Do vascular risk factors contribute to the prevalence of pressure ulcer in veterans with spinal cord injury?

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Objective: The overall goal of this observational study was to determine whether modifiable vascular risk factors contribute to the prevalence of pressure ulcers (PrU) in veterans with traumatic spinal cord injury (SCI).
Background: Given the increasingly limited financial resources in hospitals and clinics, identifying risk factors associated with the development of PrU in persons with SCI will be a major step in reducing the cost of care for these individuals, and may improve their quality of life.
Method: We retrospectively reviewed the electronic charts of 87 veterans with SCI who are being followed regularly in our SCI clinic and are enrolled in the SCI registry. The data collected included the basic demographics, presence of modifiable vascular risk factors such as hypertension, diabetes mellitus, hyperlipidemia, and current smoking; presence of incontinence and depression; and results from blood drawn for hemoglobin level, blood urea nitrogen, creatinine, and albumin levels and lipid profile on veteran's initial enrollment. Local Institution Review Board approval was obtained for the protocol.
Results: Of the 87 veterans with SCI, 27 had PrU. Comparisons between those with and without PrU found no significant differences for the demographic variables of age, gender, age of SCI onset, or SCI duration, but there was a trend for the groups to differ in ethnicity ($P = 0.05$). Similarly, the presence of modifiable vascular risk factors including hypertension, diabetes mellitus, hyperlipidemia, and current smoking did not differ between those with and without PrU. There were 36 pressure ulcer sites observed in 27 people. The proportion of pressure ulcer sites (of the 36) significantly differed by SCI severity based on the American Spinal Injury Association (ASIA) score ($P < 0.0001$).
Conclusion: This study suggests that the presence of PrU was influenced by the severity of the SCI without any contribution from modifiable vascular risk factors.

Keywords: Spinal cord injury, Pressure ulcer, Vascular risk factors

Introduction

Pressure ulcers (PrU) are common among persons with spinal cord injury (SCI).[1] The epidemiology of PrU varies considerably in patients with SCI by clinical setting, with incidence rates ranging from 0.4 to 38% in acute care, 2.2 to 23.9% in long-term care (LTC), and 0 to 17% in home care.[2,3] The annual incidence and prevalence rates for PrU have ranged from 20 to 31% and 10.2 to 30%, respectively.[4,5] Yarkony and Heinemann[6] reported prevalence rates of 8% at the first annual evaluation following rehabilitation within a model system facility, 9% at the 2-year follow-up, and 32% at 20 years post-discharge.[6] Carlson *et al.* reported a 29% prevalence rate during acute care, 3% during rehabilitation, and 17% during follow-up.[7]

PrUs occur more often among individuals with SCI who have certain demographic characteristics such as those who are elderly,[8] male,[9,10] from racial or ethnic minority backgrounds,[10] single,[11,12] less educated,[7,8,11] and unemployed (on government subsidies).[11] Some investigators have reported the occurrence of PrU to be related to SCI associated variables such as completeness of the SCI,[8,10–13] longer duration of the SCI and being functionally dependent,[14] and impaired physical and psychosocial well-being resulting in taking less responsibility for skin care.[15] Others have found poor nutrition,[8,16] alcohol abuse,[8] and being depressed[17] to be associated with PrUs in patients with SCI. Modifiable vascular risk factors such as diabetes mellitus and smoking have been associated with PrU

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development.[17] Similarly, urinary and fecal incontinence has been reported as a significant factor in PrU development.[18]

The consequences of PrU can be significant. First, PrU has the potential to affect a patient's overall quality of life and to disrupt rehabilitation, vocational, and educational pursuits, and community reintegration.[19,20] Also, PrU can lead to increased hospital readmission rates with longer lengths of stay.[21] Further, infection risk is increased in PrU and can lead to osteomyelitis, delay re-mobilization during rehabilitation, and can cause death from septicemia. Managing a single full-thickness PrU can cost as much as $70 000, and US expenditures for treating PrU have been estimated at $11 billion per year.[21,22] The development of PrU also has legal consequences: failure to prevent PrU in LTC settings results in increased litigation, with settlements favoring LTC residents in up to 87% of cases.[23] These consequences highlight the value of preventing PrU as a cost-effective measure.[24,25]

A variety of PrU preventive strategies have been suggested, including: (i) examining skin daily to allow for early detection; (ii) minimizing moisture and incontinence and keeping skin clean and dry; (iii) regular pressure relief every 15–30 minutes by performing a lateral bend, forward lean, or vertical push-up[19,22]; (iv) having an individually prescribed wheelchair with a pressure redistribution cushion, and a power or manual tilt/recline feature if manual pressure relief is not possible[19]; (v) ensuring that all equipment is functioning properly; (vi) decreasing/stop smoking and limiting alcohol consumption; and (vii) eating a well-balanced, nutritionally complete diet with monitoring of weight to prevent undesirable weight gain.[22,26] Additionally, persons with SCI and their caregivers need to be taught the importance of maintaining a healthy skin regimen to prevent PrU and its consequences.[22,27,28]

Because PrU is a major complication of SCI and has a significant effect on general health and quality of life, we examined whether modifiable vascular risk factors contribute to the prevalence of PrU. Reducing the prevalence of PrU among veterans with SCI will help improve the quality of life of SCI-affected veterans and may also have a significant impact on the Department of Veterans Affairs' financial and social resources.

Method

Participants and procedure

A total of 87 patients with traumatic SCI were identified based on retrospective review of the electronic medical records of veterans enrolled in the Spinal Cord Registry of a tertiary care Veterans Affairs Medical Center (VAMC), during the 5-year study period (January 1, 2005 to December 31, 2009). Local Institutional Review Board for Human Subjects Research and local Veterans Affairs Research and Development Committee approval was obtained for the study.

Demographic information retrospectively collected on review of the electronic charts included the following: age, race, ethnicity, and SCI descriptors including level of injury, completeness of the injury as determined by the American Spinal Injury Association (ASIA) Impairment Scale,[29] etiology (e.g. motor vehicle crash, gunshot wound, fall, diving accidents, etc.), age at onset, and time since onset of the SCI; and presence or absence of depression and urinary and fecal incontinence. Modifiable vascular risk factors studied were hypertension, hyperlipidemia, diabetes mellitus, body mass index (BMI), and current smoking. Results of patient's hemoglobin level, renal function (blood urea nitrogen and creatinine); and albumin level and lipid profile obtained on the patient's initial and yearly evaluations were also collected. Hypertension was defined as self-reported history of hypertension, use of antihypertensive medications, or blood pressure $\geq$140/90 mmHg based on the Seventh Report of Joint National Committee (JNC VII).[30] Diabetes mellitus was defined as self-reported history of diabetes mellitus, use of oral hypoglycemic agents or insulin or random plasma glucose level of $\geq$140 mg/dl. Hyperlipidemia was defined by use of lipid lowering medications or serum total cholesterol level $\geq$200 mg/dl, serum low-density lipoprotein (LDL) level of $>$135 mg/dl, and serum high-density lipoprotein (HDL) level of $<$35 mg/dl based on the National Cholesterol Education Program Adult Treatment Panel III (ATP III) criteria.[31]

Prevalence was defined as the number of PrU cases that occurred in this SCI population within a specific period of time.[32] In this study, prevalence was based on the number of persons who visited the VAMC SCI outpatient clinic for the treatment of PrU in the years January 1, 2005 to December 31, 2009 inclusive. PrU severity was defined as Stage I–IV at initial assessment.[21] If a patient had multiple PrUs, all PrUs were recorded but the severest ulcer was tracked.

Statistical analysis

Data were analyzed using SAS (SAS System for Windows, version 9.1, SAS Institute Inc., Cary, NC,

USA). Data are expressed as mean ± SD when normally distributed and median (interquartile range) when not normally distributed (Table 1). Interval data were compared between groups (with/without PrU) using a two-tailed Student's *t*-test (BMI, HDL, hemoglobin, blood urea, and creatinine) or the Wilcoxon–Mann–Whitney test (age, age of onset, years since injury, total cholesterol, LDL, triglycerides, and albumin) according to normality of distribution; categorical data were compared using the chi-square or Fisher's exact test when appropriate. Severity of SCI in relation to PrU site and severity was examined using Fisher's exact test. Multiple logistic regression analysis looked at those variables found to be significant predictors for PrU development. Significance level was set at $P < 0.05$ for all analyses.

Results

In this retrospective chart-review study, 31% of the veterans on the SCI Registry at VAMC who had traumatic SCI were treated for a PrU during the 5-year

Table 1 Variables between the two patient groups based on presence or absence of PrU (*n*, mean ± SD, or median (IQR) as appropriate)

Grouping variables	Total population ($n = 87$)	PrU ($n = 27$)	No PrU ($n = 60$)	*P*
Age (years)	60.0 (11.0)	60.0 (7.0)	59.0 (11.5)	0.38*
Sex (M:F)	85:2	27:0	58:2	0.47†
Ethnicity (white/black/Amer. Indian)	72:11:3	20:3:3	52:8:0	0.05†
Age at onset of SCI (years)	32.0 (24.0)	32.0 (28.0)	31.5 (20.5)	0.55*
Duration since SCI (years)	24.0 (26.0)	23.0 (28.)	24.5 (23.0)	0.96*
Spinal injury level				0.11‡
Cervical	44	12 (44%)	32 (53%)	
Thoracic	33	14 (52%)	19 (32%)	
Lumbosacral	10	1 (4%)	9 (15%)	
ASIA				<0.0001‡
A	32	18 (67%)	14 (23%)	
B	12	5 (19%)	7 (12%)	
C	21	4 (15%)	17 (28%)	
D	19	0	19 (32%)	
E	3	0	3 (5%)	
Etiology of SCI				0.01†
Motor vehicle accident	37	14 (52%)	23 (38%)	
Gunshot	12	5 (19%)	7 (12%)	
Fall	21	4 (15%)	17 (28%)	
Diving	4	3 (11%)	1 (2%)	
Other	12	0	12 (20%)	
Risk factors				
Hypertension ($n = 85$)	43	11 (41%)	32 (53%)	0.31‡
Diabetes mellitus ($n = 86$)	22	7 (26%)	15 (25%)	0.85‡
Hyperlipidemia ($n = 76$)	45	12 (44%)	33 (55%)	0.60‡
BMI	27.1 ± 12.0	25.7 ± 7.9	27.8 ± 7.0	0.23§
Current smoker ($n = 86$)	37	11 (41%)	26 (43%)	0.93‡
Depression ($n = 86$)	41	14 (52%)	27 (45%)	0.45‡
Incontinence ($n = 68$)	7	1 (4%)	6 (10%)	0.99†
Constipation ($n = 78$)	49	15 (56%)	34 (57%)	0.61‡
Osteomyelitis	9	8 (30%)	1 (2%)	<0.0001†
Biochemical				
Albumin (3.3–4.8 g/dl)	3.7 (0.7)	3.0 (0.9)	3.8 (0.4)	<0.0001*
Hemoglobin (13–17 g/dl)	13.2 ± 2.1	11.8 ± 1.9	13.8 ± 1.8	<0.0001§
Blood urea (6–24 mg/dl)	13.1 ± 5.5	13.4 ± 6.1	12.9 ± 5.2	0.67§
Creatinine (0.6–1.2 mg/dl)	0.9 ± 0.3	0.8 ± 0.3	0.9 ± 0.2	0.02§
Total cholesterol (120–200 mg/dl)	157.0 (46.0)	154.0 (48.0)	160.0 (43.0)	0.29*
LDL (80–130 mg/dl)	99.0 (46.0)	99.0 (50.0)	99.0 (44.0)	0.54*
HDL (35–70 mg/dl)	37.0 ± 10.3	33.6 ± 9.8	38.6 ± 10.2	0.04§
Triglyceride (30–200 mg/dl)	127.0 (72.0)	104.0 (74.0)	134.0 (82.0)	0.07*
Discharge disposition				0.32‡
Home	78	23 (85%)	55 (92%)	
Nursing home	5	3 (11%)	2 (3%)	
Homeless	1	0	1 (2%)	
Deceased	3	1 (4%)	2 (3%)	0.99†
Power mobility	34	15 (56%)	19 (32%)	0.03‡

* = Wilcoxon–Mann–Whitney test.
† = Fisher's exact test.
‡ = Chi-square.
§ = Student's *t*-test.

study period. Table 1 presents the baseline demographics of our study sample ($n = 87$) for the two groups defined by the presence ($n = 27$) or absence ($n = 60$) of PrU. No significant differences were noted between the two groups for age, gender, age of onset, duration of insult, or level of injury. There was a trend for the groups to differ in ethnicity ($P = 0.05$) with American Indians having greater odds of PrUs.

No significant differences were noted between the two groups for modifiable vascular risk factors such as hypertension, diabetes mellitus, smoking, hyperlipidemia, and obesity (as per BMI). Veterans at the time of their initial PrU diagnosis were found to have low hemoglobin (anemic), albumin (hypo-albuminemic), and creatinine levels ($P < 0.05$). Multiple logistic regression suggested albumin level to be a significant predictor of the presence of PrU, $P = 0.012$, while hemoglobin did not reach statistical significance, $P = 0.08$.

Almost 50.5% of the patients in the registry had a motor complete SCI injury (ASIA A and B), indicating the absence of motor function below the injury level, including the sacral segments S4–S5 and absence of volitional contraction of the rectal sphincter. Approximately half (52%) of these patients had PrU. The individual PrU sites did not differ significantly among the ASIA groups (A, B, and C as seen in Table 2). However, collectively, the proportion of pressure ulcer sites (of the 36) differed significantly by ASIA score A = 64%, B = 25%, and C = 11% ($P < 0.0001$). Overall Stage IV ulcers were the most prevalent PrU (Table 3). Most of the Stage IV PrUs were in ASIA A and B groups, none in the ASIA D and E groups, and a few in ASIA C group. All of the Stage IV PrUs were in patients who had sustained SCI because of motor vehicle and diving accidents rather than because of falls. Note that

Table 2 PrU site relative to severity of SCI

Patients (*n*)	Total (26)	ASIA*			*P*
		A (17)	B (5)	C (4)	
Site†					
Ankle	2	0	1	1	0.11
Foot	2	2	0	0	0.99
Heel	5	3	2	0	0.47
Ischium	15	11	2	2	0.62
Legs	1	1	0	0	0.99
Sacrum	7	4	2	1	0.81
Trochanter	2	1	1	0	0.58
Hip	2	1	1	0	0.58
Total sites	36	23	9	4	

*No one with PrU had ASIA score of D or E.
†Individuals may have had more than one pressure ulcer site.
Total number of PrUs was 36 in 26 patients.
Fisher's exact test was used for all *P* values.

Table 3 PrU stage relative to severity of SCI

Patients (*n*)	Total (26)	ASIA*			*P*
		A (17)	B (5)	C (4)	
Stage					0.38
1	1	0	0	1	
2	3	2	0	1	
3	2	1	1	0	
4	16	10	4	2	
Total number of PrUs	22	13	5	4	

56% of PrU patients used power mobility compared to non-PrU patients ($P = 0.03$). This higher use of power mobility indicates the severity of SCI sustained necessitating the use of power mobility to help achieve their independence.

Of the 27 SCI patients with PrU, 14 needed hospitalization for their PrU management (52%), while the remaining 12 patients were managed on an out-patient basis (44%). The mean duration of the in-patient stay was 15 days (range 3–28 days). Osteomyelitis was present in 8 out of 27 (30%) patients with PrU.

Discussion

In this study, PrU was present in 31% of the sample during the 5-year study period. Similar findings have been reported by Smith *et al.*[17] and Garber and Rintala,[33] who found PrU in 36% of their mail-based survey and 39% of 553 veterans in the Houston VA SCI registry over a 3-year period. Age of SCI onset, SCI duration, presence of depression, and fecal/urinary incontinence showed no significant association with the presence or development of PrU, similar to the findings of Salzberg *et al.*,[34] Mawson *et al.*,[35] and Rodriguez and Garber.[36] Smith *et al.*[17] found diabetes mellitus, smoking, and depression to influence PrU development. This was not borne out in our study. One main difference between the two studies is that the study by Smith was a mail-based survey with a 31% response rate and therefore influenced by patient self-report, whereas our study was based on regular (tri-monthly) face-to-face follow-up in the SCI clinic. Veterans with SCI on presentation with PrUs were found to be anemic, hypoalbuminemic and had low muscle mass (low serum creatinine). All of these factors were associated with having a PrU; it is not known whether they increase the risk of having a PrU or are a result of PrU. The low hemoglobin, albumin, and creatinine levels were not related to the severity of motor injury (ASIA level). In our study, American Indians had greater odds of developing PrUs; similar were the findings of Saladin *et al.* in their study of PrU prevalence in patients with SCI.[37]

The PrU presence was most associated with the severity of the injury (SCI ASIA levels A and B). Similar findings have been reported by both Curry and Casady[13] and Thiyagarajan and Silver[12] in their studies. This is due to the increased immobilization (from absent motor function) and lack of sensory feedback promotes development of PU. Veterans with the severest injury (ASIA A and B) frequently had the severest PrU (Stage IV) in our study. This severity of injury was reflected by the increased use of power mobility (56%) to help achieve their independence.

The National Pressure Ulcer Advisory panel considers PrU incidence a prime indication for quality of care in health care institutions.[38] Based on the findings of our study, we have instituted a protocol aimed at PrU prevention at our institution and it consists of: (a) educating the veteran and care-giver to maintain a healthy skin regimen, (b) initiating a dietary consult, and (c) ordering blood checks of hemoglobin, albumin, urea, and creatinine levels during their 3-month follow-up irrespective of the presence of PrU, especially in severely injured SCI patients.

The present results should be interpreted in light of a number of limitations. First, this study is limited to the veteran population and thus it is difficult to generalize to the general population. This is unavoidable as the population of veterans from which the sample was drawn is predominantly comprised of men who happen to be heavy smokers, but have easy access to quality care (our study had only two women). Second, the sample size is rather small and may preclude detecting important differences between groups. Finally, the data were not collected about prior presence of PrU. Presence of prior PrU has been found to be an important predictor of PU recurrence.[39] Despite these limitations, the completeness of the data captured by the standardized SCI registry on their regular 3-month follow-ups provides a rich dataset for better understanding PrU in the veteran population with SCI.

Conclusion

Our study suggests the following: (1) The PrU presence in patients with SCI is influenced by severity of the injury, especially ASIA levels A and B. (2) Modifiable vascular risk factors were not related to the prevalence of PrU presence in veterans with SCI. (3) Patients with poor nutrition status (as evidenced by low albumin levels) are more prone to PrU development irrespective of the severity of the injury. This argues for further prospective study of factors likely to be causal in the development of pressure ulcer. This study emphasizes the need to continue educating patients with SCI about the importance of effective regular healthy skin care and to pay attention to their hydration and nutritional status in preventing PrU development.

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