



Factors associated with contractures in acute spinal cord injury

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The purpose of this study was to examine the occurrence of contractures in acute SCI and clarify possible contributing factors such as early *versus* late admission, level of injury, completeness of the lesion, pressure ulcers, spasticity, co-existent head injury, extremity fractures, heterotopic ossification (HO), peripheral nerve injury, and shoulder pain. The records of all patients ($n=482$) admitted between 1990 and 1995 with acute SCI to a model SCI system were reviewed. Of 482 patients 44 (9%) (33 male, 11 female) developed contractures during their initial hospitalization. There were 30 tetraplegic and 14 paraplegic patients. Thirty-four patients had complete and 10 patients had incomplete lesions. The percentage of occurrence of contractures among patients admitted to the model system on the day of injury was 7.6% and among those admitted between 2 and 60 days of the injury was 15% ($P=0.05$). Patients with a pressure ulcer (14.1%) were significantly more likely to have a contracture than patients without a pressure ulcer (7.1%) ($P=0.05$). Contractures were also more common in patients with spasticity requiring medication; 12.7% of patients with spasticity compared to 7.8% without spasticity, had contractures ($P>0.05$). Patients with a co-existent or suspected head injury (15%) were more likely to have contractures than patients without it (7.4%) ($P<0.05$). Eighteen patients with a contracture had HO, extremity fracture, peripheral nerve injury or reflex sympathetic dystrophy. In conclusion, this study is one of the first to demonstrate a significant association of contractures in acute SCI with pressure ulcers and co-existent head injury and reaffirms the importance of early admission to a coordinated SCI center in the prevention of contractures.

Keywords: spinal cord injury; paraplegia; tetraplegia; contractures

Introduction

The development of contractures in patients with spinal cord injury (SCI) has been recognized but not well studied. Their occurrence in SCI patients can be an important physical factor delaying rehabilitation and may hamper dressing, seating, transfers, and interfere with nursing care. In a recent study it was shown that tetraplegic patients at the sixth cervical level who otherwise would be independent with regard to transfer skills and mobility in bed, a flexion contracture of the elbow approximately 25 degrees or more resulted in the loss of a functional level and rendered the patient as dependent as one who has tetraplegia at fifth cervical level.¹ Few data exist on the incidence of contractures in SCI and the factors related to contracture development have not been adequately clarified. We think an increased awareness of possible causes of contractures in SCI will help to decrease their occurrence. We had two main hypotheses: (1) Patients admitted to a Model SCI System within 24 h of SCI are less likely to develop

contractures than patients admitted between 24 h and 60 days of the injury. Eighty percent of acute SCI patients in this system are admitted within 24 h of the injury; (2) Patients with a pressure ulcer are more likely to develop contractures than patients without a pressure ulcer during the initial hospital stay. Other factors such as spasticity, co-existent head injury, shoulder pain, heterotopic ossification, extremity fracture, and peripheral nerve injury which could be related to contracture development were also identified.

Methods

The records of all patients ($n=482$) admitted between 1990 and 1995 with acute SCI to the University of Washington's Northwest Regional SCI System, Seattle, WA were reviewed. The frequency of contractures during the initial hospital stay were then determined. We also performed chart reviews of patients who had contractures in order to have more data about the location of contractures and the presence of shoulder pain especially in tetraplegic patients. For patients entered into the SCI database contracture was defined

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as a 'reduction in joint range of motion severe enough to have warranted or recommended specific stretching exercises' which usually also involves 'treatment with physical agents (eg cold, heat, etc), splinting or surgery' and which precludes 'functional ability consistent with the level of injury'.² Information regarding the admission time to the system, level of injury, and the completeness of the lesion was recorded. Finally, the percentage of patients with pressure ulcers, spasticity, co-existent head injury, heterotopic ossification (HO) and fracture were determined. The patients were grouped by early (<24 h of SCI) versus late (between 24 h and 60 days of SCI) admission, tetraplegia versus paraplegia, and ASIA grade of impairment. The rates of occurrence of contractures were then compared in each group. Similar analyses were performed when the patients were grouped by the presence of pressure ulcer, spasticity, or co-existent head injury. The statistical analyses of the results were made by applying Fisher's exact test for proportion comparisons and the level of significance was set at $P \leq 0.05$.

Results

Of 482 patients 44 (9%) developed contractures. There were 33 male and 11 female patients. Mean age was 37 ± 15 years. There were 30 patients with tetraplegia and 14 patients with paraplegia. Four tetraplegic patients had central cord syndrome. Table 1 shows the occurrence of contractures for the patients grouped by level of SCI, ASIA grade of impairment, time of admission to the system, and the presence of spasticity,

Table 1 Occurrence of contractures for patients grouped by certain variables

Characteristics	Total number of patients	Patients with contractures, n (%)
Paraplegia	256	14 (5.5)
Tetraplegic	226	30 (13.3)
ASIA Grade A, B, or C	362	34 (9.4)
ASIA Grade D	120	10 (8.3)
Early admission	382	29 (7.6)
Late admission	100	15 (15)
With spasticity	134	17 (12.7)
Without spasticity	347	27 (7.8)
With pressure ulcer	142	20 (14.1)
Without pressure ulcer	337	24 (7.1)
With head injury	139	21 (15.1)
Without head injury	309	23 (7.4)
With HO	13	8 (61.5)
Without HO	463	36 (7.8)
With extremity fracture	140	9 (6.4)
Without extremity fracture	333	35 (10.5)

In our system data ($n=482$) information about the presence of HO, co-existent head injury, extremity fracture, spasticity, and pressure ulcer was incomplete in 1%, 7%, 2%, 1% and 1% of the patients, respectively

pressure ulcer, HO, extremity fracture, and co-existent head injury.

Tetraplegic patients (13.3%, 30/226) had a significantly increased occurrence of contractures when compared with paraplegic patients (5.5%, 14/256) ($P < 0.01$). We were not able to define the location of contractures in four paraplegic and in five tetraplegic patients due the limitations of previous form of SCI database which only dealt with the presence of contracture but did not report the site of contracture. Of 10 paraplegic patients whose locations of contractures were defined five had upper extremity contractures whereas three patients had contractures in their lower extremities and two patients had contractures both in upper and lower extremities. Twenty-one tetraplegic patients had upper extremity involvement. Four patients with tetraplegia had contractures both in their upper and lower extremities. Shoulders were the most commonly affected joints in patients with tetraplegia and 47.8% (11/23) of these patients also had shoulder pain. Patients who had complete SCI showed no significant difference in contracture incidence compared to the patients who had incomplete SCI.

The percentage of patients with contractures was 7.6% (29/382) among patients who were admitted to the system on the day of injury and 15% (15/100) among those admitted between 2 and 60 days of injury ($P = 0.05$).

Of 44 patients, with a contracture 20 had a pressure ulcer. A total number of 34 pressure ulcers that were mostly Grade I or II developed in these patients. Only two patients had Grade III to Grade IV sacral ulcers that required myocutaneous flap closure. In the whole system, patients with a pressure ulcer (14.1%, 20/142) were significantly more likely to have a contracture than patients without a pressure ulcer (7.1%, 24/337) ($P = 0.05$). Although contractures were more common among patients who had spasticity requiring medication than the patients without spasticity the difference between two groups did not reach statistical significance. Contractures were found in 12.7% (17/134) of patients with spasticity requiring medication compared to 7.8% (27/347) of patients without spasticity ($P > 0.05$).

Twenty-one patients in our study group had documented or suspected head injury as defined by the SCI database.³ Seven patients had contusion or concussion, two had subarachnoid, subdural, or extradural hemorrhage, two had intracranial injury, and two had anoxic brain injury. Eight patients had suspected head injury but did not have any reported imaging findings. We found that patients with a co-existent or suspected head injury were significantly more likely to have contractures (15.1%, 21/139) than patients without it (7.4%, 23/309) ($P < 0.05$).

Eighteen patients with a contracture had HO, extremity fracture, peripheral nerve injury or reflex sympathetic dystrophy. There were eight patients (five paraplegic, three tetraplegic) with HO at discharge.

Three of five paraplegic patients who had HO also had either extremity fracture or co-existent head injury. Nine patients were found to have extremity fracture at the time of SCI and six of these patients were paraplegics who had multiple upper and lower extremity fractures.

Discussion

The analyses of contractures among patients with acute SCI has previously received little attention in the medical literature. Yarkony *et al.* studied the incidence of contractures in patients treated acutely in a spinal cord center *versus* general hospitals.⁴ Normal range of motion was found in 78% of joints in center patients compared to 68% in non-center patients ($P < 0.05$).⁴ Our data showed that the occurrence of contractures among early admitted patients to the system was significantly less than the patients admitted late to the system, reaffirming both the above study⁴ and the results from the National Database of SCI Model Systems.⁵ Thus, our study reemphasizes the importance of early admission of SCI patients to a coordinated spinal cord injury center. The incidence of contractures during initial hospitalization in the National Database was 4.5%,⁵ lower than our data which is 9%. Because the National Database definition for contracture is based on clinical judgment rather than routine measurement of joint range of motion there might be variations among reported rates from individual centers.

Patients with tetraplegia had a higher rate of contractures than those with paraplegia, reflecting the greater number of limbs with weakness in tetraplegia, a finding which was cited before.^{4,5} In the National Database, a significantly lower proportion of persons classified as having ASIA grade D injury had contractures by discharge when compared with those classified as having ASIA grade A, B or C injuries but this difference was no longer present at the first year follow-up.⁵ We did not find any significant differences at discharge between patients based on the completeness of the spinal cord lesion.

The results of this study provided the evidence that the development of contractures in patients with SCI could be associated with different complications occurring due to the injury itself as well as with the other concomitant traumas at the time of SCI. Pressure ulcers are one of the major complications of SCI. We found that patients with a pressure ulcer were more likely to have a contracture than patients without a pressure ulcer. Although we were not able to define which one preceded the other complication, these two important complications of SCI seem to have an impact on each other not only in the chronic periods but also in the acute stage of injury.

Spasticity, which is a phenomenon of pathologically increased muscle tone and hyperactive reflexes mediated by the loss of upper motor neuron inhibitory control, hastens the development of contractures by leaving the muscle groups in predominantly shortened positions.

Stiffness occurs more quickly if the joint is surrounded by edema. Spastic muscles, with their increase in muscle tone often cause fixed positioning of the limbs which could result in formation of contractures especially if the limb is allowed to remain fixed in that position without undergoing mobilization.^{6,7} In this study, of 44 patients with a contracture 17 had spasticity requiring medication. This proportion seems to be low but these results reflect spasticity during the initial hospital stay. Spasticity has a contribution to the contracture development but is not the sole cause of contracture. We expect increased rates of spasticity and more severe spasticity among patients with contractures at follow-up periods.

Although the accurate data for the concomitant occurrence of SCI and head injury depend on the use of selection criteria and definitions, published reports suggest that approximately half of patients with SCI have sustained head injury at the time of SCI with a range of between 13% and 58%.⁸ The incidence of concomitant SCI and head injury in this system is 31%. In our study, a significantly higher proportion of patients with co-existent or suspected head injury developed contractures when compared with the patients who did not have head injury. The higher rate of contractures found in our study in patients with concomitant head injury could be partly attributed to the observation that these patients also had other multiple injuries that prolonged their acute length of stay before being transferred to the rehabilitation unit. Life saving measures could have detracted from the management of musculoskeletal complications. The patients who have even subtle cognitive deficits might have shown less compliance with therapy for the prevention and the treatment of contractures.

Seventeen patients with a contracture had HO, extremity fracture, or peripheral nerve injury. One tetraplegic patient had reflex sympathetic dystrophy. The incidence of HO in patients with new SCI has been reported to range from 16% to 53% and of those that develop HO, 18% to 37% have a significant range of motion limitation that can interfere with activities of daily living.⁹ In our study, eight of 13 (61.5%) patients with HO had a range of motion limitation. The definition of HO by the SCI database requires documentation by X-ray or bone scan with the restriction of hip and/or knee flexion to less than 90°.¹⁰ This definition might account for the low incidence of HO with high incidence of motion restriction, in this Model SCI system.

Six of nine patients who had extremity fracture were paraplegic patients and the fractures were mostly in the upper extremities. We think that paraplegic patients who had multiple trauma should receive special attention for the prevention of contractures and other musculoskeletal problems.

Frequency of shoulder pain and contractures in the acute phase of SCI among tetraplegic patients were striking that eleven of the 23 (47.8%) tetraplegic patients who had contractures in their shoulders also

had shoulder pain. Shoulder pain, as high as 75% has been reported in acute tetraplegia.^{11,12} Waring *et al.* reported that over half of the patients with shoulder pain developed it within 2 weeks of their spinal injury and delay in initiation of shoulder range of motion exercises beyond 2 weeks post-injury was found to be a significant factor for shoulder pain.¹¹ In the same study, occurrence of loss of shoulder motion with or after the onset of shoulder pain had been documented and potential cycle of pain, inhibition of motion causing loss of motion, and more pain was suggested.¹¹ Scott and Donovan reported that prolonged positioning of the shoulder in 90° of abduction, combined with other positioning techniques, decreases the frequency and the severity of shoulder pain and loss of motion.¹³

There is probably no single reason or predominant etiology to explain all cases of contractures during the initial rehabilitation stay but acute SCI patients with pressure ulcers, co-existent head injury, and patients who are admitted late to the SCI Model Systems should receive special consideration for contracture prevention interventions as our results are evident of increased risk of contracture development for these patients.

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