Original Article

Neuropathic pain after traumatic spinal cord injury – relations to gender, spinal level, completeness, and age at the time of injury

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Study design: Retrospective register study.

Objective: To investigate the predictive value of age at the time of injury, gender, level of injury, and completeness of injury for the development of at level and below level neuropathic pain.

Setting: 'Spinalis', a postacute spinal cord injury (SCI) outpatient clinic, serving the greater Stockholm area (Sweden).

Method: All patients who visited the clinic in 1995–2000 (402 patients) for the first time were examined. The following items were selected: at-level and below-level neuropathic pain according to the International Association for the Study of Pain (IASP) criteria, age at the time of injury, gender, level of injury according to ASIA, and completeness of injury. Mean time of 6 years after the injury. Results were analysed with χ^2 analysis and logistic regression.

Results: Of all patients examined, 13% had at level pain and 27% had below level pain. Neuropathic pain was less than half as frequent (26%) in the group aged less than 20 years at the time of injury as in the oldest group (58%). The increasing trend was mainly due to below-level pain up to 39 years of age, and due to at-level pain at ages 40 and above at the time of injury. No correlation was observed to gender, level of injury or completeness of injury, except for below level pain, which was associated with complete injury.

Conclusion: The results show that neuropathic pain after SCI is common and occurs much more often in patients injured at higher ages. This indicates the importance of neuroanalgetic intervention, in particular for patients injured in higher ages.

Spinal Cord (2004) 42, 665–673. doi:10.1038/sj.sc.3101641; Published online 3 August 2004

Keywords: spinal cord injuries; neuralgia; pain; prevalence; rehabilitation

Introduction

Longstanding pain is one of the most challenging medical problems after spinal cord injury (SCI).¹ Once established, in particular the neuropathic type of pain after SCI is often difficult to treat successfully.² The incidence of overall pain has been reported to vary widely among studies,^{2–5} probably as a result of differences in diagnostic and inclusion criteria as well as the quality of available diagnostic and treatment facilities in different units. The generality and the magnitude of the problem is indicated, however, in a review by Bonica,³ who reported that across studies it appears that an average of two-thirds of SCI patients experience longstanding pain, and that in about one-third of these cases the pain is rated as severe. Pain is

also reported to be one of the factors that interfere most with daily activities and sleep.⁶

The contribution of neuropathic pain to the overall prevalence of unclassified pain after SCI seems to be less frequently studied although available data suggest that it is substantial. According to findings in a prospective study performed 5 years post injury,⁴ 41% had at-level neuropathic pain (corresponding to the segment of injury), and 34% had below-level neuropathic pain (corresponding to segments below the segment of injury), using nomenclature and criteria in compliance with the taxonomy published by a International Association for the study of Pain (IASP) task force.^{7,8}

The exploration of factors of importance for the development of longstanding pain is complicated as contributions from a multitude of physical, psychological, and sociological factors that to a varying degree are

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dependent on each other are to be expected. Nevertheless, search of isolated factors, or combinations of such factors, that correlate strongly to the development of any particular kind of pain, either positively or negatively, would be of interest both for the investigation of underlying mechanisms, possible pre-emptive treatment, and for the design of more individualised rehabilitation plans.

Previous studies have shown varying results with regard to the influence of injury level and completeness of injury to the prevalence of unclassified pain (for references, see Siddall *et al*^{4,9}). In their studies, Siddall *et al*^{4,9} showed no correlation between either injury level or completeness of injury. Previous studies¹⁰ showed that the incidence of neuropathic pain after SCI correlates positively with increasing age at injury and gender,¹¹ but could not demonstrate such associations with injury level and completeness of injury.

In this study, we wanted to further assess neuropathic pain after SCI.

The primary aim of the present investigation has been to study the odds of contracting at-level and below-level longstanding neuropathic pain after SCI as a function of: age, gender, injury level, complete *versus* incomplete injury (ASIA), and combinations of these factors. Secondary aims were to study patient estimation of the impact of the pain in their daily life, and how the incidence of complete/incomplete SCI varied with age.

Methods

Patient characteristics, demographic data, and methods of data collection

All patients consulting the SCI Unit ('Spinalis') outpatient clinic at the Karolinska Hospital in Stockholm, Sweden, during the period of 1995–2000 ($n = 402$) were included in this retrospective register study. The Spinalis post-acute unit provided yearly check-ups by a neurologist to all adult patients with traumatic and nontraumatic spinal cord disorders in the greater Stockholm area. The vast majority of the patients had early after injury been included in a SCI program including neurosurgical and orthopaedical consultations and treatment in selected cases. Data were gathered at the first time the patients were examined at the unit. The median timepoint after injury for the first examination at the unit was 6 years (range 2 months–46 years) after the injury. Many of those examined in this unit for the first time at the later time points within this range had moved into the geographic area and therefore had their first period of check-ups elsewhere. Some of the patients in this study were included also in earlier studies of different aspects of pain, using different sampling methods^{10–12} and with partly other aims.

The check-up included classification of the injury completeness according to ASIA.¹³ ASIA A corresponds to complete SCI with no motor or sensory functions preserved in the sacral segments S4–5. ASIA

B–D correspond to decreasing ranks of severity of incomplete injury where some sensory and motor functions are preserved below the level of injury. ASIA E denotes normal motor and sensory functions below the level of injury. The level of injury was defined as the lowest level with intact neurological functions. For the purpose of this study, the following generalisations were made: those belonging to ASIA B–D were analysed together because of the small patient numbers having ASIA B and C, and patients who at the time of examination at the unit were classified as ASIA E were re-classified according to their initial classification (usually from ASIA E to ASIA D). Finally, the level of injury was classified as tetraplegia and paraplegia, respectively, except for a follow-up analysis of paraplegic patients with complete injury, which were separated into those with high (Th1–9) and low (Th10–S4) injury.

The patients were divided according to age at the time of injury into the following five groups: 0–19 ($n = 91$), 20–29 ($n = 125$), 30–39 ($n = 75$), 40–49 ($n = 62$), and ≥ 50 ($n = 48$) years of age.

The pain was diagnosed by the experienced examining neurologist as neuropathic when it met the criteria presented by the IASP task force.⁸ Patients were asked to describe the distribution of the painful area as well as the quality and temporal character of the pain. The examination included the use of a cotton swab and a needle to map sensory disturbances and in selected cases also hot and warm objects, movements of joints, and palpation of soft tissue. Independent specialists with experience in pain diagnosis and treatment examined selected cases; findings were nearly always in agreement. Findings used for diagnosis of neuropathic pain were pain without primary relation to movements or signs of inflammation, and sensory disturbances to pin prick and touch within a painful territory corresponding to the SCI. The pain described could be spontaneous, or provoked by, for instance, touch or cold, continuous, and/or with paroxysmal components.

When neuropathic pain was diagnosed, it was classified as above-level pain (not described in this study), at-level pain, or below-level pain.⁷ Only two patients described above-level neuropathic pain. The pain in both these cases could be explained by brachial plexus lesions. Injuries at the segmental levels L3 and below were considered by the investigating neurologist to be difficult to divide into those with at-level pain and below-level pain (see also Siddall *et al*⁷). In our material, we had only one patient with neuropathic pain and a neurological level below L3; this patient was classified as at-level pain.

The pain was then further judged by the patient as either 'of significant importance for the daily living' or 'not of significant importance for daily living'. The vast majority of the patients diagnosed with neuropathic pain reported in retrospect that the pain had started within months after the injury, but we cannot provide further data to substantiate this.

Analysis of data

Groups and subgroupings are presented as absolute numbers and percentages. Comparisons between groups and trends were made by analysis with χ^2 and χ^2_{trend} .¹⁴ A P -value of <0.05 was considered significant. Logistic regression was used to quantify the association between a possible risk factor (age, gender, level of injury, or completeness of injury) and the presence of neuropathic pain, after adjusting for the other variables. To calculate risk factor due to age in these calculations, the age group 0–29 was used for comparison. Again, odds ratios with $P < 0.05$ were considered statistically significant. Next, receiver operating characteristic (ROC) curves^{14,15} were constructed to show the predictive value in terms of sensitivity and specificity for the possible prognostic factors with elevated odds ratios found in the previous step. Briefly, ROC curves represent the tradeoff between the false-negative and false-positive rates for every possible cutoff. A test with high predictive value would have small false-positive and false-negative rates across a reasonable range of cutoff values. In this graph, such a test would have a curve that climbs rapidly towards the upper left-hand corner of the diagram and then turns right, and would have a large area under the curve (approaching the ideal 1.0). A test with no diagnostic value would follow a diagonal path with an area under the curve of 0.5, meaning that every improvement in false-positive rate is matched by a corresponding decline in the false-negative rate, that is, 50% sensitivity and 50% specificity, which is equivalent to random outcome.

Results

Relation between age and completeness of injury

Complete SCI (ASIA A) tended to be more common in younger age groups: 53/91 (58%) of the patients in the youngest group had ASIA A as compared to only 5/48 (10%) of those who were at least 50 years old at the time of injury (Figure 1). Statistical analysis show that the

Figure 1 Prevalences of complete and incomplete SCI at different ages at the time of injury

frequencies differed ($\chi^2 = 56.88$, df 4), and that there is a significant increasing trend for incomplete injury (and a decreasing trend for complete injury) with age ($\chi^2_{\text{trend}} = 55.43$, df 1).

Factors of potential relevance for the prevalence of neuropathic pain after SCI

Overall prevalence of neuropathic pain In total, 162/402 (40%) met the criteria of neuropathic pain. Within the group with neuropathic pain, 34% described at-level pain, and 66% below-level pain as the dominating type of pain. Occasional patients described both at-level and below-level neuropathic pain. The results are summarised in Tables 1–4.

Age groups The prevalence of neuropathic pain increased with age up to 30–39 years of age (Figure 2, Table 1). Then there was a slight relative decrease at 40–49 years compared to the group aged 30–39 years. The group >50 years of age showed the highest prevalence. Neuropathic pain was less than half as frequent (26%) in the group aged less than 20 years at the time of injury as in the oldest group (58%; Figure 2). The prevalence of either one of at-level pain and below-level neuropathic pain, or both, in the different age groups was significantly different ($\chi^2 = 12.37$, df 4) and also the contribution of the increasing trend with age was significant ($\chi^2_{\text{trend}} = 18.89$, df 1). Furthermore, as can be seen in Figure 2, the increase with age was more obvious for below injury pain up to 39 years of age, whereas the main increase for at-level pain appeared to happen at the interval between the age groups 30–39 and 40–49 years of age.

Female versus male

There were more males than females in all age groups ($\approx 4:1$, see Table 2). In total, 46% of the females and 38% of the males reported neuropathic pain. This tendency of a female dominance did not reach statistical significance ($\chi^2 = 1.611$, df 1). Of the females, 14% reported at-level pain, and 31% below-level pain. Of the males, 13% reported at-level pain, and 26% below-level pain.

Complete versus incomplete injury In total, 42% of the patients with complete injury (ASIA A) and 39% of the patients with incomplete injury (ASIA B–D) reported neuropathic pain (Table 1). This difference did not reach statistical significance ($\chi^2 = 0.229$, df 1). Of those with complete injury, 9% had at-level pain, and 33% below-level pain. Of those with incomplete injury, 15% had at-level pain, and 24% below-level pain (Tables 2 and 3).

Tetraplegia versus paraplegia In total, 41% of the patients with tetraplegia and 40% of the patients with

Table 1 Prevalence of neuropathic at-level and below-level pain, in different age classes as a function of gender, ASIA, and injury level

Age	N per age group					Total %
	0–19	20–29	30–39	40–49	50–	
All	23/91 26%	45/126 36%	37/76 49%	28/61 46%	29/48 60%	162/402 40%
Male	17/73 23%	39/105 37%	28/55 51%	20/49 41%	20/37 54%	124/319 39%
Female	6/18 33%	6/21 29%	9/21 43%	8/12 67%	9/11 82%	38/83 46%
ASIA A	14/55 25%	23/57 40%	16/25 64%	9/16 56%	4/5 80%	66/157 42%
ASIA B–E	9/37 24%	22/69 32%	21/51 41%	20/45 44%	24/43 56%	96/245 39%
Paraplegia	14/57 24%	30/75 40%	23/47 49%	16/38 42%	8/17 53%	91/234 40%
Tetraplegia	9/34 26%	15/51 29%	14/29 48%	13/23 57%	20/31 61%	71/168 42%
Tetraplegia	5/20 25%	7/21 33%	5/10 50%	1/1 10%	1/2 50%	19/54 36%
ASIA A	9/34 26%	16/36 44%	11/15 73%	8/15 53%	3/3 100%	47/103 46%
Paraplegia	4/14 29%	8/30 27%	9/19 47%	12/22 55%	19/29 62%	52/114 45%
ASIA B–E	5/23 22%	14/39 36%	12/32 38%	8/23 35%	5/14 43%	44/131 34%

Table 2 Prevalence of neuropathic at-level pain in different age classes as a function of gender, ASIA, and injury level

Age	N per age group					Total %
	0–19	20–29	30–39	40–49	50–	
All	7/91 8%	13/126 10%	8/76 11%	14/61 23%	10/48 21%	52/402 12%
Male	6/73 8%	11/106 10%	7/55 13%	9/49 18%	7/37 19%	40/319 13%
Female	1/18 6%	2/20 10%	1/21 5%	5/12 42%	3/11 27%	12/83 14%
ASIA A	4/54 7%	4/57 7%	1/25 4%	4/16 25%	1/5 20%	14/157 9%
ASIA B–E	3/37 8%	9/69 13%	7/51 14%	10/45 22%	9/43 21%	38/245 15%
Paraplegia	4/57 7%	9/75 12%	3/47 6%	7/38 18%	2/17 12%	25/234 11%
Tetraplegia	3/34 9%	4/51 8%	5/29 17%	7/23 30%	8/31 26%	27/168 16%
Tetraplegia	1/20 5%	1/21 5%	1/10 10%	0 0%	0 0%	3/54 6%
ASIA A	3/34 9%	3/36 8%	0 0%	4/15 27%	1/3 33%	11/103 11%
Paraplegia	2/14 14%	3/30 10%	4/19 21%	7/22 32%	8/29 28%	24/114 21%
ASIA B–E	1/23 9%	6/39 15%	3/32 9%	3/23 7%	1/14 7%	14/131 10%

paraplegia reported either at-level pain or below-level neuropathic pain. This was not statistically different ($\chi^2 = 0.062$, df 1). Of the tetraplegic patients, 16% had at-level pain and 26% below-level pain. Of the

paraplegic patients, 11% had at-level pain and 29% below-level pain. Further analysis of the data, beyond the original intention of the study, revealed that patients with low (Th10–S4) complete paraplegia had neuro-

Table 3 Prevalences of neuropathic below-level pain in different age classes as a function of gender, ASIA, and injury level

Age	N per age group					Total %
	0–19	20–29	30–39	40–49	50–	
All	16/91 18%	32/126 25%	29/76 38%	14/61 23%	19/48 40%	110/402 28%
Male	11/73 15%	28/106 26%	21/55 38%	11/49 22%	13/37 35%	84/319 26%
(all)	5/18 28%	4/20 20%	8/21 38%	3/12 25%	6/11 55%	26/83 31%
Female	10/54 19%	19/57 33%	15/25 60%	5/16 31%	3/5	52/157 33%
(all)	6/37 16%	13/69 19%	14/51 27%	10/45 22%	15/43 35%	58/245 24%
ASIA A	10/57 18%	21/75 28%	20/47 42%	9/38 24%	6/17 35%	66/234 29%
(all)	6/34 18%	11/51 22%	9/29 31%	6/23 26%	12/31 39%	44/168 26%
Tetraplegia	4/20 20%	6/21 29%	4/10 40%	1/1	1/2	16/54 30%
ASIA A	6/34 18%	13/36 36%	11/15 73%	4/15 27%	2/3	36/103 35%
Paraplegia	2/14 21%	5/30 17%	5/19 26%	5/22 23%	11/29 38%	28/114 24%
ASIA B–E	4/23 17%	8/39 21%	9/32 28%	5/23 22%	4/14 43%	30/131 22%
Paraplegia						
ASIA B–E						

Table 4 Results of statistical analyses

	Odds ratio	95% CI	Pr > χ^2	χ^2 , degree of freedom, critical value
<i>At-level or below-level neuropathic pain (n = 162)</i>				
Male/female				1.611, df 1, cv 3.851
Tetraplegia/paraplegia				0.062, df 1, cv 3.851
Complete/incomplete injury				0.229, df 1, cv 3.851
Age classes (all 5)				12.376*, df 4, cv 9.488
Age 30–49	1.978*	1.272–3.075	0.002	
Age 50+	3.344*	1.753–6.378	0.006	
<i>At-level pain (n = 52)</i>				
Male/female				0.079, df 1, cv 3.851
Tetraplegia/paraplegia				1.733, df 1, cv 3.851
Complete injury				2.403, df 1, cv 3.851
Age classes (all 5)				9.988*, df 4, cv 9.488
Age 30–49	1.884	0.986–3.601	0.055	
Age 50+	2.592*	1.125–5.973	0.025	
<i>Below-level pain (n = 110)</i>				
Male/female				0.594, df 1, cv 3.851
Tetraplegia/paraplegia				0.211, df 1, cv 3.851
Complete injury	2.109*	1.297–3.430	0.003	3.161, df 1, cv 3.851
Age classes (all 5)				9.649*, df 4, cv 9.488
Age 30–49	1.930*	1.163–3.201	0.010	
Age 50+	3.251*	1.596–6.622	0.001	

* $P < 0.05$

pathic pain more often (23/33, 70%) than patients with high thoracic (Th1–9) complete paraplegia (24/70, 34%); $\chi^2 = 44.57$, df 1. There was no difference in mean age between these two injury groups (26 and 27 years, respectively).

Analysis across factors Logistic regression was used to analyse the contribution of a single variable after adjusting for the other variables. With this analysis, the only variable that significantly predicted the prevalence of at-level or below-level neuropathic pain was age 30–49

Figure 2 Neuropathic pain related to age

years and 50+ ($P < 0.01$), using the age group 0–29 years for comparison. Also, only one variable, people aged 50+, significantly predicted at-level neuropathic pain ($P < 0.05$). Three variables predicted below-level neuropathic pain: age 30–49 years ($P = 0.01$), age 50+ ($P = 0.001$), and complete injury ($P = 0.01$; see Table 4).

ROC curves were made from the variables age 30–49, age 50 (compared to a reference group age 0–29 years of age) and an interaction term (age 50, gender, level; Figure 3), showing different cutoff levels for sensitivity and specificity. The low departures from the diagonal of the diagram indicate that the association neuropathic pain–age shown previously is rather weak as an

Figure 3 ROC curves for models where the variables age 30–49 and an interaction term (age 50+, level, gender) are included. The ROC curves produced from the results in the present study are close to diagonal, showing that the models with estimated log (odds) factors are weak instruments of prediction (see Methods for further explanation)

Figure 4 Patient rating of neuropathic pain as a problem in daily life

instrument for predicting the prevalence of neuropathic pain from these variables.

Patient rating of the pain as a problem in their daily life In total, 72% of the patients with neuropathic pain reported that their pain is a large problem or a problem to some extent. The remaining 28% reported that the pain was not a problem. Patients in the latter group often said that they had got used to the pain (Figure 4). The frequency of patients rating the pain as a problem in daily life was not significantly different between the age classes ($\chi^2 = 1.20$, df 4).

Discussion

The main finding of the present study, as was found regarding overall pain incidence in an earlier study,¹² is that the prevalence of neuropathic pain is positively correlated with increasing age at the time of the injury. No significant systematic correlation was found for overall neuropathic pain after SCI: gender, injury level, or completeness of injury. Furthermore, none of these parameters predisposed for at-level or below-level pain, except for complete SCI, which predicted below-level neuropathic pain.

Methodological issues

This investigation focused specifically on neuropathic pain after SCI. A key question is the accuracy of the diagnosis, that is, the separation of neuropathic pain from other kinds of pain. In this study, standard criteria presented by the IASP task force^{7,8} were used in examinations by a neurologist specialised in SCIs. Also, the percentage of patients with neuropathic pain after SCI obtained in the present study is within the range of

previous studies.^{4,9,10,12} These two factors support the reliability of the diagnoses of neuropathic pain made in this investigation. Furthermore, in this study, the patients were reported as having neuropathic pain, regardless of pain severity. Even though this approach may have reduced some of the ambiguity as to when to report pain, the frequency of pain reports may well have been influenced by environmental and psychological factors. For instance, it appeared to be difficult for the patients to describe more than the type and localisation of the dominating pain, which is accounted for in this study. It is therefore reasonable to assume that the presentation here is an underestimation of the true number of cases with combined at-level and below-level neuropathic pain. This would not, however, change the major conclusions in this study.

The patient data obtained in this study were in most cases gathered at late time points after the injury (2 months–46 years, mean 6 years). It has recently been reported⁴ that at-level neuropathic pain tends to start within months, whereas below-level neuropathic pain may start early but tends to start somewhat later, during the first years after the injury. Once established, both usually persist.⁴ Late onset of neuropathic pain was reported also by Störmer *et al*.¹⁶ Thus, this study is likely to include mainly patients for whom the pain pattern has stabilised, but also an unknown but conceivably smaller number of patients for whom in particular below-level neuropathic pain may develop later. It should be noted that in this study, we analyse the prevalence of neuropathic pain in patients who suffered their injury at different years of age, rather than neuropathic pain related to age regardless of at what age the injury happened. As neuropathic pain in most cases appears soon after the injury and then remains for the rest of the patient's life, we do not think that the increase in pain prevalence in patients who suffered injury in the later parts of their life that we report here simply reflect an increasing prevalence in older patients.

It is possible that the quality of the care of acute SCI patients is important for the risk of developing severe neuropathic pain. For instance, intense and insufficiently treated nociceptive pain may give rise to central sensitisation processes that increase the magnitude of already present neuropathic pain. Whether such circumstances are involved in the pathogenesis of neuropathic pain is unknown. In the present study, we investigated the prevalence of neuropathic pain regardless of intensity. As recovery from neuropathic pain seems to be rare,⁴ we therefore believe that the results presented here are relevant regardless of the quality of available care.

Importance of studied parameters for the occurrence of neuropathic pain

The results of the present study show that the prevalence of neuropathic pain is positively correlated to increasing age at the time of injury. This is in accordance with several previous studies.^{10,16–18} The results of this study also showed that incomplete injuries were more com-

mon in the higher age groups, possibly as a result of a less violent life style in older ages with fewer high energy accidents, and of a relative weakness of the spine that increases the chance of fracturing the spine also after mild trauma. Analysis with logistic regression showed, however, that the increased prevalence of pain at higher age was not associated with complete or incomplete SCI.

Furthermore, the results of this study indicate that the prevalence of below-level pain had its peak increase in patients aged up to 40 years at the time of injury, whereas the prevalence of at-level pain dominated among those injured after 40 years of age. This does not seem to have been reported previously.

The ratio male:female was about 4:1 in all the five age groups. This relation corresponds well with previous studies.^{18–20} The present study did not reveal any statistically significant gender difference in the prevalence of neuropathic pain. This does not seem to have been reported previously. An earlier study has reported that women have higher prevalence of nociceptive pain after SCI.¹¹ It is possible that the results would have shown such difference also in this study if we had chosen to ask for neuropathic pain of significant importance rather than for neuropathic pain in general.

The results of this study show no overall difference in the prevalence of neuropathic pain between those with paraplegia and tetraplegia. More detailed analysis of the data, however, showed that complete paraplegic patients with low injuries (Th10–S4) had neuropathic pain nearly twice as often (70%) as those with high thoracic injury (Th1–9; 34%). This difference was not an effect of age as these two injury groups had very similar mean age (26 versus 27 years). A similar trend was demonstrated by Siddall *et al*,⁴ who demonstrated that tetraplegic patients had below-level neuropathic pain more often than paraplegic patients. One hypothesis is that injuries to the comparatively small-diameter thoracic cord results in neuropathic pain less often than those close to the spinal cord enlargements, simply as a result of less injured nervous tissue.

The results of this study showed no overall difference in the prevalence of overall neuropathic pain between those with complete and incomplete injury, using χ^2 analysis. The results of the logistic regression analysis, however, did show a significant increase for below-level neuropathic pain after complete injury. A similar finding was obtained by Siddall *et al*⁹ shortly after injury, but not in their follow-up study 5 years later.⁴ The distinction between complete and incomplete injury in this study is based on symptoms revealed in the ASIA classification rather than pathological/anatomical examinations of the actual SCI. The true extent and nature of the injury, which is likely to be of interest for the understanding of processes of importance for the development of neuropathic pain, is only incompletely and indirectly indicated by the ASIA classification. It is, for instance, possible that some of the complete SCI had comparatively restricted lesions, whereas in other cases incomplete injuries have extensive lesions, with multiple potential sites for pain-promoting interactions with partly preserved ascending sensory pathways.

The results of the present investigation show that in total 12% of people with SCI had at-level neuropathic pain and 28% below-level neuropathic pain. Thus, the results are roughly comparable to the prevalence of at-level pain and below-level pain reported by Siddall *et al.*^{4,9} The significance of the moderate differences is uncertain. They can possibly be explained by differences in criteria for pain report and the time point at which the measurements were made.

Interference of pain on the quality of daily living

Pain is one of the most important factors for interference with daily life activities after SCI.⁶ We therefore used the opportunity to ask the patients in this study to rate how much the pain affected their daily life. In total, 70% of those with pain answered that pain affected their life a lot ('much' or 'to some extent'), corresponding to 28% of all patients in the study. We cannot discern to what extent this finding reflects the contribution of neuropathic pain rather than a mixture of neuropathic and nonspecified pain. Although not formally examined in this study, a common statement among patients who reported that the pain did not affect their life was that they had got used to the pain and therefore did not think much about it. Our results show a lower rate of distress caused by the pain than those of Anke *et al.*¹⁸ who found that the pain caused significant psychosocial stress in 46% of patients. Taken together, the findings confirm that the pain associated with SCI is a major cause of distress.

Possible neurobiological explanations

The observation that the prevalence of neuropathic pain in age classes increases with age has no clear explanation. Analogous findings have been reported for postherpetic neuralgia.²¹ No systematic studies in animals seem to have been performed with this question. It may be speculated that the increase is related to a relative decrease in the plasticity of the nervous system with age and therefore a loss of fine-tuning in the delicate balance that regulates the transmission of nociceptive signals to higher centres. At-level and below-level neuropathic pains are expected to have different pathogenetic mechanisms (for review, see Sjölund²²). Explanations include spontaneous firing pain circuits, ephapses, and disturbances in pain regulating descending pathways. Except from the possibility of an age-related narrowing of intervertebral foramina, we cannot explain the finding in this study that the prevalence of below-level pain increases more with age in the age groups injured from 0–19 up to 30–39 years, whereas the prevalence of at-level pain increases more in the age groups above 39 years.

Clinical applications

The results confirm that neuropathic pain after SCI is an important problem that often interferes significantly with functions in daily life, and that careful pain diagnosis and adequate treatment is an important

ingredient in the rehabilitation process. Even though this study shows that both the sensitivity and the specificity are too low to allow prognostic rating in the individual cases for any of the parameters investigated in this study, the results should be of interest for considering special attention to the treatment of neuropathic pain in patients who suffer SCI at higher ages, at least at the group level.

Acknowledgements

We thank Mr Backheden at the Department of Learning, Informatics, Management and Ethics (Lime) at the Karolinska Institute for statistical support.

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