Evaluation of a clinical protocol to assess and diagnose neuropathic pain during acute hospital admission: Results from traumatic spinal cord injury.

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Abstract

Objectives: A clinical protocol was developed for clinicians to routinely assess and initiate treatment for patients with neuropathic pain (NP) in an acute care setting. The objectives of this study were to: 1) determine the incidence and onset of NP in patients with traumatic SCI during acute care and 2) describe how the implementation of a clinical protocol impacts the assessment and diagnosis of NP.

Methods: The study was a cohort analysis with a pre-post-test utilizing a historical control. Data was retrospectively collected from a patient registry and charts. Participants were randomly selected in cohort 1 (control) and cohort 2 (NP clinical protocol).

Results: The incidence of NP was 56% without significant difference between the cohorts (p=0.3). Onset of NP was 8 days (SD=14) across the study and >85% of the participants with NP were diagnosed within two weeks. Participants with incomplete injuries had a significant earlier onset than participants with complete injuries (6.2 ± 12.8 days, 10.9 ± 15.8 days; p=0.003). The mean number of days from hospital admission to initial assessment decreased with use of the NP clinical protocol (3.7 ± 5.7 days; p=0.02).

Discussion: This study demonstrates a high incidence and early onset of NP in traumatic SCI during acute hospital care, with an earlier emergence in participants with incomplete injury. The NP clinical protocol ensured continuous assessment and documentation of NP while decreasing the time to an initial screen, but did not impact diagnosis.
Introduction

Following a spinal cord injury (SCI), neuropathic pain (NP) can occur from damage to the neural tissues and nociceptive pain can result from damage to non-neural tissues.\(^1\) A combination of both types may be present and identification is important for treatment.\(^1\) The prevalence of NP among persons with SCI is high, ranging from 15-38% in acute care and up to 59% in the community,\(^2\)–\(^8\) with NP impacting the prevalence of comorbidities such as insomnia, depressive syndromes and anxiety.\(^9\) Of employed subjects, 38% reported some level of work impairment and the total annual cost per subject in the community was USD 26,270.\(^9\)

Given the impact of NP on a person’s functioning, quality of life and financial burden, accurate diagnosis and early treatment with appropriate medication is critical. Recognizing NP can be difficult for a clinician lacking the specialized training and clinical experience required to assess a patient’s history and perform a physical examination for definitive diagnosis.\(^10\) As a result, screening tools such as the DN4 or Leeds Assessment of Neuropathic Symptoms and Signs, were developed to diagnose NP.\(^10\)–\(^12\) Once diagnosed, treatments can include anticonvulsants (e.g. gabapentin, pregabalin), tricyclic antidepressants (e.g. amitriptyline, nortriptyline, desipramine), serotonin noradrenaline reuptake inhibitors, controlled-release opioids, cannabinoids and other analgesics (e.g. selective serotonin reuptake inhibitors, tramadol, lidocaine).\(^13\)–\(^15\) The most recent Canadian guidelines for the pharmacological management of chronic NP provide a stepwise progression for the treatment of NP and emphasize an individualistic approach that considers efficacy, side-effects and accessibility while recognizing nonpharmacological interventions (e.g. physiotherapy, exercise and psychological treatment) as essential.\(^15\)
Pain experts at Vancouver General Hospital (VGH) suspected that there was a higher incidence of NP than was previously reported. Despite the need to promptly diagnose and treat NP, there was no standardized protocol at the hospital to differentiate nociceptive and NP, or facilitate early intervention in an acute setting. To address this gap, a group of pain experts at VGH developed and implemented a hospital-wide clinical protocol for all patients in acute care referred to as the Vancouver Acute Neuropathic Pain Treatment Guideline (VANPTG).

Specifically, the VANPTG was developed for a general clinician to routinely assess acute patients for NP, prescribe initial treatment according to a clinical algorithm, and initiate a pain expert consultation.

The Acute Spine Unit (ASU) was selected as one of the first units to implement the protocol. There was interest in determining the incidence of NP in traumatic SCI patients and examining changes in pain management. The objectives of this study were to: 1) determine the incidence and onset of NP in patients with traumatic SCI in the acute phase of care and 2) describe how the implementation of a clinical protocol impacts the assessment and diagnosis of NP.

Materials and Methods

SCI Care

In the province of British Columbia, the VGH ASU is the only specialized spine unit in a level 1 trauma centre. The ASU has 32 beds that are staffed with seven spine surgeons and a pain specialist, in addition to nursing and allied health staff with expertise in SCI management. Each year, this unit admits over 900 patients with complex trauma or disorders of the spinal column and/or cord. It also has an onsite Peri-Operative Pain Service, a Complex Pain and Addiction Service and a physiatry consultation service.
NP Protocol

In 2010, the Peri-operative Pain Advisory Committee at VGH, composed of anaesthesia, psychiatry, palliative care, clinical pharmacy and nursing disciplines was convened to develop the VANPTG (see Figure, Supplemental Digital Content 1, http://links.lww.com/CJP/A447 for the Pain Assessment Record; Figure, Supplemental Digital Content 2, http://links.lww.com/CJP/A448 for the VANPTG). The VANPTG was intended as a hospital-wide protocol for all acute care patients.

The VANPTG consists of a protocol for general clinicians to routinely assess all acute patients for pain using a Pain Assessment Record with questions involving NP symptoms, prescribe initial treatment with an algorithm and initiate a pain expert consult. According to the VANPTG, nurses in the ASU are required to assess patients with SCI every 12 hours using the Pain Assessment Record that incorporates items from the DN4 questionnaire.11

Based on input from Peri-operative Pain Advisory Committee, the Pain Assessment Record was adjusted to include NP symptoms (i.e. burning, painful cold, electrical shocks, tingling, pins & needles, numbness, itching) and allodynia so that the decision to consult a pain expert can be made without a physical exam. When a patient has at least three NP symptoms or significant allodynia (greater or equal to 4 out of 10 on a Numeric Rating Scale), treatment is initiated following an algorithm and a referral to a pain expert is made to confirm the diagnosis. The pain expert uses their experience, the patient’s history and a physical exam that follows guidelines from the International Association for the Study of Pain and generally uses a grading system.18 See Figure 1 for a description of patient care flow in the ASU. For this study, an on-unit, fellowship-trained anaesthesiologist, a psychiatrist with a specialty in pain management,
and the Peri-Operative Pain Service anaesthesiologists and physiatrists are defined as pain experts. Physicians from other disciplines and nurses are referred to as general clinicians.

**Study Design and Sample**

This is a cohort study with a pre- and post-test study design utilizing a historical control. Data was retrospectively collected from the Rick Hansen Spinal Cord Injury Registry (RHSCIR)\(^1\) and abstracted from patient charts. The study sample consisted of participants over 15 years of age, diagnosed with a new traumatic SCI who were admitted to the ASU and enrolled in RHSCIR from July 1, 2004 to March 31, 2012. The participants were divided into cohorts based on exposure to the NP protocol (cohort 1, historical control; cohort 2, VANPTG). It was not possible to conduct a chart review on the large number of eligible participants within the cohorts; therefore, a power analysis was conducted to determine the number of participants needed to answer the study objectives. The study sample was randomly selected using the Simple Random Sampling function in Statistical Analysis Software®, Version 9.3.

Institutional approval for this study was obtained from the University of British Columbia (Clinical Research Ethics Board) and Vancouver Coastal Health (Research Operational Approval). Based on the Tri-Council Policy Statement (TCPS2 2014), Article 3.7A, an alteration to the requirements for consent was approved by the Clinical Research Ethics Board for this study; therefore, participants were not required to provide written or verbal informed consent. This study was limited to the review and analysis of existing data that did not involve any therapeutic, clinical or diagnostic intervention. The researchers took appropriate measures to protect the privacy of individuals and to safeguard identifiable information. Results presented in the manuscript are aggregated data devoid of identifiable information.
Data Collection

Data was retrospectively collected by one of the authors (SEP) for the acute phase of care which refers to the time a patient is admitted to an acute care hospital. The average length of stay for this population was 36 days (median 27 days and range 2 to 191 days), including both emergency and acute care. Injury and demographic data were obtained from RHSCIR. Data elements collected from participant charts included general clinician and pain expert assessment notes regarding NP, completion of the screening tool (Yes/No), diagnosis of NP (Yes/No) and NP medication records. Descriptors such as “burning, shooting pain” and “hypersensitive to touch” were included, as well as documentation of NP diagnostic terms such as “neuropathic pain” or “nerve pain,” to identify the presence of NP. The completion of the screening tool was only collected for cohort 2.

The gold standard for NP diagnosis was based on documentation by pain experts. To identify any false negative diagnoses, the clinical nurse specialist (LMB) examined the charts for documentation of NP symptoms for participants who had a negative NP diagnosis according to a general clinician (a clinician who is not classified as a pain expert) that was not confirmed by a pain expert.

Analysis

Comparison Between the Cohorts

Statistical Analysis Software® Version 9.3 was used for all analysis with p<0.05 as the threshold of statistical significance. Comparisons were made between cohorts 1 and 2 unless otherwise specified. The cohorts were compared using Chi-square test, Fisher’s exact test, or T-test depending on the type of variables to determine if there was any difference in the distribution of demographic and injury variables.
NP Incidence, Documentation and Onset

The incidence of NP was calculated by dividing the number of participants with a NP diagnosis by the total number of participants in the cohort. The percent of participants with documentation was calculated by dividing the number of participants with NP documentation by the total number of participants in the cohort. NP documentation refers to clinical documentation relating to NP either from chart notes or the screening tool – this data reports the presence or absence of NP. NP diagnosis refers to the presence of NP. In cohort 1, NP data was only collected from the chart notes, in cohort 2 NP data was collected from the chart notes and the screening tool.

To compare the incidence and the documentation by the source of the data (general clinician or expert-derived), the incidence and documentation was assessed using the data from the general clinicians and the pain expert information separately. The incidence of NP was compared between the cohorts using Chi-square test. Since the gold standard was based on documentation by pain experts, the expert-derived incidence was used for determination of the NP incidence in this population.

The cohorts were then combined to determine if there was any difference in the incidence and documentation of NP based on injury severity (completeness of the SCI). The same comparison was repeated for the onset of NP. NP onset was defined as the time from the injury to the earliest positive NP diagnosis either by a general clinician or a pain expert; however, only participants confirmed by a pain expert were included in the onset calculations. This was done so that the time it took for an expert consult did not impact on the number of days to onset.
NP Protocol Adherence

The adherence to the VANPTG protocol was determined by calculating the percentage of documented screening using the Pain Assessment Record. Diagnostic accuracy of general clinicians was assessed by comparing the percentage of general clinician diagnoses that matched the pain expert diagnoses. Treatment was indicated by a prescription record for at least one of the following medications gabapentin, nortriptyline, pregabalin, desipramine and amitriptyline/ketamine cream. Treatment correction was calculated by examining the percentage of treatments initiated by general clinicians that were either stopped or dosage adjustments by pain experts. Chi-square test was used for comparisons.

NP Management Practice

The effect of the VANPTG implementation in changing the NP management practice was examined by comparing any difference in time between the cohorts for the following data variables: injury, hospital admission, initial screening, first positive diagnosis (general clinician or pain expert), pain expert diagnosis, expert NP consultation and treatment initiation. For all the milestones that used the first positive diagnosis, only participants that were confirmed by an expert were included. The cohorts were compared using the Chi-square test and Wilcoxon-Mann-Whitney test depending on the type of data.

Results

Baseline Comparison of Study Sample

There were a large number of participants eligible for this study (n=594 in cohort 1, n=132 in cohort 2) and 276 participants were randomly selected for inclusion (see Figure 2). A detailed description of the demographic and injury variables for each cohort is shown in Table 1.
There was no statistical difference among the cohorts except for mechanism of injury (p=0.03) and neurological classification at admission (P=0.04).

**NP Incidence, Documentation and Onset**

The comparison of NP incidence between the cohorts is shown Figure 3A. The expert and general clinician-reported incidences both increased (7.2 and 3.5%, respectively), however, there was no significant difference in the incidence reported by either the expert (p = 0.3), or the general clinician (p = 0.6) following implementation of the VANPTG. The NP incidence over the entire study period was 56.3%, as reported by the experts and 68.9%, as reported by the general clinicians (Table S1, Supplemental Digital Content 3, http://links.lww.com/CJP/A449).

The comparison of the NP documentation between the cohorts is shown in Figure 3B. The percent of participants with expert and general clinician-reported documentation both increased significantly. The percent of participants with expert documentation significantly increased (p = 0.03) by 14.1% to 81.4% with the implementation of VANPTG. The percent of participants with general clinician documentation significantly increased (p < 0.0001) by 32.1% to 100% with the implementation of VANPTG (Table S2, Supplemental Digital Content 4, http://links.lww.com/CJP/A450).

No statistical significance was found among the cohorts with respect to NP onset (9 ± 17 and 6 ± 6 days; p=0.7) and the mean onset over both cohorts was 8 ± 14 days. The cumulative distribution of NP onset is shown in Figure 4. The shape of the graph shows a sharp increase in the number of NP cases diagnosed within the first week of injury with 71% and 87% of all the participants with NP diagnosed by seven and 14 days, respectively.

When the cohorts were pooled and participants with complete SCI (AIS A) were compared against those with incomplete SCI (AIS B, C or D), the incidence did not significantly
differ \((p = 0.2)\), however, the expert documentation differed significantly \((p = 0.007)\), where participants with complete SCI had a higher percent of participants with documentation (Figure 5 and Table S3, Supplemental Digital Content 5, http://links.lww.com/CJP/A451). Of the participants with incomplete injuries, 35% lacked documentation compared to 18% of the participants with complete injuries. Across the cohorts, the time from injury to the earliest positive diagnosis or onset was significantly earlier for incomplete injuries \((p=0.003)\), see Table 2 for a summary. Figure 4 shows the cumulative distribution of NP onset between incomplete and complete injuries. Of all the participants who were diagnosed with NP during the acute phase, 80% of those with incomplete and 57% of those with complete injuries were diagnosed within seven days. No such difference in onset was seen when participants with cervical injury were compared to those with thoracic or lumbar injury for all injury severities \((\text{AIS A-D})\) \((p = 0.5)\).

**NP Protocol Adherence**

The comparisons of cohorts for NP screening, diagnosis and treatment are summarized in Table 3. The screening portion of VANPTG implemented in cohort 2 had a high adherence of 99\% \((n = 69)\). There was no difference among the cohorts in the documentation of NP in chart notes by general clinicians \((p = 0.3)\), – this data was collected by chart review only (excluding use of screening tool). There was a significant difference in the percentage of participants assessed by a pain expert \((P=0.03)\), with an increase to 81.4\% following VANPTG. Among the cohorts, the diagnostic accuracy of the general clinicians \((p = 0.4)\), the number of participants who received treatment for NP \((p = 0.9)\) and treatment correction \((p = 0.5)\) also did not change significantly.

**NP Management Practice**
A comparison of cohorts for the milestones of NP management is summarized in Table 4. There was no change in the time from injury to the hospital admission among the cohorts (p = 0.3). The initial screening occurred within a week following admission to the hospital and was significantly less following implementation of the VANPTG; the mean time was 3.7 ± 5.7 days (p = 0.02) from hospital admission to the initial NP assessment. The mean time was 1.1 days (SD = 2.0) from the initial screening to the positive diagnosis of NP, which was significantly longer in cohort 2, however, the time from injury to first positive diagnosis was not significantly different following implementation.

**Discussion**

This study determined the NP incidence and early onset in an acute SCI population and evaluated the effect of VANPTG on pain assessment and diagnosis compared to previous practice. The average incidence of NP during the entire study period was 56% and onset was on average, 8 days following injury, with approximately 71% diagnosed in the first week. The implementation of VANPTG significantly increased the percent of patients assessed with NP documentation and significantly decreased the average number of days from hospital admission to initial screening, without impacting treatment or diagnosis.

**NP Incidence, Documentation and Onset**

To date, the incidence of NP in the SCI population is primarily reported in the rehabilitation or community setting.\(^4,20-24\) The prospective studies have focused on discrete time points to screen for NP, contrasting the current study that occurs in an acute setting where patients are regularly assessed for pain. We have examined all NP together and have not separated by location (above or below-level), so direct comparisons are difficult. Siddall et al reported that at 2 weeks following injury 38% and 14% of their population had at level and
below level NP, respectively, and at 5 years this increased to 41% and 34%. At 3 months, Finnerup et al, had >30% of their population with NP which increased to 49% at 3.5 years. According to these studies, our 56% incidence is at the higher end of the range. Although our study was retrospective and conducted as a quality improvement initiative, the data was collected from current clinical practice and reflects a high incidence during an early acute timeframe that has not been analyzed previously.

Our incidence is higher than Street and colleagues who reported an incidence of 15% in a similar traumatic SCI population. The difference is likely due to the reporting source. We used NP diagnosis by a pain expert as the definition of NP in our study, and this incidence was similar across cohorts regardless of the protocol. Street and colleagues used surgeon reports during their weekly rounds to determine the status of NP. The rounds may not have captured cases where NP was effectively managed. Since our measurement of incidence occurs continuously, immediately following admission, and includes a team of pain experts for the diagnosis, we believe it is an accurate estimate of the incidence in an acute traumatic SCI population.

The introduction of new treatment guidelines did not significantly impact the incidence of NP in this patient population, but did significantly increase the documented assessment of NP, irrespective of the profession recording the clinical data. The entire population of the second cohort had NP documentation by the general clinician, with 99% screened using the VANPTG, showing the guidelines’ value and adherence. The higher incidence reported by the general clinician compared to the pain experts was expected due to the methodology of the guidelines that promote an initial screen by a general clinician with less stringent criteria, lacking a physical exam, compared to the pain expert consultation. To correct for any over-diagnosis, all participants screened as positive by the general clinician are confirmed by a pain expert and
treated accordingly. The VANPTG ensured all participants were assessed, had NP documentation and streamlined the pain expert consultation process.

There is limited evidence regarding the onset of NP after SCI, particularly early in the acute phase (or less than one month following injury). Siddall and colleagues found that the majority of their participants with NP first report at two weeks post-injury (53% of those with at-level NP and 41% of below-level).3 Interesting, several groups have found different progression of at-level versus below-level NP, where at-level pain has an earlier onset.3,4,6,7 In the present study, the majority of our participants also reported NP at two weeks, 87% of those with NP were first diagnosed by 14 days and 71% by seven days. Average onset was 8 days (SD = 14) following injury across our study period, which indicates that NP emerges earlier than any of the current literature screens for NP.

When the incidence, documentation and onset of NP were compared by completeness of injuries, the incidence did not differ significantly (p = 0.2), while the percent of participants with NP documentation and the onset of NP did differ between the complete and incomplete populations in the study. The percent of the participants with NP documentation was found to be significantly higher in the complete SCI population (p = 0.007) compared to the incomplete population and the onset earlier for the incomplete SCI population (p = 0.003) compared to the complete population. This demonstrates that participants with incomplete SCI are less likely to be assessed for NP. Those that lack NP documentation could represent the less severely injured proportion of the incomplete injuries that have a shorter length of acute stay. Of clinical interest, the onset of NP was significantly earlier for incomplete compared to complete injuries (6.2 days versus 10.9 days), suggesting the importance of early NP assessment and documentation of incomplete injuries. Two prospective longitudinal studies did not find differences in the
prevalence of NP based on the completeness of injury. However, one of these studies did find that incomplete injuries had a higher prevalence of allodynia in the first 6 months following injury. The impact that the severity of injury has on the incidence of NP in this population will require further study with a prospective design to reduce the number of participants that lack documentation of an NP assessment.

**NP Management Practice**

The relatively high incidence of NP in the traumatic SCI population likely reinforced the importance of early assessment, treatment and expert consultation in the ASU, even prior to the new treatment guidelines. The implementation of the VANPTG protocol was effective with almost all participants being screened and all participants having NP documentation. As a result of implementing the VANPTG, there was a significant one day decrease (4.9 days in cohort 1 to 3.7 days in cohort 2) in the time to initial screening following admission to VGH. However, there were no significant differences in the overall time from injury to obtaining a positive diagnosis (p = 0.7) or in the time from positive diagnosis to receiving treatment (p = 0.8). Taken together with the consistently high cohort incidence, these results suggest that the VANPTG had only a minor impact on management practice and diagnosis of NP in the acute spine unit.

The negative time from positive diagnosis to treatment demonstrates that the ASU team is comfortable initiating treatment while confirming the diagnosis and management with the pain expert. The extent (84%) to which the general clinician diagnosis of NP agrees with the expert diagnosis suggests that in a setting with a high incidence and access to pain experts, general clinicians are proficient in recognizing and treating NP. Having access to a pain expert on the ASU was in place before 2004 and may explain why no significant changes were seen in treatment. In the recently published SCI Acute and Rehabilitation Standards by Accreditation
Canada, there is a requirement for the program to evaluate and manage pain. Future studies should evaluate the VANPTG program at a centre that does not have a specialized spine unit to analyze the impact on NP treatment.

**Study Limitations**

It is important to consider the limitations when interpreting the results of this study. Since this study used retrospective data collected from hospital charts, only data recorded as part of a routine clinical practice was available. As clinicians generally document problems that require attention, the absence of NP would not be as meticulously recorded as the presence of NP, especially in cohort 1, which did not have an effective documentation tool to prompt clinicians to record the absence of NP symptoms. If the absence of NP was not recorded in the medical chart, the assessment was not likely documented leading to a falsely-reported longer time to the initial screening. Some clinicians may not have documented the presence of NP but initiated the treatment based on clinical judgment, which could have led to the treatment initiation percentage being higher than the NP diagnosis percentage. As well, our gold standard of diagnosis by the pain experts has not been independently validated. A future prospective design with an independently validated VANPTG would improve the quality of data on NP incidence and onset.

The VANPTG was developed as a hospital-wide initiative and was not targeted to patients sustaining a traumatic SCI. Since its development, there have been advances in the standardized classification SCI pain with the publication of the International Spinal Cord Injury Pain (ISCIP) Classification. A prospective study will include more details specific to SCI pain, including the ISCIP classification and other domains of pain (location, intensity and extent).

Although the present study did not address side effects of the treatments for neuropathic pain, the side effects to these pharmaceuticals are an important part of treatment and should be
included in future prospective research. Additionally, we were only able to report on the number of comorbidities and not specific comorbidities that may influence the development of NP. For the scope of this paper, as a retrospective chart review, these details were not included, however it should be noted that few participants were taken off medication (or had treatment corrected) suggesting that side effects were not an issue for the treatment of this patient population.

Results from this study support the perception that the incidence of NP in the acute traumatic SCI population is higher (56%) and the onset is earlier (8 ± 14 days) than previously reported. The finding that incomplete injuries have an earlier onset is novel and should be included in SCI pain management education and to inform future research since little is known about NP immediately following injury. The implementation of a hospital-wide NP protocol improved assessment documentation and timely care in a specialized SCI centre by increasing the NP documentation and decreasing the time to initiate screening but did not impact the overall time from injury to treatment. However, given that the ASU was vigilant in the management of NP, lessons learned from this program may inform other SCI programs.
References


Figure Legends

FIGURE 1. The flow of neuropathic pain management milestones. An overview of the two most common pathways for assessing and managing neuropathic pain in patients with traumatic SCI admitted to the ASU. ASU indicates acute spine unit; SCI, spinal cord injury.

FIGURE 2. An overview of the participant selection process. This is a flow diagram that depicts the participant selection process and the final number of participants in each cohort. ASU indicates acute spine unit; tSCI, traumatic spinal cord injury.

FIGURE 3. The dot plot comparisons of Cohort 1, the control group, and Cohort 2, the group with the implemented Vancouver Acute Neuropathic Pain Treatment Guidelines. A) The percent of the participant population diagnosed with neuropathic pain, as reported by the pain expert or the general clinician. B) The percent of the participant population with neuropathic pain documentation, as reported by the pain expert or the general clinician. * indicates p<0.05; *** indicates p<0.001.

FIGURE 4. The cumulative distribution of neuropathic pain onset. The cumulative percentage of participants diagnosed with neuropathic pain according to the date of onset. The percentages represent the proportion of only those who have neuropathic pain during their acute stay as confirmed by a pain expert. NP indicates neuropathic pain.

FIGURE 5. The dot plot comparisons of incomplete and complete spinal cord injuries based on either the incidence or the assessment documentation of neuropathic pain. ** indicates p<0.01.

Supplemental Digital Content

Figure S1, Supplemental Digital Content 1.tif
Figure S2, Supplemental Digital Content 2.tif
Table S1, Supplemental Digital Content 3.doc
Table S2, Supplemental Digital Content 4.doc
Table S3, Supplemental Digital Content 5.doc
Table S4, Supplemental Digital Content 6.doc
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<td></td>
<td></td>
<td>0.03*</td>
</tr>
<tr>
<td>Fall</td>
<td>39.3 (66)</td>
<td>44.3 (31)</td>
<td></td>
</tr>
<tr>
<td>Sports</td>
<td>30.4 (51)</td>
<td>12.9 (9)</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>22.0 (37)</td>
<td>28.6 (20)</td>
<td></td>
</tr>
<tr>
<td>Other Traumatic Cause</td>
<td>8.8 (14)</td>
<td>14.3 (10)</td>
<td></td>
</tr>
<tr>
<td>Number of Comorbidities at Admission, % (n)</td>
<td></td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>0</td>
<td>68.5 (115)</td>
<td>70.0 (49)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>18.5 (31)</td>
<td>14.3 (10)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8.9 (15)</td>
<td>8.6 (6)</td>
<td></td>
</tr>
<tr>
<td>&gt;3</td>
<td>4.2 (7)</td>
<td>7.1 (5)</td>
<td></td>
</tr>
<tr>
<td>aMean ISS ± SD</td>
<td>24.4 ± 10.5</td>
<td>27.5 ± 15.3</td>
<td>0.3</td>
</tr>
<tr>
<td>aReceived Spinal Surgery, % (n)</td>
<td>93.9 (92)</td>
<td>92.9 (39)</td>
<td>&gt;0.9</td>
</tr>
<tr>
<td>aMean Time from Injury to Hospital Admission ±SD</td>
<td>2.3 ± 6.7 d</td>
<td>1.5 ± 3.5 d</td>
<td>0.3</td>
</tr>
<tr>
<td>aMean Time from Hospital Admission to ASU Admission ±SD</td>
<td>3.8 ± 7.5 d</td>
<td>3.5 ± 5.6 d</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Abbreviations: Days, d; Acute Spine Unit, ASU; ASIA Impairment Scale, AIS; Injury Severity Score, ISS; Lower Motor Neuron lesion, LMN; Standard deviation, SD; Upper Motor Neuron lesion, UMN; p<0.05 indicated by *.

aSample size for ISS values are n=147 in cohort 1, n=45 in cohort 2.
bSample size for Received Spinal Surgery values are n=98 in cohort 1, n=42 in cohort 2.
cSample size for Mean Time from Injury to Admission values are n=165 in cohort 1, n=70 in cohort 2.
dSample size for Mean Time from Hospital Admission to ASU Admission values are n=167 in cohort 1, n=70 in cohort 2.
Table 2. Onset of Neuropathic Pain by Injury Severity

<table>
<thead>
<tr>
<th>Onset</th>
<th>Complete SCI Injury (n = 83)</th>
<th>Incomplete SCI Injury (n=152)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean NP Onset ± SD (days)</td>
<td>10.9 ± 15.8</td>
<td>6.2 ± 12.8</td>
<td>0.003**</td>
</tr>
<tr>
<td>Median (Min-Max)</td>
<td>6 (0 - 83)</td>
<td>3 (0 - 106)</td>
<td></td>
</tr>
<tr>
<td>No. Patients with Onset Data</td>
<td>51</td>
<td>81</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: Neuropathic Pain, NP; Spinal Cord Injury, SCI; Standard Deviation, SD; p<0.01 indicated by **.

Note: A complete SCI includes participants diagnosed with AIS A injuries and an incomplete SCI includes AIS B, C and D injuries. All times to NP onset are reported in days and confirmed by a pain expert. Three participants were missing AIS and not included in this analysis.

Table 3. Comparison of Assessment for Neuropathic Pain by Cohort

<table>
<thead>
<tr>
<th>Assessment Variable</th>
<th>Cohort 1 (n=168)</th>
<th>Cohort 2 (n=70)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening Tool Usage, % (n)</td>
<td>N/A</td>
<td>98.6 (69)</td>
<td></td>
</tr>
<tr>
<td>Patients with General Clinician NP chart notes data ( ^\beta )</td>
<td>75.6 (127)</td>
<td>81.4 (57)</td>
<td>0.3</td>
</tr>
<tr>
<td>Patients with Expert reported NP data( ^\dagger ), % (n)</td>
<td>67.3 (113)</td>
<td>81.4 (57)</td>
<td>0.03*</td>
</tr>
<tr>
<td>Patients with Expert and General Clinician reported NP data( ^\dagger )</td>
<td>95</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Expert and General Clinician matches, % (n)</td>
<td>82.1 (78/95)( ^|$</td>
<td>87.5 (42/48)( ^|$</td>
<td>0.4</td>
</tr>
<tr>
<td>Treatment Initiated, % (n)</td>
<td>76.2 (128)</td>
<td>75.7 (53)</td>
<td>0.9</td>
</tr>
<tr>
<td>Treatment Corrected, % (n)</td>
<td>3.9 (5/128)( ^|$</td>
<td>7.6 (4/53)( ^|$</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Abbreviations: Neuropathic Pain, NP; p<0.05 indicated by *.

\( ^\dagger \) NP data refers to documentation relating to NP either in the chart notes or a completed NP screen

\( ^\beta \) Chart notes data refers to NP documentation within the chart notes (this does not include the screening tool used in Cohort 2).

Note: Percentages are calculated as a percent of the total cohort number (n) unless indicated by \( ^\|$.

No screening tool was used in Cohort 1.
Table 4. Comparison of Cohorts for Mean Time to Care Milestones for Assessing and Managing Neuropathic Pain

<table>
<thead>
<tr>
<th>Milestones</th>
<th>Cohort 1 (n=168)</th>
<th>Cohort 2 (n=70)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury → Hospital admission</td>
<td>2.3 ± 6.7 d</td>
<td>1.5 ± 3.5 d</td>
<td>0.3</td>
</tr>
<tr>
<td>Median, (Min-Max)</td>
<td>1 (0 - 53)</td>
<td>1 (0 - 23)</td>
<td></td>
</tr>
<tr>
<td>Hospital admission → Initial screening</td>
<td>4.9 ± 8.6 d</td>
<td>3.7 ± 5.7 d</td>
<td>0.02*</td>
</tr>
<tr>
<td>Median, (Min-Max)</td>
<td>2 (0 - 82)</td>
<td>1 (0 - 28)</td>
<td></td>
</tr>
<tr>
<td>Initial screening → First positive diagnosis</td>
<td>0.3 ± 1.7 d</td>
<td>1.1 ± 2.0 d</td>
<td>0.0002***</td>
</tr>
<tr>
<td>Median, (Min-Max)</td>
<td>0 (0 - 16)</td>
<td>0 (0 - 7)</td>
<td></td>
</tr>
<tr>
<td>Injury → First positive diagnosis</td>
<td>9.0 ± 16.5 d</td>
<td>5.9 ± 6.0 d</td>
<td>0.7</td>
</tr>
<tr>
<td>Median, (Min-Max)</td>
<td>4 (0 - 106)</td>
<td>3 (0 - 25)</td>
<td></td>
</tr>
<tr>
<td>First positive diagnosis → Treatment</td>
<td>-0.52 ± 4.83 d</td>
<td>0.02 ± 1.15 d</td>
<td>0.8</td>
</tr>
<tr>
<td>Median, (Min-Max)</td>
<td>0 (-30 - 8)</td>
<td>0 (-3 - 5)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: Days, d; Neuropathic Pain, NP; p<0.05 indicated by *; p<0.001 indicated by ***.

Note: First positive diagnosis here refers to the earliest diagnosis of NP either by a general clinician or an expert, where all participants included have been confirmed by an expert. The number of patients with the data required to calculate each milestone differs in each cohort and is included for reference in Table S4, Supplemental Digital Content 6, http://links.lww.com/CJP/A452.
**Figure 2**

- **Cohort 1**
  - Jul 1, 2004 to Apr 1, 2010
  - Admitted to study site
  - ≥15 years old
  - New tSCI
  - Consented for inclusion in registry

- **Cohort 2**
  - Oct 1, 2010 to Mar 31, 2012
  - Admitted to study site
  - ≥15 years old
  - New tSCI
  - Consented for inclusion in registry

- **Power calculation**
- **Random selection**

- **Cohort 1**
  - **184**
  - Data extracted from registry
  - Chart abstraction

- **Cohort 2**
  - **92**

- **Cohort 1**
  - **16**
  - Missing inpatient ASU stay

- **Cohort 2**
  - **22**
  - Missing inpatient ASU stay
  - Outdated version of screening tool

- **Cohort 1**
  - **168**

- **Cohort 2**
  - **70**
A) Incidence

% of Population with Neuropathic Pain

- Expert
- General
- Clinician

Cohort 1  Cohort 2

B) Documentation

% of Population with Documentation

- Expert
- General
- Clinician

Cohort 1  Cohort 2

*  ***
Figure 5

Incidence

Documentation

% of Population

△ Incomplete SCI  × Complete SCI

**