34)]. When analyzing the influence of age, it was found that it also modifies significantly the risk of being confined to a wheelchair [OR = 1.14; 95% CI (1.010–1.299)]. Likewise, in this regression

Table 2 Results in the logistic regression study

	Odds ratio	95% C.I.	P	
ASIA at admission	27.9	(1.80–434.34)	0.017	Significant
Age	1.14	(1.010–1.299)	0.034	Significant
Idiopathic cases	21.4	(0.549–837.4)	0.101	Not sign

Odds ratios for association with 'wheelchair user'. Significance assumed if $P \leq 0.05$. See text for comment

study there seems to be a tendency towards obtaining a better functional outcome in those patients classified as suffering from idiopathic spinal cord infarction, without reaching statistical significance ($P=0.10$) (Table 2).

Discussion

Acute Spinal Cord Ischemia Syndrome is an infrequent disease¹ but can cause permanent disabling sequelae. It mainly affects the area of the anterior spinal artery at a dorsal level, causing the anterior spinal artery syndrome, described by Spiller in 1909.⁴ It is characterized by a sudden and rapidly progressive onset, sharp pain and accompanied by clinical manifestations of palsy, sphincter control loss and deficit of thermalgesic sensitivity with relative preservation of position and vibratory sense.^{4–6,23} Its most frequent etiology for many years was syphilitic disease.⁴ At present, the most common etiology is considered to be arteriosclerosis, together with embolism of distinct origin, aortic pathologies, disc herniation, acute systemic hypotension, associated to angiography, sympathectomy, aortic and spinal surgery, therapeutic embolization of renal and spinal arteries, and other vascular procedures.^{1,4,7,23} There are some cases for which vascular risk factors cannot be found, being classified as idiopathic.^{2,6,13,23–25} In these cases, the diagnosis is made under strictly clinical considerations, by excluding other etiologies of myelopathy by means of the current battery of explorations, image studies and biological tests. In the present series, no patient included in the idiopathic group developed another type of myelopathy during the follow-up period.

There are other pathologies affecting the spine for which an ischemic mechanism has been found responsible for the neurological injury. Some of these are: intrinsic or extrinsic septic infectious processes; compression due to tumors; and vascular malformations.²¹ As these pathologies could be associated with another physiopathological mechanism for spinal cord damage, whose evolution can be modified by means of diverse therapeutic techniques, we have preferred to exclude them from this review. Additionally, because of their clinical similarity with transverse myelitis, the cases for which biological data supported this latter syndrome^{1,20,21} were also excluded. In our series, the cases assessed as idiopathic represented the highest percentage (36.1%), followed by those associated with

aortic surgery (25%). Spinal cord ischemia is located at a thoracic or thoracolumbar level in a great majority of cases. At present, the appearance of a spinal cord ischemic syndrome after abdominal aorta surgery continues to be unpredictable and fortuitous,^{7,11} in spite of the preventive measures used, and it often affects the thoracolumbar region due to the distribution of spinal cord arterial irrigation.^{4,7} Neurological recovery is inversely related to the degree of ischemic neuronal damage.²⁶ In animal models, the duration of the ischemia is related to histological damage and motor recovery.²⁷

We must point out that patients referred to the Spinal Cord Injuries Unit at our center present a moderate or severe neurological deficit, because the Department of Neurology follows up transitory or slight ischemic syndromes. Consequently, the cases found at our Service generally consist of established spinal cord infarction syndromes.

In our series, the neurological syndrome, classified according to the ASIA impairment scale, improved in the great majority of patients (Table 1), but only 42.9% of the patients who survived reached walking ability. Mortality was high (22.2%), but this fact could not be related to any of the etiological groups. A high mortality rate (18.3%) is also pointed out in the meta-analysis carried out by Foo & Rossier,² and in the study of Szilagyi.⁸

Results were analyzed using a multivariable regression pattern so as to try to establish the factors that might influence the functional outcome. We agree with authors such as Waters *et al*³ and Little *et al*²⁶ that motor preservation after the acute episode is the best prognosis rate. Waters *et al.* argues that motor recovery prognosis is unfavorable in those patients whose complete motor deficit continues for over a month.³ Little *et al* states that the lack of M-response in the neurophysiological study of muscles which are distal to the injury 10 days after spinal cord infarction is indicative of an unfavorable prognosis.²⁶ All this overlaps with the concept of prognosis for spinal cord injuries of traumatic etiology.²⁸ A recent study by Iseli *et al*²⁹ agrees with this idea, showing that the severity of the initial neurological injury constitutes the main factor which determines the prognosis, both in traumatic spinal cord injuries and in medical causes. However, only 9% of our patients who were classified as ASIA A or B on the initial examination reached walking ability, which was very different from that 35% of patients with the same features pointed out in

the mentioned study. The results in Iseli's series also differ from the functional prognosis of traumatic spinal cord injuries, since in the review carried out by Waters *et al* on a sample of traumatic injuries,^{28,30} it is established that less than 1% of paraplegics reach ambulatory ability in the community if they do not present motor contraction in their lower limbs within a month. If motor power develops within a month this percentage increases greatly for both paraplegia and incomplete tetraplegia (>70%, >21% respectively).³⁰ In our sample, 64.6% of the patients with initial ASIA C or D achieved some ambulatory ability.

However, regardless of the degree of ASIA impairment, we have checked in our series that an advanced age in patients is a significant risk factor for an unfavorable functional evolution and in becoming wheelchair users: from the results it can be interpreted that there is a risk 1.14 times higher of remaining a wheelchair user for each year of age increase. In this respect the present series also differs from Iseli's results,²⁹ where age is not an influential factor for the functional prognosis of both traumatic and non-traumatic spinal cord injuries. In McKinley's review on epidemiology and prognosis in non-traumatic spinal cord injuries a higher average age is indicated for these patients,³¹ whose associated medical pathology, together with a reduction in their memory and learning abilities implies less efficiency in the rehabilitation process. This happens even more frequently in the group of paraplegic patients with non-traumatic etiologies: this group reaches a 'plateau' on the scale of early functional independence, with a lower percentage of improvement than the group of paraplegics of traumatic etiologies.³¹ We think that in our series the patients behave in a similar way in the results of the rehabilitating process; their age and poor condition being decisive in their unfavorable global functional prognosis.

Other authors^{2,25} have pointed out that ischemic myelopathy of idiopathic etiology has a more favorable evolution than other types. In our series this statement could not be statistically confirmed, although there may be a tendency to this effect ($P=0.10$).

Sphincter disturbance is an important sequel in the whole neurological syndrome, therefore it has been included among studied variables. The percentage of patients showing bladder sphincter dysfunction and who need to use some method to treat this is high (60.7%), and it is related to the functional level of ambulatory ability reached ($P=0.001$).

We have not been able to connect the MRI findings with the clinical evolution of the neurological syndrome. The images obtained overlap with the ones described in several reviews,^{15–19} with an enlargement of the spinal cord in T1 and high signal intensity more or less defined in T2 which affects several longitudinal segments. We have also checked that the pathological signal in the T2 sequence is reduced in size in the course of time. It becomes linear, affecting the two

anterior thirds of the spinal cord,¹⁶ and in late stages it becomes an image of myelomalacia. A suitable time has not been made clear for the prognosis of spinal cord infarction through MRI and its specificity, nor the value of the image intensified with paramagnetic contrast (Gadolinium - DTPA).³²

In summary, in our experience acute spinal cord ischemia is a serious disease whose functional sequelae are disabling in a high percentage of patients. Initial neurological assessment following ASIA/IMSOP criteria is the best predictor of prognosis, and it is important to say that, in our country an advanced age is a negative factor for functional recovery.

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