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ORIGINAL ARTICLE

A Study of the Factors Associated with Risk for Development of Pressure Ulcers: A Longitudinal Analysis

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Abstract

Background: Pressure ulcers (PUs) are prevalent in hospitalized patients; they may cause clinical, psychological, and economic problems in these patients. Previous studies are cross-sectional, have used pooled data, or cox-regression models to assess the risk for developing PU. However, PU risk scores change over time and models that account for time varying variables are useful for cohort analysis of data. **Aims and Objectives:** The present longitudinal study was conducted to compare the risk of PU between surgical and nonsurgical patients, and to evaluate the factors associated with the development of these ulcers over a period of time. **Materials and Methods:** We evaluated 290 hospitalized patients over a 4 months period. The main outcomes for our analysis were: (1) Score on the pressure risk assessment scale; and (2) the proportion of individuals who were at severe risk for developing PUs. We used random effects models for longitudinal analysis of the data. **Results:** The mean PU score was significantly higher in the nonsurgical patients compared with surgical patients at baseline (15.23 [3.86] vs. 9.33 [4.57]; $P < 0.01$). About 7% of the total patients had a score of >20 at baseline and were considered as being at high-risk for PU; the proportion was significantly higher among the nonsurgical patients compared with the surgical patients (14% vs. 4%, $P = 0.003$). In the adjusted models, there was no difference for severe risk for PU between surgical and nonsurgical patients (odds ratios [ORs]: 0.37, 95% confidence interval [CI]: 0.01–12.80). An additional day in the ward was associated with a significantly higher likelihood of being at high-risk for PU (OR: 1.47, 95% CI: 1.16–1.86). **Conclusion:** There were no significant differences between patients who were admitted for surgery compared with those who were not. An additional day in the ward, however, is important for developing a high-risk score for PU on the monitoring scale, and these patients require active interventions.

Key Words: *India, longitudinal analysis, pressure ulcers, risk factors, surgical/nonsurgical*

What was known?
- Occurrence of pressure ulcer (PU) in hospitalized patients has clinical, emotional, and psychological implications
- PU may add to the total cost of patient management and be an important economic burden
- Some of the risk factors for PU include age, activity, nutrition, and depression.

Introduction

Pressure ulcers (PUs) defined as "a localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear" by the National Pressure Ulcer Advisory Panel[1] are an important health concern in hospitalized patients and those receiving palliative care. Previous studies have reported that the prevalence of PU in hospitalized patients ranges from 1.8% to as high as 47.6% in different categories of patients.[2-12]

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Although many studies reported the prevalence to be higher in older patients, children are also at risk, and the prevalence of PU in the pediatric population was also relatively high (about 27%).[13,14] The occurrence of PU in hospitalized patients has clinical, emotional, and psychological implications. Studies have highlighted that patients with PU have grieving issues, psychospiritual concerns, relationship problems, and social isolation.[15,16] In addition, PU may add to the total cost of patient management and be an important economic burden.[17-19]

Previous studies have identified multiple risk factors for PU. Some of these include age, activity, nutrition, and depression.[5,10,20] However, the proper implementation of monitoring, education, and care programs help in reduction of the occurrence of these ulcers.[21] Indeed, a systematic review on prevention of PU identified the following components as important strategic tools: PU specific interventions and documentation;

multidisciplinary teams; skin champions; education; and regular feedback.[22] In addition, patient and care giver's education also helps in the reduction of incidence of these ulcers.[23] Furthermore, regular monitoring of the skin using scales, the use of oil-based products to maintain skin integrity, and repositioning as per schedule helps in reduction of these ulcers.[9,24,25]

Most of the studies assessing the risk factors associated with PU are cross-sectional. While some authors have presented pooled prevalence or changes in prevalence from multiple data, others have used cox-regression models to estimate the hazard for developing PU.[6,26,27] However, the risk scoring for developing PU is a dynamic process and scores change over time. Thus, models that account for variation of scores over time will be useful for cohort analysis of data over a period of time; thus, we designed the following longitudinal study.

The objectives of the study were: (1) To compare the risk of developing PU in surgical and nonsurgical patients; and (2) to evaluate the factors associated with having a high-risk score for development of PU over a period of time (using a Pressure Score Risk Assessment Tool).

Materials and Methods

Study design

The present study was a longitudinal analysis of secondary data collected from 290 patients in a tertiary care center in Mumbai, Maharashtra, India.

Study population, study sample, and study procedures

We evaluated 290 inpatients admitted (surgical and at risk nonsurgical patients) over a 4 months period. All the patients admitted to the hospital over this 4 months period with a score of 10 or more on the Waterlow Pressure Ulcer Risk Assessment Tool at baseline were included in the study sample. A data abstraction sheet was created to enter clinical data of these patients from existing medical records. The following data were abstracted for each patient: (1) Information of about hospitalization (date of admission and date of discharge); (2) demographic information (age and sex); (3) anthropometric information (height, weight, and body mass index [BMI]); (4) clinical information (diagnosis, type of surgery, date of surgery, and co-morbidities); and (5) PU risk assessment score.

The patients were evaluated using the Waterlow Pressure Ulcer Risk Assessment Tool.[28,29] For BMI categorization, we used cut-off values used in the Indian population and the skin type reflected changes in dark skinned individuals.[30-32] The items measured on the scale were BMI, skin assessment, mobility, continence, appetite, special risk (like neurological deficit). The nutritional status and medications are also captured in the Pressure Ulcer Risk Assessment Tool. All these parameters were used to calculate the total score of patients at risk of PU. If the cumulative score was 10 or more, intensive skin and back care were initiated for the prevention of PUs in these patients. If the score was between 10 and 20, the care was provided every 2 h. The care included skin assessment and back massage with olive oil[25] with emphasis on pressure points. These skin changes were regularly noted by the nursing staff. If the score was >20, the care (back massage and cutaneous assessment) was provided every hour. Furthermore, an air mattress was used for these patients. Though many patients were at risk for developing PU, none of the patients included in our study sample developed PUs.

Variables examined

The variables were based on the conceptual models described by Braden and Bergstrom, Benoit and Mion, Messer, and Coleman *et al.*[33-36] Many of the parameters (such as mobility, continence, neurological deficit, nutrition, and medications) are captured by the Waterlow Pressure Ulcer Risk Assessment Tool, and are used to calculate the total score. The two main outcomes for our analysis were: (1) Score on the pressure risk assessment scale; and (2) the proportion of individuals who were at very high-risk for developing at PUs (defined as having a score of 20 or more on the scale). The explanatory variables were: type of patient (surgical or nonsurgical), age (categorized as 18–39, 40–59, 60–79, and >80 years), sex (female and male), time (measured as a continuous variable), BMI (measured as a continuous variable), and the presence of associated clinical condition (such as diabetes mellitus and hypertension - categorized as the presence of diabetes mellitus only, presence of hypertension only, presence of both hypertension and diabetes mellitus, and none of the these conditions).

Statistical methods

We calculated the means and standard deviations (SDs), and medians and ranges for linear outcomes; the means were compared using the *t*-test and the medians were compared using the Mann–Whitney Ranksum test. We calculated the proportion for categorical variables; the proportions were compared using the Chi-square test or Fisher's exact test for low expected cell counts. We used random effects (REs) models for longitudinal analysis of the data. These models take into account the between-subject and within-subject effects and are useful for time varying variables.[37] Both our outcomes (total score and proportion of individuals who were at very high-risk for developing at PUs) changed over the entire stay of the patients in the wards. Hence, RE models were a useful alternative to model these outcomes. We built the RE models in the following sequence: Null model; univariate models for crude estimates; and multivariate analysis for adjusted estimates.

We used random intercept and slope in the models for the linear outcome (score of pressure assessment scale) and just the random intercept for the categorical outcome (odds ratio [OR] for being at severe risk).[38] We used the Akaike information criteria to assess the fit of the models. Data were analyzed using Stata Version 13 (StataCorp, College Station, Texas, US).

The study was approved for secondary data analysis by the Institutional Ethics Committee of the hospital.

Results

There was a total of 209 surgical and 81 nonsurgical patients in our study population. The mean age (SD) of the surgical patients was significantly lower compared with the nonsurgical patients (49.9 [19.3] vs. 65.4 [12.6], $P < 0.001$). The mean age (SD) of the males in our population was 59.6 (17.5) years, and the mean age (SD) of the female patients was 50.7 (19.2) years; the difference was statistically significant ($P = 0.0001$). The median total time of the surgical patients in the study was 5 days (range 1–36 days), and by the nonsurgical patients was 6 days (range 1–46 days); the difference was not statistically significant ($P = 0.07$). Some of the common surgeries in our patients were lower segment cesarean section (27%), total knee replacement (19%), hip replacement (10%), laparoscopic surgeries (10%), and exploratory laparotomy (8%). The main surgical procedures among women were lower segment cesarean section (37%) and total knee replacement (21%). Some of medical conditions diagnosed in our patients were infectious diseases (31%), cardiac failure (21%), cancer (16%), neurological disorders (10%), renal pathology (5%), anemia (4%), and peripheral vascular diseases (2%).

The mean PU score was significantly higher in the nonsurgical patients compared with surgical patients at baseline (15.23 [3.86] vs. 9.33 [4.57]; $P < 0.01$). The baseline scores were, however, similar in both surgical and nonsurgical patients with a history of diabetes mellitus [Table 1]. About 7% of the total patients had a score of >20 at baseline and were considered as being at very high-risk for PUs; the proportion was significantly higher among the nonsurgical patients compared with the surgical patients (14% vs. 4%, $P = 0.003$). We also found that female nonsurgical patients were significantly more likely to have a score > 20 compared with female surgical patients (15% vs. 1%, $P = 0.002$); however, there was no significant differences among males. Additional data are presented in Tables 1 and 2.

We found that after adjusting for demographic parameters and associated clinical conditions, the mean pressure score was significantly lower in the surgical patients compared with nonsurgical patients over the study period (–1.61, 95% confidence intervals [CIs]: –2.58, –0.64). In general, after adjusting for other parameters, the mean score increased by 0.16 (95% CI: 0.08–0.25) units with one additional day in the ward. Similarly, the mean PU score was significantly higher in patients with a history of diabetes mellitus compared with those who did not have it 2.42 (95% CI: 1.07–3.76). All the unadjusted and adjusted estimates from RE linear models are shown in Table 3. Even though in the unadjusted model, we found that surgical patients were less likely to be at very high-risk for PUs (OR: 0.15, 95% CI: 0.04–0.59), after adjusting for other covariates, there was no such difference (OR: 0.37, 95% CI: 0.01–12.80). However, in general, an additional day in the ward was associated with a significantly higher likelihood of being at very high-risk for PUs (OR: 1.47, 95% CI: 1.16–1.86).

Table 1: The proportion of patients who were at severe risk (score >= 20) at baseline in 290 patients attending a tertiary care centre in Mumbai, India

	Surgical patients		Non-surgical patients		*P*
	All patients *N* (%)	Score ≥ 20 *n* (%)	All patients *N* (%)	Score ≥ 20 *n* (%)	
All	209 (100)	8 (4)	81 (100)	11 (14)	0.003
Age					
18 - 39	82 (39)	1 (1)	5 (6)	0 (0)	>0.99
40 - 59	51 (24)	4 (8)	18 (22)	3 (17)	0.37
60 - 79	65 (30)	3 (5)	51 (63)	7 (14)	0.10
≥80	11 (5)	0 (0)	7 (9)	1 (14)	0.39
Sex					
Male	72 (34)	6 (8)	42 (52)	5 (12)	0.53
Female	137 (66)	2 (1)	39 (48)	6 (15)	0.002
Associated clinical conditions					
Only DM	19 (9)	4 (21)	9 (11)	1 (11)	>0.99
Only HT	41 (20)	0 (0)	13 (16)	4 (31)	0.002
Both DM and HT	24 (11)	2 (8)	43 (53)	4 (9)	>0.99
None	125 (60)	1 (2)	16 (20)	2 (13)	0.06

Table 2: The baseline mean scores in 290 patients attending a tertiary care centre in Mumbai, India

	Total N (%)	Score at baseline mean (SD)	Score at baseline mean (SD)	*P*
Type of patient	All	Surgical	Non-surgical	
	290 (100)	209 (72)	81 (28)	
All		9.33 (4.57)	15.23 (3.86)	<0.01
Age				
18 - 39	87 (30)	8.65 (4.07)	12.80 (1.48)	0.03
40 - 59	69 (24)	8.84 (5.17)	16.28 (3.95)	<0.01
60 - 79	116 (40)	10.09 (4.62)	15.04 (3.96)	<0.01
≥80	18 (6)	12.09 (3.56)	15.71 (3.64)	<0.01
Sex				
Male	114 (39)	11.19 (5.36)	14.98 (3.15)	<0.01
Female	176 (61)	8.34 (3.76)	15.51 (4.52)	<0.01
Associated clinical conditions				
Only DM	28 (10)	13.84 (5.08)	15.22 (2.82)	0.46
Only HT	54 (19)	9.15 (3.68)	16.69 (4.80)	<0.01
Both DM and HT	67 (23)	12.17 (5.17)	14.86 (3.93)	0.02
None	141 (49)	8.15 (3.99)	15.06 (3.33)	<0.01

Table 3: The mean scores from random effects linear models in 290 patients attending a tertiary care centre in Mumbai, India

	Unadjusted Models Estimate (95% Confidence Intervals)	Adjusted Models Estimate (95% Confidence Intervals)
Type of Patient		
Surgical	-3.14 (-3.92, -2.36)	-1.61 (-2.58, -0.64)
Non-surgical	Reference	Reference
Time of stay (per day increase)	0.24 (0.17, 0.31)	0.16 (0.08, 0.25)
Age		
>=80	4.69 (1.28, 3.15)	1.99 (0.09, 3.88)
60 - 79	3.19 (2.37, 4.02)	1.51 (0.53, 2.49)
40 - 59	2.2 (1.28, 3.15)	0.54 (-0.39, 1.48)
18 - 39	Reference	Reference
Sex		
Male	1.35 (0.60, 2.11)	0.29 (-0.47, 1.06)
Female	Reference	Reference
Body mass index (per unit increase)	-0.01 (-0.07, 0.06)	0.05 (-0.01, 0.11)
Associated clinical conditions		
Only DM	3.32 (2.08, 4.56)	2.42 (1.07, 3.76)
Only HT	2.08 (1.14, 3.01)	0.83 (-0.18, 1.84)
Both DM and HT	2.81 (1.94, 3.68)	0.98 (-0.07, 2.03)
None	Reference	Reference
Constant		10.04 (8.06, 12.02)
AIC		7902.70

DM: Diabetes Mellitus, HT: Hypertension

Discussion

Thus, adequate supervision, monitoring, and regular scoring helped us to reduce the occurrence of PUs in our patients. Indeed, with this prevention strategy, there were no cases on PU in our population. Even though the scores were higher in the nonsurgical patients compared with the surgical patients, we did not find the likelihood for very high-risk to be significantly different in both these groups. Some of the factors that were associated with higher risk were - older patients, patients with diabetes mellitus, and patients who stayed longer in the ward.

It has been regularly discussed that age is an important factor associated with a higher risk for developing PU.[11,20,39,40] Some of the potential reasons for this risk are increased the fragility of the skin and poor

temperature regulation.[20,41-44] Yusuf *et al*. have reported that the mean skin temperature was significantly higher in individuals with PU and local skin changes.[45] An important prevention strategy for PU is the judicious use of emollients.[20,46,47] Thus, the regular use of olive oil for skin massage was useful for reduction of the occurrence of skin changes and ulcers in our patients. Apart from age, other conditions such as nutritional status and co-morbidities (such as lung disorders, peripheral vascular diseases, dementia, and diabetes mellitus) are important factors associated with PU. Indeed, Iizaka *et al*. reported that malnutrition was significantly associated with the development of PU, more so severe PUs.[48] Furthermore, they also found that the prevalence of PU was lower in patients in whom the health care providers had regularly monitored the nutritional status.[48] Thus, along with skin care, monitoring the nutritional status may be an important prevention strategy.[49]

Among the co-morbidities monitored, we found diabetes mellitus to be significantly associated with a higher score of occurrence of PU. It is one condition that affects tissue perfusion and has been shown to be associated with higher occurrence of ulcers.[50] It has been suggested that some of potential pathogenic mechanisms for the occurrence of ulcers in diabetics are: angiopathy, neuropathy, hypoxia, and deranged neuropeptide signaling.[51] Thus, the treatment of such co-morbidities will be an important tool in prevention and management of these ulcers, particularly in high-risk patients. It is also important that nurses recognize these co-morbidities that place patients at risk for PU and actively prevent the occurrence of PU in these patients. These may include intensive monitoring of these patients, shifting positions frequently, and the use of additional preventive measures such as mattresses in these patients. Another feature associated with a higher score for PU is the length of stay in the hospital.[5] We also found that an additional day was associated with a 47% increase in risk of having a score of > 20 (suggestive of very high-risk). Interestingly, Theisen *et al*.[11] have reported that the presence of PU is an independent predictor of a longer duration of hospitalization. Thus, on one hand a longer stay in the hospital was significantly associated with a high-risk for ulcers; whereas, on the other hand, however, ulcers themselves were associated with longer duration of hospital stay; thus, there appears to be a bidirectional relationship between ulcers and length of stay. In our study population, however, after adjusting for potential confounders, we did not find odds of very high-risk to be significantly different between surgical and nonsurgical patients, even though the mean scores were significantly higher in the nonsurgical patients. Thus, it will be very important to monitor the latter set of patients rigorously and intervene at the slightest indication of skin changes.

The present study was not without its limitations. Our population was limited to adult patients; studies have shown that children may also have a high prevalence of these ulcers.[13,14] Thus, our study associations may not be entirely applicable to this population.

Nonetheless, this study is an important contribution to the literature on PU. It is one of the first studies that has used REs models for longitudinal analysis. These analyses account for the within-individual and between-individual correlations; thus, accounting for the fact that the same individual has been followed over time adds a longitudinal component to the literature on evidence based practice in nursing. We found that regular monitoring, use of the pressure risk assessment tool to score the risk of development of PUs, and prompt intervention helps in preventing PU in the hospitalized patients. Indeed, we did not have any cases of PU in our study subjects. The use of olive oil for back massage has proved beneficial to patients at risk of developing PU. This may be useful for care especially in resource constrained settings where the use of expensive skin barriers may not be feasible in all patients. Even though old age and diabetes mellitus were associated with a higher score for PU, there were no significant differences between patients who were admitted for surgery compared with those who were not. An additional day in the ward, however, is important for developing a high-risk score for PU on the monitoring scale, and these patients require active interventions.

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What is new?

- It is one of the first studies that has used random effects models for longitudinal analysis and adds a longitudinal component to the literature on evidence-based practice in pressure ulcer (PU) management
- Regular monitoring, the use of pressure risk assessment tool to score the risk of development of PUs, and prompt intervention helps in preventing PU in the hospitalized patients
- Even though old age and diabetes mellitus were associated with a higher score for PU, there were no significant differences between patients who were admitted for surgery compared with those who were not
- An additional day in the ward, however, is important for developing a high-risk score for PU on the monitoring scale, and these patients require active interventions.

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