Incidence of pressure ulcers in a neurologic intensive care unit

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Objectives: **To determine the risk factors for pressure ulceration in an intensive care setting, to evaluate the Braden scale as a predictor of pressure ulcer risk in critically ill patients, and to determine whether pressure ulcers are likely to occur early in the hospital stay.**

Design: **Cohort study of patients with no preexisting ulcers with a 3-month enrollment period.**

Setting: **The neurologic intensive care unit and the neurologic intermediate unit at a primary care/referral hospital with a level I trauma center.**

Patients: **A total of 186 patients entered the study.**

Intervention: **Within 12 hrs of admittance, initial assessment, photographs, and Braden score were completed. Patients were re-examined every 4 days or at discharge from the unit, whichever came first.**

Main Outcome Measures: **Determining risk factors for pressure ulcers, performing detailed statistical analyses, and testing the usefulness of the Braden score as a predictor of pressure ulcer risk.**

Results: **Twenty-three of 186 patients developed at least one pressure ulcer (incidence = 12.4%) after an average stay of 6.4 days. The Braden scale, which measures six characteristics of skin condition and patient status, proved to be a primary predictor of ulcer development. No ulcers developed in the 69 patients whose Braden score was 16 or higher. The likelihood of developing a pressure sore was predicted mathematically from the Braden score. However, being underweight was a significant and distinct factor in pressure ulcer development.**

Conclusions: **Pressure ulcers may develop within the first week of hospitalization in the intensive care unit. Patients at risk have Braden scores of ≤16 and are more likely to be underweight. These results suggest that aggressive preventive care should be focused on those patients with Braden scores of ≤13 and/or a low body mass index at admission. (Crit Care Med 2001; 29:283–290)**

KEY WORDS: decubitus ulcer; skin ulcer; intensive care unit; spinal cord injuries; head injuries; critical care; incontinence; Braden score; body mass; logistic regression

Pressure sores (formerly called decubitus ulcers) are localized areas of tissue necrosis that develop when soft tissue is compressed between a bony prominence and an external surface for a prolonged period of time (1). Healthy, active people can develop these ulcers when anesthesia, sedation, disease, or injury immobilizes them and causes diminished pain sensation (2). Prevalence studies from Europe, South Africa, and Canada show that 3% to 11% of all hospitalized patients have pressure related skin ulcers (3). Although some patients are admitted to hospitals with preexisting ulcers and others develop them during their stay, pressure sores are a significant and increasing source of suffering and financial burden. In a United States study, 17% of 634 hospitalized patients had a pressure ulcer or were deemed to be at risk for developing one (3). A recent study estimates the average incremental cost of hospitalization due to pressure sores, adjusted for other admission predictors, to be $15,229 and a lengthening of stay of 8.2 days (4). In the United Kingdom, the cost of pressure ulcer care is estimated to have risen from £60 million in 1973 to £150 million in 1982 (5). Extended hospitalization is particularly harmful for elderly patients because they may lose their independence, rehabilitation may be delayed, and normal social networks of support may weaken, making it more difficult for them to go home (6). Preventive care must focus on decreasing the incidence of new ulcers, however, such care can be an expensive use of hospital resources. Thus, it is important to have the best possible definition of an "at risk" population so that these resources can be focused.

Most previous reports have addressed the problems of pressure ulcers in chronic care institutions. Only one article published since 1966 involved the prevention of pressure ulcers in an intensive care unit (ICU) (7). The Braden scale is coming into increasing use as a measure of pressure sore risk but has not been fully researched in terms of its applicability in critical care settings. Therefore, the objectives of this study were to determine the following: 1) if certain risk factors increase the likelihood of developing ulcers in an intensive care setting; 2) if pressure ulcers are likely to occur early in the hospital stay; 3) the correlation between the Braden scale and new ulcer development; and 4) if an improved definition of an "at risk" population can be proposed specifically for critically ill patients.

METHODS

This was a prospective cohort study of patients admitted to the neurologic intensive care unit (NICU) and the neurologic intermediate unit (NIMU) at Memorial Hermann Hos-

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Funded, in part, by the Hermann Center for Wound Healing, Memorial Hermann Hospital, Houston, TX and the Thomas D. Cronin Chair, Department of Plastic Surgery, The University of Texas Medical School at Houston.

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pital in Houston, TX. Many patients are young adults with spinal cord or closed head injuries who were in good health before hospitalization. The neurologic units were selected because of the following: a) data within our institution suggested a higher prevalence of pressure sores in these units than in our other intensive care units; b) adequate nurse and clinician support was available to perform the study; c) admissions were sufficient to ensure adequate enrollment in the 3-month study period; d) the likelihood of preexisting pressure ulcers was low inasmuch as many patients were admitted from the community with either stroke or head trauma; and e) the broad age range of patients in these units would increase generalization of the findings.

The study was approved by the institutional review board of the University of Texas Health Science Center, Houston, with the requirement that consent be obtained from the patient or family member for photographs. If this request was refused, no photos were taken. Patients were admitted to the neurologic units between June 1 and August 31, 1995, and were inspected visually and photographically for any evidence of skin breakdown. Photographs were an effective tool because they provided secondary confirmation of ulcer formation, an opportunity to make sure minor skin changes were not overlooked, and minimized discrepancies between data collectors. Before the study began, ten participating nurses received special training in the following: a) evaluating pressure ulcers; b) following standardized photographic methods; and c) completing study documents including the Braden scale. According to hospital standards, nursing staff were required to turn the patient every 2 hrs unless there were orders specifically prohibiting turning (usually due to concerns regarding unstable intracerebral pressures). A number of support surfaces were in use and these were recorded in the database.

Pressure ulcers are classified into four stages (8). In this study, two additional labels, N for necrotic and G for granulating, were employed. Lesions covered with a necrotic eschar cannot be staged because the wound base cannot be evaluated, and the presence of granulation tissue in deep wounds precludes an accurate evaluation of the level of tissue impairment. The four stages of ulcer development are defined as:

- Stage I: Nonblanchable erythema of intact skin.
- Stage II: Partial-thickness skin loss of epidermis, dermis, or both. The ulcer is a superficial abrasion, blister, or shallow crater.
- Stage III: Full-thickness skin loss with subcutaneous tissue damage or necrosis that may extend down to but not through underlying fascia. The ulcer is a deep crater with or without undermining of adjacent tissue.
- Stage IV: Full-thickness skin loss with extensive destruction, tissue necrosis, or damage to muscle, bone, or supporting structures (tendon, joint capsule, etc.) Undermining and sinus tracts may be associated.

Because the skin remains in tact in stage I lesions, they are not "ulcers" in the usual sense. In addition, it is widely agreed that nonblanching erythema cannot always be reliably assessed, nor can it be accurately depicted in photographs. By contrast, stage II lesions involve skin breakdown. For this reason, we considered only Stage II ulcers as significant findings at the time of follow-up examination.

Patients with any of the following criteria were excluded from the study:

1. A pressure ulcer of stage II or higher on initial assessment, n = 9
2. Discharge from the unit <24 hrs after admission, n = 33
3. Diagnosis of brain death on life support pending organ donation, n = 6
4. No evaluation by nursing staff within 12 hrs after admission, n = 17.

We were unable to obtain consent for photographs for only four patients. All other patients had complete photographic documentation. Level of consciousness was denoted either by the Glasgow coma scale (1–15) or by the following arbitrary designation in the assessment form: 1) unresponsive; 2) withdraws to pain; 3) opens eyes; 4) follows commands; 5) answers questions; 6) alert. Data were also kept on whether patients were transferred from other hospital units, and the type of mattress, overlay, or other support surface that was in use at the time of initial and follow-up assessment.

Within 12 hrs of admission, an initial assessment form was completed and the Braden scale score was calculated. The Braden scale is a risk index that composites six areas of risk into a single number. The scale has a minimum value of 6 and a maximum value of 23. The subscales reflect sensory perception, skin moisture, activity, mobility, nutritional status, and friction and shear. Table 1 describes the Braden scale in more detail. Critically ill patients will have a low score, indicating an increased risk for pressure ulcers. Higher scores are seen in persons with less severe injuries or illnesses and signify a decreased risk for pressure ulcer occurrence (9). An event document was completed upon discovery of a stage II or higher pressure ulcer, upon transfer to another unit or location, or upon death. The location and stage of the ulcer were also recorded. Previous records of the NICU indicated an average stay of 4 days. This study was, therefore, designed to evaluate patients every 4 days, or upon discharge, whichever came first. It should be clearly understood that the term "length of stay" means length of stay in the NICU. If a patient developed an ulcer on the second day, it was discovered on the fourth day. More frequent evaluation was considered but rejected because the evaluation process requires turning the patient over, which is a preventive measure for pressure ulcers. Hence, frequent evaluation could interact

Table 1. Braden score construction (abbreviated definitions)

Sensory perception Ability to respond meaningfully to pressure related discomfort	1. Completely Limited	2. Very Limited
Moisture Degree to which skin is exposed to moisture	1. Constantly Moist	2. Very Moist
Activity Degree of physical activity	1. Bedfast	2. Chairfast
Mobility Ability to change and control body position	1. Completely Immobile Cannot make even slight changes in body or extremity position	2. Very Limited Makes Occasional slight changes in body or extremity position
Nutrition Usual food intake pattern	1. Very Poor Never eats a complete meal (<2/3 of meal)	2. Probably Inadequate Usually eats about half a meal
Friction and Shear	1. Problem Requires moderate to maximum assistance in moving. Slides frequently	2. Potential Problem Moves feebly or requires assistance. Some sliding

with the ulcer development and bias the results toward fewer ulcers.

Data Analysis. Univariate analysis was conducted to assess the association of new ulcer development with age and gender, potential risk factors, admitting diagnoses, and ranges of the Braden scale. This study recorded data on the presence, absence, or measured level of a variety of factors that have been identified as potential contributors of pressure sore development. Each is separately described. Contingency tables, correlation analysis, and point biserial correlation techniques were employed. The correlation coefficients reported are point biserial because the development of new sores is recorded as a 0 = no and 1 = yes. Thus, a positive correlation is an association with new ulcer development and a negative correlation is associated with nondevelopment. Almost all patients had more than one characteristic that previous studies have identified as an indicator of pressure sore risk. The second level of analysis utilized multivariable techniques (regression and logistic regression analysis) to evaluate the concurrent effects of several factors in the development of ulcers. A third level of analysis used these techniques on the subgroup of patients who had low Braden scores using both paired and unpaired analyses.

RESULTS

During the 3-month period of the study, 186 patients were enrolled. Glasgow coma scale or the alternative description of consciousness were recorded for all but one patient. Glasgow coma scale, recorded in 57% of patients, ranged from 3 to 15 with an average of 12. The remaining 43% of patients, as rated on the alternative system, ranged from 1 (unconscious) to 6 (alert) with an average score of 4.7. Twenty patients (11%) were recorded as being on mechanical ventilation. Twenty-three patients developed pressure ulcers (stage II or higher), yielding a crude incidence rate of 12.4% during their stay in the NICU, assuming that all patients were at risk. The most common locations were sacrum/coccyx (25%), heel (14.6%), and ischium (10.4%). The average length of stay in the NICU was 6.4 days. Photographic documentation proved valuable. Although patients with preexisting stage II ulcers were to be excluded from this study, on review of enrolled patients, three were found to have photographic evidence of preexisting stage II ulcers and these were subsequently excluded from analysis. One patient whose stage II pressure ulcer was evident in photographs had been assessed as having intact skin on study discharge assessment forms. In all other cases, skin or wound assessments correlated with photographic documentation.

Factors known to affect the incidence of pressure sores were examined individually. Age and gender are examined together because of their interrelationship in NICU admissions. Men were more likely to be admitted because of motor vehicle accidents or gunshot wounds; women were more likely to be admitted with cerebrovascular accidents and were more often in poor health with thin skin and subcutaneous tissues because of age. As a consequence, the 102 males were younger (49.8 yrs) than the 84 females (60.9 yrs). The youngest patient was 14 and the oldest was 95. The youngest patient with pressure sores was 16 and the oldest was 95. Table 2 shows the incidence of sores by gender in three age groupings. The Mantel-Haenszel statistics used to combine the three tables indicate no significant age or gender relationship with the incidence of sores, despite the presence of some apparent trending in the tables.

Patient height and weight were recorded for 149 patients, 16 of whom developed ulcers. A relative body mass score (BM) was constructed using the equation: BM = 10.815 × weight in pounds divided by height in inches. The normal range is 19–24. Overweight patients represented 59.1% of the group and had an ulcer incidence rate of 5.7%; normal weight patients represented 36.9% of the group with an incidence rate of 11.5%. The six underweight patients, who represented only 4% of the total, had an incidence rate of 50.0%. These differences were moderately significant, with $p = .08$ in a chi-square test, indicating that underweight patients are at greater risk of developing pressure sores, and overweight patients are seemingly at lower risk. Figure 1 displays the distribution of body mass. The average was 27, a moderately overweight condition. The two vertical lines in Figure 1 delineate the normal weight range.

Twenty-three patients were recorded as being incontinent (either urine or stool). Their incidence rate for pressure ulcers was 26.1% vs. 10.4% for the continent group. This was a significant difference, with $p = .033$. Serum albumin was tested in 68 of 186 patients. It has been suggested that a serum albumin below 35 g/L is an indicator of pressure sore risk. The pressure sore incidence rate for patients with an albumin at or below 35 g/L was 21.4%, whereas for the normal albumin group it was 7.7%. This was not significant in a chi-square test ($p = .135$) but was significant in a correlation analysis ($p = .025$). A logistic regression also found a significant relationship ($p = .033$). This illustrates the difference in power between a simple classification procedure and graduated scale procedures. The 81 bedbound patients (patients who could not sit on the side of the bed or in a chair) had an incidence rate of 15.2% compared with 8.6% for the non-bed-bound group. The difference was not significant ($p = .175$). Correlation analysis showed a similar result.

Most patients had multiple diagnoses. The competing risks of spinal cord injury, head injury, and stroke were all nonsignificant with p values ranging from .397 to .893. Diabetes could not be evaluated because there were only seven diabetics

Table 1. Continues

3. Slightly Limited	4. No Impairment	Score
3. Occasionally Moist	4. Rarely Moist	
3. Walks Occasionally	4. Walks Frequently	
3. Slightly Limited Makes frequent though slight changes in body or extremity position independently	4. No Limitation	
3. Adequate Usually eats over half a meal or is on tube feeding of TPN regimen	4. Excellent Eats most of every meal	
3. No Apparent Problem Moves in bed or chair in dependently		
	Total Score	

Table 2. Age and gender vs. ulcer incidence

Age Group (Yrs)	New Ulcers	Male	Female	Total
40 or younger	Yes	6 (15.4%)	0 (0%)	6 (11.5%)
	No	33 (84.6%)	13 (100%)	46 (88.5%)
	Total	39	13	52
41 through 65	Yes	5 (14.7%)	2 (6.5%)	7 (10.8%)
	No	29 (85.3%)	29 (93.6)	58 (89.2%)
	Total	34	31	65
66 through 95	Yes	5 (16.7%)	5 (12.8%)	10 (14.5%)
	No	25 (83.3%)	34 (87.2%)	59 (85.5%)
	Total	30	39	69

Mantel-Haenszel chi-square analysis: Homogeneity between age groups: $\chi^2 = 0.9726$, 1 degree of freedom (*df*), p value = .61 (NS). Association between gender and new ulcers: $\chi^2 = 2.5763$, 2 *df*, p value = .11 (NS).

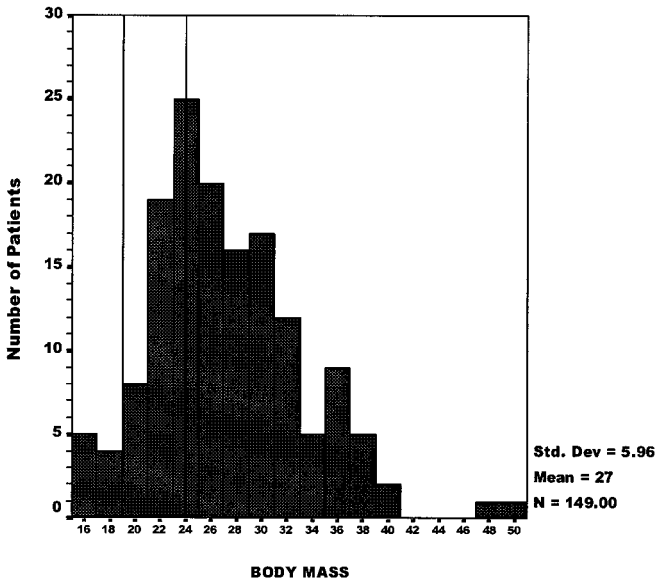

Figure 1. Body mass distribution.

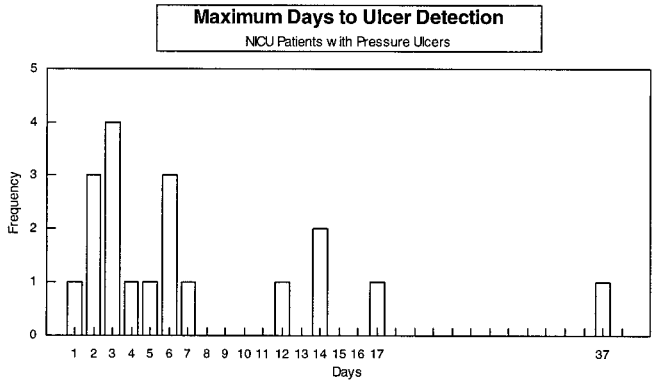

Figure 2. Maximum days to ulcer development. *NICU*, neurologic intensive care unit.

and their diagnosis was always accompanied by other competing risks.

Both correlation and logistic regression showed that length of stay in the ICU was not a significant factor in the development of pressure sores ($p = .31$). Figure 2 shows the distribution of the maximum number of days to pressure sore development in 19 ulcer patients with known length of stay in the NICU. Eight of the 19 (42%) developed an ulcer within only 3 days. The average length of stay in the ICU was 6.4 days with no significant difference between patients with pressure sores or without ($p = .47$).

The patients in this study had Braden scores ranging from 8 to 23. All of the 23 patients with pressure sores had a Braden score of 15 or less. The Braden score had the highest correlation with new ulcer development among all of the factors noted above. For the 117 patients with scores of 15 or less, the overall incidence rate was 19.7% vs. the incidence rate of 0% for those above 15. The incidence rate increased as the Braden score decreased. A curve was fitted to the observed incidence rate at each Braden scale point so that risk can be predicted more accurately than can be done with dichotomous cutoff scores. Figure 3 shows the results of this study. The equation fitted is: incidence = 174.82 − 19.65 (Braden score) + 0.55 (Braden score)^2; $r^2 = .94$. Use this equation for Braden scores between 6 and 16; above 16 incidence = 0. The plotting data are shown in the left portion of Table 3.

Multivariable Analysis. Multivariable analysis is the evaluation of the simultaneous effects of two or more variables on a response variable. The causal or driver variables may be intercorrelated and, thus, contain common information about the response being examined. Thus, seemingly different causal factors that have a univariate correlation with the response may fail to be significant when evaluated as competing factors. Some will emerge as strong predictors and others will fail to add significant information about the response variable.

The correlation table showing the simple correlations and intercorrelations among the proposed predictors of pressure sore development is the starting point for multivariable analysis and is shown in Table 4. The Braden score, albumin, and days of stay in the NICU are measured variables. The body mass index (BMI) is recorded as: −1 = underweight, 0 = normal, and +1 = overweight. All others are coded: 0 = characteristic absent, 1 = characteristic present. Using a simple classification of underweight or not underweight provided the best simple correlation with new sore development but it only identified six patients. The full-range BMI performed much better in multivariate analyses. Consequently, BMI was listed in the correlation table and the other body mass measures were not. The

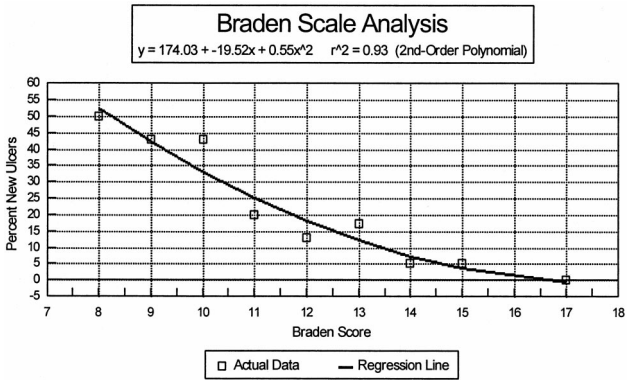

Figure 3. Incidence vs. Braden score.

Table 3. Observed and predicted incidence of pressure ulcers and average length of stay by Braden score

	New Ulcer Development		Days of Stay in NICU	
Braden Score	Predicted Incidence (%)	Observed Incidence (%)	Observed Average	Predicted Average
6	76.72	None	None	15.2
7	64.25	None	None	12.9
8	52.78	50.0	9.5	11.2
9	42.53	42.9	9.2	9.9
10	33.38	42.9	12.0	8.6
11	25.31	20.0	7.2	8.0
12	18.33	13.0	8.3	7.3
13	12.45	17.4	7.6	6.7
14	7.65	5.0	4.9	6.1
15	3.95	5.0	5.8	5.7
16	1.22	0	6.6	5.2
17	0	0	4.2	5.0
18			4.3	4.7
19			4.4	4.5
20			4.7	4.2
21			4.6	4.0
22			4.0	3.8
23			3.0	3.6

NICU, neurologic intensive care unit.

Predicted Incidence = 174.82 − 19.65 (Braden score) + 0.55 (Braden score)^2; $r^2 = 0.94$. Predicted Days of Stay = 103.08 (Braden Score)$^{-1.07}$, $r^2 = 0.83$.

Predicted values for Braden scores of 6 and 7 have not been validated through clinical observation. r^2 values are high because averages were used rather than individual stay times.

actual body mass (BM) and BMI performed equally well in the multivariate model.

Correlation with the Braden Score. Examination of the correlation table indicates that all of the proposed causal factors that have a significant correlation with pressure sores also have a significant correlation with the Braden score. Length of stay in the NICU is not correlated with new ulcer development or any other causal factor but is highly correlated with the Braden score. Figure 4 shows the average days of stay in the NICU for pressure sore patients and patients who did not develop pressure sores, by Braden score. New ulcer patients averaged shorter stays than those without ulcers in six of the eight Braden score categories from 8 to 15. If length of stay was longer for those developing new sores, the reverse should have been observed. An analysis of variance to determine the importance of sore development and Braden score on days of stay showed the sores to be highly nonsignificant ($p = .609$) and the Braden score to be highly significant ($p = .000$). The same result is obtained when the data are restricted to the 112 patients with Braden scores of 15 and below ($p = .503$ and $p = .005$). Figure 5 shows the regression curve depicting the average days of stay versus Braden score. The plotting data are shown in the right-hand columns of Table 3.

The initial analyses restricted the data to those who were the most directly comparable in terms of risk. Three types of stepwise logistic regression analyses were conducted as follows: 1) with risk factors excluding albumin; 2) with risk factors including albumin; and 3) risk factors and the Braden score. Albumin was measured so infrequently that it severely reduced the sample sizes in the multivariable logistic regressions. The first model consisted of 84 patients and indicated no significant factors other than the BMI. *p* Values for the nonsignificant risk factors were all above .20. Backward elimination removed all of them, leaving the BMI as the only useful variable ($p = .0133$, $r^2 = .118$). When albumin was added to the model, the patient count dropped to 34 and no significant variables emerged. When albumin was removed and the Braden score added, both the Braden score and BMI were significant, with *p* values of .014 and .041, respectively. The r^2 increased to .224. When the same models were run on all patients, the new data set contained 149 patients. The same results were obtained. The Braden score and BMI *p* values were .0002 and .0430, respectively. The r^2 increased to .364. Table 5 shows the breakout of categories by Braden score. Clearly the underweight group with low Braden scores is the highest risk group.

Age and gender were examined in a multivariate analysis with respect to their relationship to the Braden score and to the incidence of pressure ulcers. Using a factorial model in which age, gender, and the age·gender interaction terms were fitted, no significant relationships could be determined. The model using the same age and gender factors to predict body mass found that the main effect of age was not significant ($p = .19$), but gender ($p = .018$) and the interaction between age and gender was significant ($p = .011$). Females tended to be more overweight than males on the average, but this tendency was more pronounced in the middle years (ages, 30–60 yrs). Females beyond age 65 tended to be somewhat thinner than males (the interaction effect). These results did not change after adjusting for their Braden scores.

Predicting Stage II Pressure Sore Development Using Braden Score and Body Mass. Logistic regression is useful for analyzing cumulative factor effects but it is

Table 4. Correlations

Factor	Statistic	Sores	Braden Score	Body Mass Index
Sores	Pearson's correlation	1.000	−.403	−0.258
	p-value		.000	.002
	Sample size		186	149
Braden Score	Pearson's correlation	−0.403	1.000	.163
	p-value	0.000		.047
	Sample size	186		149
Body Mass Index	Pearson's correlation	−0.258	0.163	1.000
	p-value	0.002	.047	
	Sample size	149	149	
Bowel incontinence	Pearson's correlation	0.157	−.294	.077
	p-value	0.033	.000	.353
	Sample size	186	186	149
Albumin	Pearson's correlation	−.272	.299	.144
	p-value	.025	.013	.281
	Sample size	68	68	58
Bedbound	Pearson's correlation	.099	−.261	−.134
	p-value	.177	.000	.103
	Sample size	186	186	149
Days of stay	Pearson's correlation	.076	−.316	.015
	p-value	.310	.000	.857
	Sample size	180	180	144
Spinal injury	Pearson's correlation	−.062	−.095	−.050
	p-value	.397	.197	.545
	Sample size	186	186	149
Head wound	Pearson's correlation	.057	−.059	−.039
	p-value	.437	.425	.641
	Sample size	186	186	149
Stroke	Pearson's correlation	.012	−.053	.064
	p-value	.873	.474	.439
	Sample size	186	186	149
Hypertension	Pearson's correlation	−.031	−.051	−.048
	p-value	.679	.491	.561
	Sample size	186	186	149

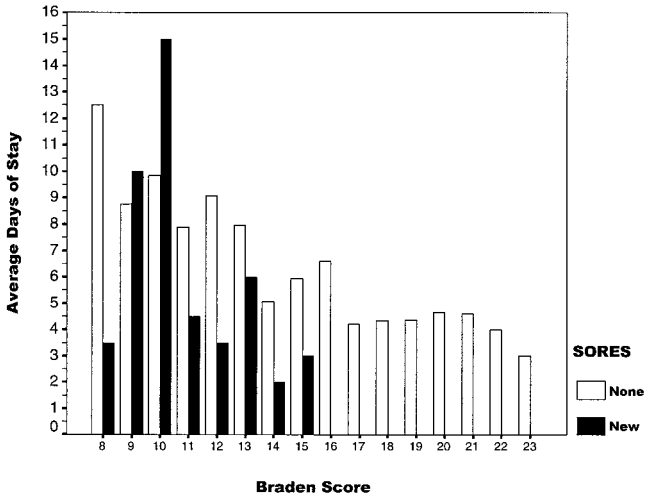

Figure 4. Average length of stay by Braden score and new ulcer development.

difficult to interpret the response measure (Y) because it is measured as the logarithm of the odds ratio of the pressure sore group vs. non-pressure sore group. Thus we revert to multiple regression modeling to predict the probability of incidence of pressure sores. The best fitting model for the NICU data were a curvilinear model employing the Braden-score, the Braden score squared, body mass, and the cross-product of the Braden score and body mass. Body mass is used here instead of BMI because it is a continuous measure, not a categorical summarization. The fitted equation is: predicted probability = 2.685 − 0.215·Braden + 0.00336·Braden^2 − 0.0519·body mass + 0.00306·Braden·body mass, for Braden score ≤17. Predicted probability = 0 for Braden scores of 18 or more.

Figure 6 shows the results of this equation for three different body mass values, 16 (very underweight), 21.5 (middle of normal range), and 27 (moderately overweight).

DISCUSSION

Previous researchers have identified the following factors as increasing the likelihood of developing a pressure ulcer: immobility, malnutrition, incontinence, hypoalbuminemia, spinal cord injury, stroke, hypertension, reduced consciousness, fractures, and being bed-bound (3, 10, 20). Age and gender may or may not be significant, depending on the populations studies and how the multisite data are pooled (22, 23). Patients with spinal cord injuries, neurologic impairment, or advanced age are at high risk for pressure ulcers (13, 20). An estimated 50% to 80% of patients with spinal cord injuries develop pressure ulcers at least once in their lives (4). In this study, patients were examined soon after injury, as opposed to patients who have been immobile for years, and this may be one reason that these results do not show spinal cord injury as a risk factor for pressure ulcers. The small number of patients (15) with spinal cord injuries may partially account for the low relative risk.

Incidence studies typically examine the number of persons developing a condition divided by the total persons at risk per unit of time (21). This study suggests that in the ICU, the passage of time may not be as important a factor as previously believed but we concur with the idea that a broadly based study group is needed to determine who is at risk and to what degree. The Allman (4) study on hospital cost and length of stay defined the at-risk patients as being 55 yrs of age or older, expected to be confined to bed or chair (or with hip fracture), and expected to remain in the hospital for at least 5 days. When this grid is imposed on our database, 83.1% of the patients are filtered out, but 78.9% of the pressure sore patients are removed as well, thus indicating that this definition would have been ineffective in providing a better focus on pressure sore patients in our setting. More recent studies have defined the at

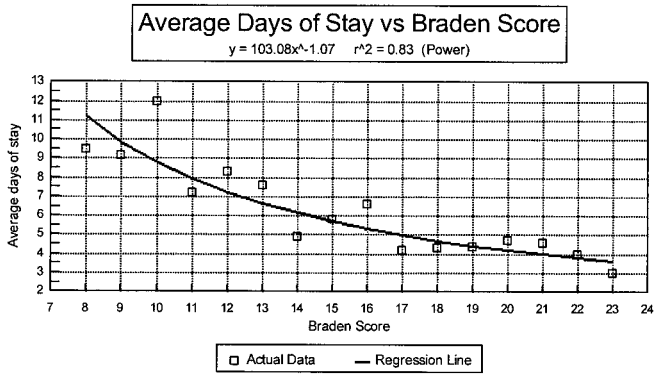

Figure 5. Length of stay vs. Braden score.

The Braden score was a better predictor of pressure ulcer formation than the presence of any single factor or combination of factors except body mass.

Table 5. Body mass index by Braden score

Braden Score	Body Mass Index[a]				Total Patients
	Underweight	Normal	Overweight	Unknown	
8	1 (1)	1 (0)	1 (0)	5 (3)	8
9	1 (1)	1 (1)	4 (1)	1 (0)	7
10	1 (0)	5 (3)	4 (1)	4 (2)	14
11	1 (1)	2 (1)	3 (0)	4 (0)	10
12	1 (0)	4 (0)	5 (0)	5 (1)	15
13		8 (2)	14 (2)	1 (1)	23
14		5 (0)	13 (1)	2 (0)	20
15		9 (1)	3 (0)	8 (0)	20
16		3 (0)	6 (0)	1 (0)	10
17		6 (0)	9 (0)	1 (0)	16
18		4 (0)	8 (0)	3 (0)	15
19		4 (0)	5 (0)	2 (0)	11
20		1 (0)	5 (0)		6
21		1 (0)	4 (0)		5
22	1 (0)		3 (0)		4
23		1 (0)	1 (0)		2
Total patients	6	55	88	37	186
Total scores	3	8	5	7	23
% Sores	50	11.5	5.7	18.9	10.7

[a]Number of patients with pressure sores is in parentheses.

risk group as being over age 18 and having been admitted within 3 days (22, 23). Our study indicates that for ICU patients, even this may be too restrictive. The Braden score and body mass define risk far more effectively. In the NICU setting, defining the at-risk group as those with a Braden score of 13 or lower eliminated 58.6% of the population but overlooked only 8.7% of the patients who developed pressure sores (2 of 23).

Although the curves in Figures 5 and 6 depict increasing risk as Braden score and body mass decrease, practical application of these findings is better served using a cutoff score for nursing orders. Recent articles by Braden, Bergstrom, and associates (22, 23) have indicated different cutoff scores for different institutional settings. They studied tertiary care facilities, veteran's hospitals, and skilled nursing care facilities and recommended cutoff scores of 16, 19, and 18, respectively. Their protocols differ from ours in four major respects: 1) they included stage I ulcers and we did not; 2) they made initial examinations within the first 72 hrs of admission and we made ours within 12 hrs; 3) our Braden scale measurements were skewed more to the lower end than theirs; and 4) they tracked for the full length of hospital stay and we tracked only the period in which the patient was in the NICU. These differences will certainly introduce differences in results. Some of the differences in results however, are likely due to body mass differences that could not be filtered out in their studies. The cutoff score of 16 described in their earlier studies would certainly have been effective with a false negative rate of 0%, but would have had a much higher false positive rate of 81.9%, and an accuracy of only 44.1%.

This research indicates that risk of a stage II ulcer increases significantly with a Braden score of ≤13. If 13 is the score that triggers preventive care, this would decrease the population considered to be at risk to 41.4% (77/186) of NICU admissions in this study. The positive predictive value is 27.3% (21/77) but the false negative rate is only 1.8% (2/109) and the sensitivity is 91.4% (21/23). The accuracy is 68.9% (125/186). This seems to be a reasonable working rule. No cutoff score can guarantee that it will separate all the at-risk patients from those not at risk in a large population, so some measure of risk must be accepted if a cutoff score is used. Because dissipating the preventive care resources over all admissions is an impractical solution, the alternative suggested by our results is to focus on those patients with Braden scores of ≤13, regardless of body mass, but expect a higher ulcer incidence among the low body mass subgroup.

Length of stay in the NICU is not correlated with new ulcer development but is highly correlated with the Braden score. This suggests the possibility that causal factors influence the level of the Braden score, and the Braden score, in turn, can be used to predict both the incidence of new ulcers and the length of stay in the NICU.

CONCLUSIONS

The Braden score was a better predictor of pressure ulcer formation than the presence of any single factor or combination of factors except body mass. It is, therefore, a valid and useful tool for identifying NICU patients who have an increased risk of developing pressure sores if the score ≤13. These data suggest that low body mass should be used in addition to the Braden score because it increases

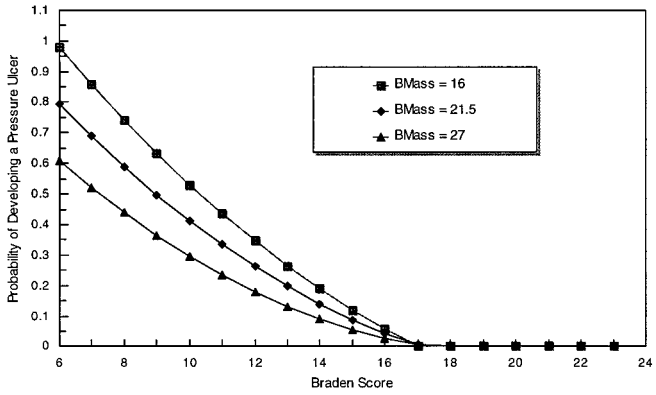

Figure 6. Pressure sore incidence by Braden score and body mass (*Bmass*).

the risk of new ulcer development and is not directly measured by the Braden scoring system. Although pressure ulcers are often viewed as a subacute problem, 68.4% of the pressure sores in this study developed in the first 7 days of ICU admission. These results further increase the challenge to hospital staff who are focused on acute life support in the early days of ICU admission. Because dissipating preventive care resources over all critical care patients is an impractical solution, the alternative suggested by our results is to focus on those patients who are admitted to the intensive care unit with low body mass or with Braden scores of ≤ 13.

ACKNOWLEDGMENTS

We are grateful to the nurses of the NICU and NIMU for making this study possible, especially Anna Banford, RN, MSN, Eileen Adair, RN, BSN, Nina Pitogo, RN, BSN,and Melissa Enger, RN, BSN. We also acknowledge the assistance of Noreen Lemak, MD, and Callye Bowie in manuscript preparation.

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