A retrospective review of lower extremity fracture care in patients with spinal cord injury

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Context/Objective: To identify circumstances surrounding incident lower extremity fractures (ILEFs) in patients with spinal cord injury (SCI) and to describe the impact of these fractures on service needs and provision of pharmacological therapies for osteoporosis.

Design: Retrospective medical record review.

Setting: Four Veterans Affairs Medical Centers in the USA.

Participants: One hundred and forty patients with traumatic SCI who sustained an ILEF from 2002 to 2007.

Outcome measures: Fracture circumstances and use of assistive devices were described using percentages, means, and standard deviations. Fisher's exact test was used to determine the relationship between fracture site, and patient age and duration of SCI. Differences in pharmacological provision of therapies for osteoporosis pre- and post-fracture were examined using exact McNemar's test.

Results: One hundred and fifty-five ILEFs were identified in 140 patients. Tibia/fibula and femur fractures were the most common fractures. Fracture site was not related to patient's age or duration of SCI. Almost one-third of all fractures occurred during transfers to and from wheelchairs. Post-fracture, the provision of new or modified assistive devices, primarily wheelchairs, was frequent, occurring in 83% of patients in the year post-fracture. Few patients transferred residence to a nursing home following the fracture. There was a significant difference in the use of pharmacological therapies for osteoporosis in the first year post-fracture compared with the year prior to the fracture ($P < 0.01$), with significant differences in the volume of prescriptions for calcium supplements ($P < 0.01$) and bisphosphonates ($P = 0.02$). Overall, the amount of prescriptions for osteoporosis increased the year post-fracture (56%) from the year pre-fracture (39%); this increase was secondary to increases in prescriptions for calcium supplements (pre = 13%; post = 30%) and bisphosphonates (pre = 2%; post = 7%).

Conclusions: We have identified that wheelchair and other transfer activities are a key area that could be a focus of fracture prevention in SCI. The need for new or modified assistive devices and/or wheelchair skills retraining post-fracture should be anticipated. Examination of whether treatments for osteoporosis following a fracture can prevent future osteoporotic fractures is warranted.

Keywords: Lower extremity fractures, Spinal cord injury, Wheelchairs, Osteoporosis therapies

Introduction

In the USA, between 225 000 and 296 000 persons are living with a traumatic spinal cord injury (SCI), and more than 10% receive their care within the Veterans Health Administration (VHA) system.¹ However, there is little information concerning fracture circumstances

and their impact in this population. Therefore, our primary study objectives were to utilize a detailed case series report to identify the circumstances under which lower extremity fractures occurred, to identify whether these fractures were associated with new equipment needs, changes in patient residence, or provision of pharmacological therapies for osteoporosis. Our secondary, exploratory objective was to describe dual energy X-ray absorptiometry (DXA) utilization for bone

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mineral density testing (BMD) in the 1 year prior to and following the incident fracture.

Methods

Characteristics of study population

We conducted a chart review of all patients with a traumatic SCI of at least 2 years' duration with incident lower extremity fractures (ILEFs) identified at three VA SCI centers (Hines, Memphis, and Puget Sound) and one large SCI clinic (Durham) contained in the Veterans Affairs Spinal Cord Dysfunction (SCD) Registry from 2002 to 2007 (Fig. 1). This duration of SCI was chosen based on the pathophysiology of osteoporosis in SCI, in which a new steady state between bone formation and resorption is re-established approximately 2 years after SCI.¹ Fractures were defined using *International Statistical Classification of Diseases, 9th revision* codes (ICD-9) for fractures of the lower extremity including: femoral neck (820.xx), pelvis (808.xx), femur (820.xx, 821.xx), patella (822.xx), and tibia/fibula (823.xx) over the study time period. A fracture was considered incident if there were no encounters with the same three-digit ICD-9 codes within a 120-day time period prior to the identified fracture.²

Clinicians and/or study nurses experienced in performing chart reviews in SCI performed detailed reviews of these electronic medical records. Age, race, sex, duration of SCI, body mass index (BMI), smoking and alcohol-use status, and prior history of fractures (since SCI) were obtained. All information

was obtained from the date in the chart in which data were available in the 1-year time period closest to the incident fracture.

Fracture circumstances

The circumstances surrounding the fracture were noted, including whether this occurred during a motor vehicle collision (MVC), while walking, transferring (not using a wheelchair), using a wheelchair (including transfers), bathing/showering, toileting, while using a chair other than wheelchair, while in bed, or other circumstances. If the fracture mechanism was unknown or was not indicated in the medical record, it was coded as circumstances unknown. How often the fracture was discovered incidentally during care for another condition was also recorded.

Changes in residence and equipment needs following fracture

Patient residence (home without home healthcare, home with home healthcare services, assisted living facility, nursing home, or unknown) pre- and post-fracture was recorded. Among those who did not have a change in residence post-fracture, we recorded the frequency in which additional assistance was required in the year following the fracture. The need for additional assistance was considered present if there was documentation in the chart that there was increased assistance needed from family and/or non-traditional caregivers, absent if there was specific documentation that increased

Figure 1 CONSORT diagram

assistance was not needed, and not known if there was no notation on this. The provision of new or modified equipment following the fracture, and the type of equipment required, were recorded.

Treatment with pharmacological therapies to prevent future fractures

In the 1-year time period prior to and following the fracture, how often a prescription for osteoporosis was given including calcium or vitamin D supplements, bisphosphonates, calcitonin, or teriparatide was recorded.

BMD measurements by DXA

In the 1-year time period prior to and following the fracture, the frequency of BMD testing by DXA was recorded.

Statistical analyses

Descriptive statistics are reported. Fisher's exact test was used to determine the relationship between fracture site, and patient age and duration of SCI. Exact McNemar's test³ was performed to determine differences in pharmacological provision of therapies for osteoporosis pre- and post-fracture. Final assessment of pre-/post-differences of various pharmacological therapies was evaluated via Bonferroni-adjusted significance levels.

The unit of analysis was the patient for all data. Some categories do not add up to 100% because the categories were not mutually exclusive.

This research study was reviewed and approved by the Institutional Review Boards of the four VA facilities, in which the chart reviews were conducted.

Results

Demographic and clinical characteristics of study population

One hundred fifty-five ILEFs occurring in 140 patients were identified during the time period of this study. The mean age of the study population for the case series was 57 years, and the mean duration of SCI was 26 years. The majority were Caucasian males, past smokers, and current alcohol users with a normal BMI or overweight. More than one-third had a prior history of a fracture. Approximately two-thirds of the patients had paraplegia and more than half had a complete SCI (Table 1).

The relationship of fracture to patient age and duration of SCI in quartiles is shown in Table 2. Exact duration of SCI was not available in 21 patients. There was no significant relationship between fracture location and patient age or duration of SCI.

Table 1 Descriptive characteristics of study population (*n* = 140)

Characteristic	Mean $\pm$ SD; absolute number (%)
Age (years)	56.5 $\pm$ 11.8
Duration of injury (years) (range 2.4–60.3)	25.5 $\pm$ 60.3
Race	
African American	26 (18.6%)
Caucasian	93 (66.4%)
Asian	1 (0.7%)
Hispanic	1 (0.7%)
Unknown	19 (13.6%)
Sex	
Female	2 (1.4%)
Male	137 (97.9%)
Unknown	1 (0.7%)
BMI	
Underweight (<18.5)	8 (5.7%)
Normal (18.5–24.99)	47 (33.6%)
Overweight (25–29.99)	44 (31.4%)
Obese (>30)	35 (25.0%)
Unknown	6 (4.3%)
Cigarette smoking status	
Current	38 (27.1%)
Past	50 (35.7%)
Never	37 (26.4%)
Unknown	15 (10.7%)
Alcohol use	
Current	49 (35.0%)
Past	41 (29.3%)
Never	38 (27.1%)
Unknown	12 (8.6%)
History of prior fracture	
Yes	47 (33.6%)
No	64 (45.7%)
Unknown	29 (20.7%)
Completeness of SCI	
Complete	71 (50.7%)
Incomplete	57 (40.7%)
Unknown	12 (8.6%)
SCI level	
Paraplegia	94 (67.1%)
Tetraplegia	43 (30.7%)
Unknown	3 (2.1%)
Ambulatory status	
Ambulatory	2 (1.4%)
Not ambulatory	138 (98.6%)

Fracture location

The majority of fractures occurred in the tibia/fibula (*n* = 83) (54%) or femur (*n* = 52) (33%). Most patients (92%) had a single lower extremity fracture site, 10 had two lower extremity fracture sites, and 1 patient had three lower extremity fracture sites. Seven fractures were bilateral, approximately one-third (*n* = 55) were comminuted, and two fractures were open.

Fracture circumstances

Fracture location by circumstance under which the fracture occurred is provided in Table 3. There were 188 circumstances for fractures identified, indicating that for some patients, multiple circumstances

Table 2 Fracture location by age and duration of spinal cord injury

Patients with fractures (n = 140) Quartiles	Lower extremity fractures (#) and site (n = 155)					N
	Pelvis	Hip	Femur	Patella	Tibia/fibula	
Age (years) mean = 56.5 (SD = 11.8)						
Q ₁ = 47.2 (29.9–47.2)	0	3	12	3	21	35
Q ₂ = 55.8 (47.2–55.8)	1	1	14	1	22	35
Q ₃ = 63.8 (55.8–63.8)	0	5	9	0	24	35
Q ₄ = 87.1 (63.8–87.1)	1	5	17	0	16	35
Duration of spinal cord injury (years)* Mean = 25.5 (SD = 13.2)						
Q ₁ = 16.3 (2.4–16.6)	0	1	8	1	22	29
Q ₂ = 24.3 (16.6–24.3)	2	2	14	3	14	30
Q ₃ = 34.1 (24.3–34.1)	0	2	9	0	21	31
Q ₄ = 60.3 (34.1–60.3)	0	5	12	0	15	29

*Data were missing for 21 patients.

Table 3 Fracture location by circumstance*

Location (n = 155)	Circumstances (n = 188)									Total
	MVA	Walking	Transfer	Wheelchair	Bath/shower	Toilet	Bed	Other	Unknown	
Hip	0	2	5	6	0	2	0	5	2	14
Femur	4	0	16	23	1	1	4	10	6	52
Pelvis	0	0	0	2	0	0	0	0	0	2
Patella	0	0	0	3	0	0	0	0	1	4
Tibia/fibula	6	1	20	33	4	1	1	12	17	83
All sites	10 (5%)	3 (2%)	41 (22%)	67 (43%)	5 (3%)	4 (2%)	5 (3%)	27 (14%)	26 (14%)	

*Totals do not sum to 100% because some patients had multiple fractures and/or multiple circumstances for fractures. Column percentages represent % of total circumstances (n = 188).

contributed to the fracture. Sixty-seven fractures (43%) occurred while using a wheelchair; of these, 16 (24%) occurred during transfers into or out of the wheelchair. The circumstances for wheelchair-related fractures that did not occur during transfers included: trip or fall due to environmental hazard (n = 9); collision with object (n = 17); equipment failure (n = 5); other (n = 6); unknown (n = 14). Fractures from transfers (not while using a wheelchair) were also common, occurring in 22% of fractures. The remainder of other recorded fracture circumstances included occurrence during a MVC (5%) or while walking (2%; in the two ambulatory patients), bathing (3%), toileting (2%), in bed (3%), or other (14%). Circumstances were unknown for 14% of fractures. Alcohol or other substance abuse was implicated in a small minority (3%) of patients (not reported in table).

Seven fractures (5%) were discovered incidentally during outpatient care for another unrelated condition.

Changes in residence and equipment needs following fracture

Figs. 2A and 2B depicts patient residence at the time of fracture and at 1-year post-fracture. Four patients, who were not in a nursing home prior to the fracture, were discharged to a nursing home following the fracture.

In two patients who resided in a nursing home prior to the fracture, discharge location was unknown post-fracture. Among those who did not have a change in residence post-fracture (n = 27), 20% required additional assistance after the fracture.

Eighty-three percent of all patients received modified or new equipment post-fractures, including: 42% wheelchair modifications, 21% a new wheelchair, 19% other equipment, 2% recreational equipment modifications, 44% a lower limb brace, and 33% transfer equipment.

Provision of pharmacological therapies for osteoporosis pre- and post-fracture

Thirteen percent of the patients received calcium supplements, 33% vitamin D supplements, 2% bisphosphonates, and no one received calcitonin or teriparatide in the year prior to the fracture. In the first year post-fracture, 30% of the patients received calcium supplements, 38% vitamin D supplements, 7% bisphosphonates, and <1% (n = 1) calcitonin. No one was prescribed teriparatide in the first year post-fracture (Fig. 3). In the year post-fracture, there was a significant difference in prescriptions for pharmacological therapies for osteoporosis, compared with the year prior to the fracture (P ≤ 0.01). Usage of any pharmacological therapy for osteoporosis was greater for patients post-fracture (56%)

Figure 2 Patient residence status pre- and post-fracture

versus pre-fracture (39%). In particular, there were significant differences in prescriptions for calcium supplements ($P < 0.01$) and bisphosphonates ($P = 0.02$), but not Vitamin D supplements ($P = 0.37$) in the year post-fracture, compared with the year prior to the fracture, after excluding calcitonin and teriparatide from the calculation of the Bonferroni-corrected critical significance level. Inclusion of all five *a priori* pharmacological osteoporosis therapies in the correction resulted in a marginally significant difference for bisphosphonates at $P < 0.08$.

BMD measurements by DXA

Less than five percent of patients had BMD testing done by DXA either in the year prior to or following the fracture.

Figure 3 Prescription medications for osteoporosis pre- and post-fracture

Discussion

This case series identifies that transfers, particularly while using a wheelchair, are a principal time in which fractures occur and that there is a substantial increase in provision of new or modified assistive devices post-fracture, suggesting changing needs. Additionally, a fracture appears to trigger provision of pharmacological therapies for osteoporosis. These fractures, however, do not commonly result in nursing home placement.

In agreement with other studies,^{2,4} the most common lower extremity fracture sites in our study were the tibia/fibula followed by the femur. Older age and longer duration of SCI are risk factors for fractures in SCI.⁵ Our data extend these findings to report that fracture location is independent of age and duration of SCI.

Transfer-related activities were the most common circumstance during which lower extremity fractures occurred in these patients, with the majority of these occurring during transfers to or from a wheelchair. In agreement with this, significant increases in adverse consequences from wheelchair use have recently been reported in patients with SCI.⁶ In our study, in five patients, wheelchair equipment malfunction was a circumstance that directly led to the fracture. This underscores the importance of existing recommendations from the US Food and Drug Administration that wheelchairs should be tested using American National Standards Institute Rehabilitation Engineering and Assistive Technology Society of North American testing standards to assess performance and safety and estimate life expectancy of a wheelchair.⁷ In addition, patients should be equipped with the most appropriate wheelchair for their needs, given adequate training in safe wheelchair use, and education in the dangers involved.⁸ Regular wheelchair skill assessments and retraining (as needed) should be included as continuing care for patients with SCI.⁹ Our study extends these

recommendations^{8,9} to suggest that safe transfers from wheelchairs might be a targeted area for fracture prevention. In agreement with others,^{10,11} a wide variety of other circumstances were noted to be associated with the fractures in our study.

That the majority (83%) of patients received either modifications to an existing wheelchair or a new wheelchair following the fracture is not previously reported information. In accordance with this, significant increases in the number of SCI patients reporting wheelchair repairs since 2004–2006 have recently been reported.⁶ It may be that the high rate of new equipment needs identified in our study occurred from the fracture itself, especially since therapeutic specialists evaluated approximately half of these patients following their fracture and may have identified this need. Alternatively, the need for the additional equipment may just represent a point of contact with the healthcare system and this equipment need may have existed prior to the fracture.

In this series, fractures did not commonly lead to nursing home placement. It has been shown that discharge to the community, rather than to an extended care unit or nursing home is desirable in the SCI population.^{12–14} In fact, location of discharge is given the most significance of all possible rehabilitation outcomes by the Uniform Data System for Medical Rehabilitation.^{13,14} These data on post-discharge location in SCI following lower extremity fracture are in sharp contrast with the non-SCI population as a whole, of whom 27–58% require nursing home residence in the year following a hip fracture.^{15,16} Notably, however, the non-SCI population who have hip fractures are substantially older (mean age 83 years in women and 84 years in men)¹⁷ than the patients in our study who sustained a fracture, who had a mean age of 56 years.

In this series, very few patients had a DXA in the year prior to or after a fracture. This is in contrast with a study that included self-report of DXA use from VA providers in patients with SCI, in which more than half of providers indicated that they ordered diagnostic studies, including DXAs as part of osteoporosis assessment in SCI.¹⁸ That there was such low use of DXA in our study, may have been because there are no definite recommendations or guidelines for use of DXA in SCI. Loss of BMD in SCI is multifactorial and it remains uncertain whether DXA measurements can predict fractures in this population.^{19,20}

In agreement with a report of overall use of calcium/vitamin D supplements in SCI,²¹ approximately one-third of patients received these supplements prior to and following the fracture. Other pharmacological therapies for osteoporosis including bisphosphonates, teriparatide,

and calcitonin were rarely prescribed prior to the fracture. However, the occurrence of a fracture did appear to increase the likelihood that pharmacological therapies for osteoporosis, in particular calcium supplements and bisphosphonates, were prescribed.

This study has a number of strengths. This was a detailed review of fractures in the SCI population, in which little information currently exists, and chart reviews were performed by experienced clinicians who were familiar with the medical records and the care provided at their centers. Potential areas of intervention for future studies to prevent and manage fractures in SCI and useful information for the practicing clinician in managing fracture care in patients with SCI were identified.

Limitations

These data were obtained from chart reviews, and as such, there was a substantial amount of missing data. The ability to evaluate changes in functional status, activity, and quality of life from retrospective chart reviews is limited. Fractures of the ankle and foot were not included in this series, although these fractures do occur in SCI.¹¹ These fractures were not examined because in the population without SCI it remains controversial as to whether they are associated with osteoporosis.^{22–28} However, ankle fractures in patients with neuropathy who do not have an SCI are particularly challenging to treat and have been reported to have substantial complications²⁹; thus, we plan to include these fractures in the SCI population in future research. We reported standard BMI categories as defined in the general population (<http://www.cdc.gov/obesity/adult/defining.html>, accessed 2013 May 10). However, it is recognized that standard BMI categories underestimate body fat in men with SCI,³⁰ and that patients with SCI can experience an increase in body mass fat without a simultaneous increase in weight or BMI.^{31–33} Further, the Academy of Nutrition and Dietetics recommends as imperative that SCI-adjusted formulae should be used to calculate BMI (<http://www.guideline.gov/content.aspx?id=14889>, accessed 2013 July 19).

Doses of medications prescribed or compliance with drug therapies was not examined. There were very few patients in our series that had a DXA done, limiting our ability to draw conclusions about use of DXA, pre- and post-fracture in SCI.

Finally, our review was limited to fracture patients at four VA hospitals in the USA and may not be applicable to the SCI population as a whole. Comprehensive services that are readily available at the VHA,³⁴ may

not be obtainable in the general population where cost may limit access to diagnostic and therapeutic services. Moreover, more than one-third of Veterans with SCI/D utilizing VA services are also recipients of services under Medicare and/or Medicaid³⁵ and Medicare or Medicaid data were not included.

Conclusion

In conclusion, transfer activities to and from a wheelchair are times during which a high number of lower extremity fractures occur in patients with SCI. These fractures are associated with substantial initiation of new or additional equipment and pharmacological therapies for osteoporosis but do not result in a change of residence for the patient.

Disclaimer statements

Contributors TA, JNS, HH, SPB, and LC were directly responsible for chart review information. LC, FMW, and ASC worked with statistical analysis and SCI registry information. All authors contributed to the design, writing, and final approval of the manuscript.

Funding This work was supported by the Department of Veterans Affairs, Veterans Health Administration, Health Services Research and Development #IIR 08-033.

Conflicts of interest None.

Ethics approval The study was approved by the Veterans Affairs Institutional Review Board and principles of the Declaration of Helsinki were followed.

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