



PATIENT-SPECIFIC AND SURGICAL CHARACTERISTICS IN THE DEVELOPMENT OF PRESSURE ULCERS

By Dana Tschannen, RN, PhD, Ondrea Bates, RN, MS, AkkeNeel Talsma, RN, PhD, and Ying Guo, PhD

CE 1.0 Hour

Notice to CE enrollees:

A closed-book, multiple-choice examination following this article tests your understanding of the following objectives:

1. Identify 4 patient characteristics that increase the surgical patient's risk of developing a pressure ulcer during hospitalization.
2. Describe the stages of pressure ulcers according to the National Pressure Ulcer Advisory Panel.
3. Discuss the importance of early pressure ulcer risk identification and incorporation in the surgical plan of care.

To read this article and take the CE test online, visit www.ajcconline.org and click "CE Articles in This Issue." No CE test fee for AACN members.

©2012 American Association of Critical-Care Nurses
doi: <http://dx.doi.org/10.4037/ajcc2012716>

Background Implementation of the ruling on the Inpatient Prospective Payment System by the Centers for Medicare and Medicaid has challenged nurses to focus on the prevention of pressure ulcers. Despite years of research, pressure ulcers are still one of the most common complications experienced by patients in health care facilities.

Objective To examine the relationship between patients' characteristics (age, sex, body mass index, history of diabetes, and Braden Scale score at admission) and care characteristics (total operating room time, multiple surgeries, and vasopressor use) and the development of pressure ulcers.

Methods In a cohort study, data from the electronic medical records of 3225 surgical patients admitted to a Midwest hospital, from November 2008 to August 2009 were analyzed statistically to determine predictors of pressure ulcers.

Results A total of 12% of patients (n = 383) had at least 1 pressure ulcer develop during their hospitalization. According to logistic regression analysis, scores on the Braden Scale at admission ($P < .001$), low body mass index ($P < .001$), number of vasopressors ($P = .03$), multiple surgeries during the admission ($P < .001$), total surgery time ($P < .001$), and risk for mortality ($P < .001$) were significant predictors of pressure ulcers.

Conclusion Scores on the Braden Scale at admission can be used to identify patients at increased risk for pressure ulcers. For other high-risk factors, such as low body mass index and long operative procedures, appropriate clinical interventions to manage these conditions can help prevent pressure ulcers. (*American Journal of Critical Care*. 2012;21:116-125)

With the increased focus on patient safety and quality of care, understanding how to prevent pressure ulcers has become a major interest in acute care hospitals. Approximately 2.5 million patients are treated for pressure ulcers in acute care facilities in the United States annually, and approximately 60 000 patients die each year of complications related to pressure ulcers. The Agency for Healthcare Research and Quality¹ reported a nearly 80% increase from 1992 to 2006 in hospital stays of patients with pressure ulcers, resulting in annual costs of \$11 billion for treatment related to the ulcers.²

A pressure ulcer is defined as any area of skin or underlying tissue that has been damaged by unrelied pressure or pressure in combination with friction and shear.³⁻⁵ Pressure ulcers occur when soft tissue is compressed between a bony prominence and an external surface for a prolonged time.⁶ Compression causes diminished blood supply, which in turn leads to decreased oxygen and nutrient delivery to the affected tissues. These decreases cause the affected tissue to become ischemic and potentially necrotic.⁷ The National Pressure Ulcer Advisory Panel⁶ has provided a mechanism for grading the stage of a pressure ulcer. The system has 6 stages: suspected deep-tissue injury, stage I, stage II, stage III, stage IV, and unstageable (see Table 1 for definitions). Regardless of stage, pressure ulcers can cause extreme discomfort and often lead to serious, life-threatening infections, which substantially increase the length of stay and total costs of care and compromise quality of life.⁸

In addition, in accordance with the ruling on the Inpatient Prospective Payment System by the Centers for Medicare and Medicaid,⁹ hospitals are no longer reimbursed for care related to stage III and stage IV pressure ulcers that develop during a hospital admission. The ruling provides a strong impetus for hospitals and researchers to better understand patients' risk factors and processes of care that may

contribute to increased risk for pressure ulcers. Pressure ulcers can develop in a short time (eg, 3 days for postoperative patients)¹⁰; therefore, the key to preventing ulcers is to accurately identify patients who are at risk for this complication. Patients undergoing surgical procedures who are immobile for long periods and are unable to change positions are at greater risk than are patients who are mobile.¹¹ Because of sedation and anesthesia, surgical patients cannot sense the numbness or pain that prolonged pressure causes and subsequently are unable to change position to relieve the pressure.

Research Purpose

The purpose of our study was to examine the relationship between patient and process characteristics and development of pressure ulcers in a population of surgical patients. Patients' characteristics, as noted in Figure 1, included age, sex, body mass index (BMI; calculated as the weight in kilograms divided by height in meters squared), Braden Scale score at admission, risk for mortality, and history of diabetes. Although these factors do not directly cause pressure ulcers, they may increase the risk for the ulcers.¹⁴ Process characteristics included maximum operating time, total operating time, number of surgeries during this admission, and use of vasopressors (a proxy for tissue perfusion).

The specific study questions were as follows:

1. What characteristics of surgical patients are associated with the development of pressure ulcers?
2. What process characteristics are associated with the development of pressure ulcers in surgical patients?

Methods

Design and Sample

This study used a cohort design. Data on all patients admitted to a Midwest hospital who had a

From 1992 to 2006, a nearly 80% increase in hospital stays of patients with pressure ulcers has been reported.

About the Authors

Dana Tschannen is a clinical assistant professor and **AkkeNeel Talsma** is an assistant professor at University of Michigan, School of Nursing, Ann Arbor, Michigan. **Ondrea Bates** is a clinical manager at Oakwood Hospital and Medical Center, Dearborn, Michigan. **Ying Guo** was a doctoral student at the University of Michigan School of Public Health when the study was done; she is now a biometrician at Merck Research Laboratories, Merck & Co., Inc, Rahway, New Jersey.

Corresponding author: Dana Tschannen, RN, PhD, Clinical Assistant Professor, University of Michigan, School of Nursing, 400 N Ingalls, Rm 4152, Ann Arbor, MI 48109 (e-mail: djvs@umich.edu).

Table 1
Characteristics of hospital and patients

Data variable	Conceptual definition	Source
Hospital's characteristics		
Maximum time in operating room	Longest time a patient spent on the operating room table (hours) while undergoing a single operation	Electronic medical record
Total time in operating room	Sum of all the time (hours) that a patient experienced in the operating room	Electronic medical record
Number of surgeries	Total number of surgeries a patient underwent during the hospitalization	Electronic medical record
Use of vasopressor medications	Use of a vasopressor medication (eg, dopamine, norepinephrine [Levophed], phenylephrine [NeoSynephrine], vasopressin) during the patient's hospital stay	Electronic medical record
Patients' characteristics		
Age	Patient's demographic (years)	Electronic medical record (admission H&P; FHPA)
Sex	Patient's demographic (male/female)	Electronic medical record (admission H&P; FHPA)
Body mass index	Calculated as the weight in kilograms divided by the height in meters squared (using the admission weight and height)	Electronic medical record (admission H&P; FHPA)
History of diabetes	Patient has diagnosis of diabetes mellitus (type 1 or 2)	Electronic medical record (admission H&P; FHPA)
Score on Braden Scale at admission	Determined by using the Braden pressure ulcer risk scale (computed as a sum of the subscale scores)	Electronic medical record
Risk for mortality	Specific to the APR DRG the patient is assigned and is based on the principal diagnosis (principal reason for the admission) and underlying diagnosis (secondary diagnosis)	Administrative database
Pressure ulcer ^a	Stage I: Intact skin with non-blanchable redness of a localized area usually over a bony prominence Stage II: Partial thickness loss of dermis presenting as a shallow open ulcer with a red pink wound bed, without slough Stage III: Full-thickness tissue loss. Subcutaneous fat may be visible but bone, tendon, or muscle are not exposed Stage IV: Full-thickness tissue loss with exposed bone, tendon, or muscle Deep tissue injury: Purple or maroon localized area of discolored intact skin or blood-filled blister due to damage of underlying soft tissue from pressure and/or shear Unstageable: Full-thickness tissue loss in which actual depth of the ulcer is completely obscured by slough (yellow, tan, gray, green, or brown) and/or eschar (tan, brown, or black) in the wound bed	Electronic medical record

Abbreviations: APR DRG, All Patient Refined Diagnosis Related Group; FHPA, functional health pattern assessment; H & P, health and physical.

^a Staging definitions based on those of the National Pressure Ulcer Advisory Panel.⁶

surgical procedure completed during the period November 1, 2007, to August 31, 2009, were included. Patients were included in the study if they had undergone surgery, were older than 18 years, and were admitted to 1 of the 5 study units (3 intensive care units and 2 intermediate care units) for more than 48 hours. Approval was obtained from the appropriate institutional review board before the study began.

Data Variables

Definitions for each of the study variables and the source of each variable are included in Table 1. A patient was considered to have a hospital-acquired pressure ulcer if the ulcer was documented in the medical record as a stage I or greater, as defined by the pressure ulcer staging guidelines developed by the National Pressure Ulcer Advisory Panel.⁶ Patients with a pressure ulcer at the time of admission were

included as having a hospital-acquired pressure ulcer only if an additional pressure ulcer developed during their hospital stay.

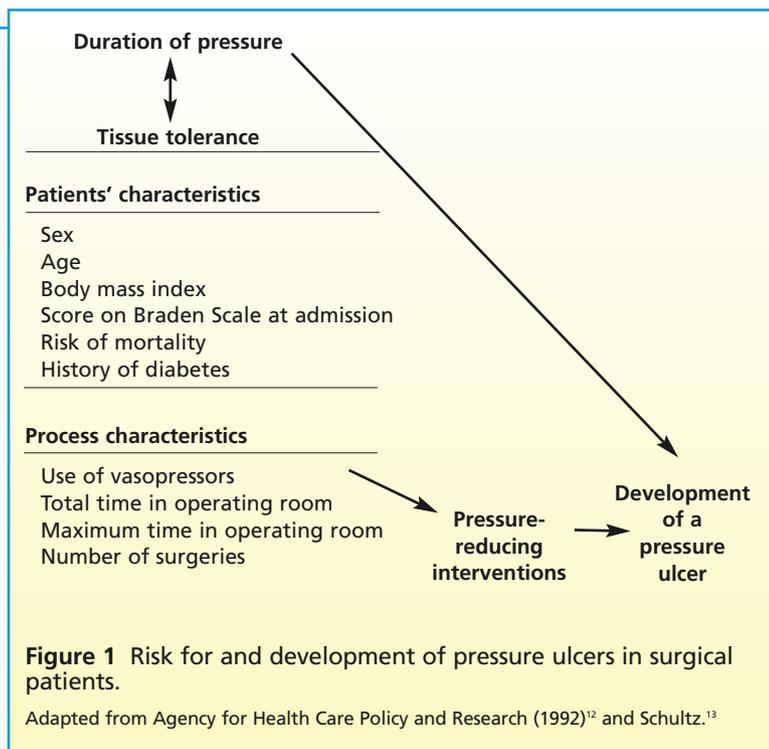
Process measures included number of surgeries during the admission, maximum time in the operating room, total time in the operating room, and use of vasopressors. Maximum time in the operating room referred to the longest time a patient spent on the operating room table while undergoing a single surgery. Total time in the operating room was the sum of all the time in the operating room that a patient experienced during the admission. The number of surgeries was computed as the total number of surgeries that a patient underwent during the admission. Finally, use of vasopressors referred to use of vasopressor medication during the hospital stay (yes/no).

Patients' demographics included age, sex, BMI, score on the Braden Scale at admission, history of diabetes, and risk for mortality. BMI was calculated by using the admission height and weight reported in the electronic medical record. BMI classification was as follows: less than 18.5, underweight, 18.5 to 24.9, normal; 25.0 to 29.9, overweight; and higher than 30.0, obese.¹⁵ Braden scores were determined by using the Braden Scale for pressure ulcer risk.¹⁶⁻¹⁹ The Braden risk assessment consists of 6 subscales: sensory perception, skin moisture, activity, mobility, friction and shear, and nutritional status.^{16,18} The total score ranges from 6 to 23. Lower scores indicate greater risk for the development of pressure ulcers. Correlations for pairs of raters that range from $r=0.99$ to $r=0.83$ ($P<.001$) have been reported.¹⁸ In studies^{18,19} on the predictive validity, sensitivity for a Braden score of 16 or less ranged from 83% to 100% and specificity from 64% to 90%. History of diabetes was determined by reviewing patients' medical records (either the admission history and physical or the functional health pattern assessment).

Risk of mortality was obtained by using All Patient Refined Diagnosis Related Group (APR DRG) software (3M Health Information Systems, Salt Lake City, Utah). Every DRG receives a score ranging from 1 to 4; low numbers indicate no or little risk of mortality, and 4 indicates an extreme risk of mortality.²⁰ On the basis of the principal diagnosis (ie, the diagnosis that is the reason for the admission), a DRG is assigned. Information about procedures, comorbid conditions, and so on is used to assign a risk-of-mortality score.

Data Analysis

All data were obtained from the electronic medical records and administrative databases with the



assistance of hospital nurse leaders and information technology staff. The data set was stripped of all patient identifiers to protect patients' anonymity. Data obtained were verified for completeness, odd values, and other inconsistencies. When extreme values could not be reconciled, the data were not included in the specific analyses. Univariate analysis was first applied to compare patients' characteristics and hospital process characteristics between patients who did and did not have a pressure ulcer develop. Specifically, for continuous variables, an unpaired *t* test was used for data with normal distribution, and the Mann-Whitney test was used for data without a normal distribution. For categorical variables, means of χ^2 tests or Fisher exact tests (as applicable) were compared. Statistical analyses included calculation of proportions for categorical variables and standard deviations for continuous variables. For multivariate analyses, logistic regression was applied. In order to avoid excluding potential factors too early, those variables with $P<.30$ at univariate analysis (ie, potential association with the development of pressure ulcers) were selected as potential candidates for entry into multivariate logistic regression analysis. A stepwise selection method was used to identify significant independent risk factors for the development of pressure ulcers. Variables included in the final model were at the significance level of $P<.05$. For variables entered in the

All patients who had a surgical procedure were included in the study.

Table 2
Characteristics of patients and hospital process compared between patients with and without development of a pressure ulcer (univariate analysis)^a

Characteristic	No pressure ulcer (n = 2842)	Pressure ulcer (n = 383)	P
Age, mean (SD), range, y	58.5 (15.9), 1-96	61.7 (15-95)	<.001
Body mass index, ^b mean (SD), range	28.9 (7.0) 13-76.2	27.6 (7.5), 12.8-67.3	<.001
Total time in operating room, mean (SD), range, h	5.4 (2.6), 0.2-23.5	6.9 (4.5) 0.5-36.6	<.001
Maximum time in operating room, mean (SD), range, h	5.3 (2.5), 0.2-23.5	6.3 (3.6), 0.5-23.7	<.001
Braden score on admission, mean (SD), range	17.0 (3.1), 6.0-24.0	14.8 (3.2), 6.0-23.0	<.001
Sex			.81
Female	1161 (40.8)	154 (40.2)	
Male	1681 (59.2)	229 (59.8)	
History of diabetes			<.001
No	2205 (77.6)	257 (67.1)	
Yes	637 (22.4)	126 (32.9)	
Use of vasopressors			<.001
No	2322 (81.7)	220 (57.4)	
Yes	520 (18.3)	163 (42.6)	
Number of surgeries			<.001
1	2749 (96.7)	332 (86.7)	
>1	93 (3.3)	51 (13.3)	
Risk of mortality			<.001
1	1072 (37.7)	29 (7.6)	
2	952 (33.5)	76 (19.8)	
3	563 (19.8)	130 (33.9)	
4	255 (8.9)	148 (38.6)	

^a Unless otherwise indicated, data are expressed as number (percentage).

^b Calculated as the weight in kilograms divided by the height in meters squared.

A pressure ulcer developed during hospitalization in 12% of the 3344 admissions.

final model, analysis of pair-wise interactions between the variables via a logistic regression entry procedure ($P < .05$) was done to determine whether these interactions significantly improved the model fits. The strength of the association between the dependent and independent variables was represented as the odds ratio (OR), with corresponding 2-sided 95% CIs.

The ability of the final model to predict the development of pressure ulcers was evaluated by using receiver operating characteristic (ROC) curves derived by plotting the true-positive rate (sensitivity) and false-positive rate ($1 - \text{specificity}$). Sensitivity is a measure of how many incidents (the development of a pressure ulcer) were successfully predicted, and specificity is the percentage of no incidents predicted. The model that produced an area under the curve nearest to a value of 1 was regarded as the most effective in predicting the development of a pressure ulcer. The Hosmer-Lemeshow goodness-of-fit test was also used to assess accuracy of the model.

With this approach, nonsignificant discrepancies between observed and predicted outcomes (ie, $P > .05$) indicate that the fit for a given model is acceptable. All statistical tests were 2-tailed, and P less than .05 was considered significant in all analyses. SAS 9.2 statistical software (SAS Institute Inc, Cary, North Carolina) was used for all analyses.

Results

Characteristics of the Sample

Complete data were available for 3344 admissions. For patients with multiple admissions, data on only the first recorded hospital admission were used, resulting in a final study population of 3225 patients. Of the patients in the study, 88% ($n = 2842$) did not acquire a pressure ulcer. In the remaining 12% ($n = 383$), at least 1 pressure ulcer developed during the patient's hospitalization. The mean age of the patients was 58.9 years (SD, 16.0). A total of 59.2% of the study population were men. The mean BMI was 28.7 (SD, 7.1; range, 12.8-76.2).

Table 2 provides an overview of patients' and process characteristics of the sample. With the exception of sex, process and patients' characteristics

differed significantly between patients who did and did not have development of a pressure ulcer. Patients in whom a pressure ulcer developed were older ($P < .001$), had longer total ($P < .001$) and maximum ($P < .001$) operating room times, and were more likely to have more than a single surgical procedure ($P < .001$). In addition, patients in whom a pressure ulcer developed were more likely to have diabetes ($P < .001$), be treated with vasopressors ($P < .001$), and be deemed at higher risk for mortality ($P < .001$). BMI values ($P < .001$) and Braden scores on admission ($P < .001$) were lower for patients in whom a pressure ulcer developed than for patients in whom no ulcer developed.

Multivariate Analysis

For multivariate logistic regression analysis, the dependent variable was development of a hospital-acquired pressure ulcer. Because of the high correlation between total and maximum operating room times, only the total time was included in the model. The initial model included 9 independent variables: age, sex, BMI, Braden score at admission, history of diabetes, risk of mortality, use of vasopressors, number of surgeries, and total operating room time. Table 3 shows the results of the multivariate logistic regression analysis. A total of 7 independent variables made a significant contribution to the development of a pressure ulcer: BMI, Braden score at admission, history of diabetes, risk of mortality, use of vasopressors, number of surgeries, and total operating time. The strongest predictors were risk of mortality (odds ratio [OR] range, 2.32-11.15; $P < .001$) and number of surgeries (OR, 2.23; $P < .001$). When all other factors in the model were controlled for, patients who had more than 1 surgery were more than 2 times more likely to acquire a pressure ulcer than were patients who had only 1 surgery. Likewise, patients with a mortality risk of 4 were 11 times more likely to acquire a pressure ulcer than were patients with a mortality risk of 1.

Total operating room time was also a significant predictor of pressure ulcers. Specifically, a 1-hour increase in time in the operating room increased the risk for pressure ulcers by 1.07 (OR, 1.07; 95% CI, 1.03-1.11; $P < .001$). In addition, patients who received vasopressors during their hospital stay were 33% more likely to acquire a pressure ulcer than were patients who did not receive vasopressors. Patients who had a history of diabetes were 49% more likely to acquire a pressure ulcer than were patients without such a history. The odds ratio for BMI was 0.97, indicating that each additional point increase in BMI reduced the risk for pressure ulcers

Table 3
Results of multivariate logistic regression analysis^a

Predictors	Odds ratio	95% CI	P
Body mass index	0.97	0.95-0.98	<.001
History of diabetes	1.49	1.14-1.95	<.001
Use of vasopressors	1.33	1.03-1.73	.03
Number of surgeries	2.23	1.45-3.44	<.001
Total time in operating room	1.07	1.03-1.11	<.001
Braden score at admission	0.89	0.86-0.93	<.001
Risk of mortality (reference, 1)			<.001
2	2.32	1.49-3.62	
3	5.50	3.58-8.45	
4	11.15	7.1-17.5	

^a Hosmer-Lemeshow goodness-of-fit test for this model: $\chi^2 = 12.5$, $df = 8$, $P = .13$.

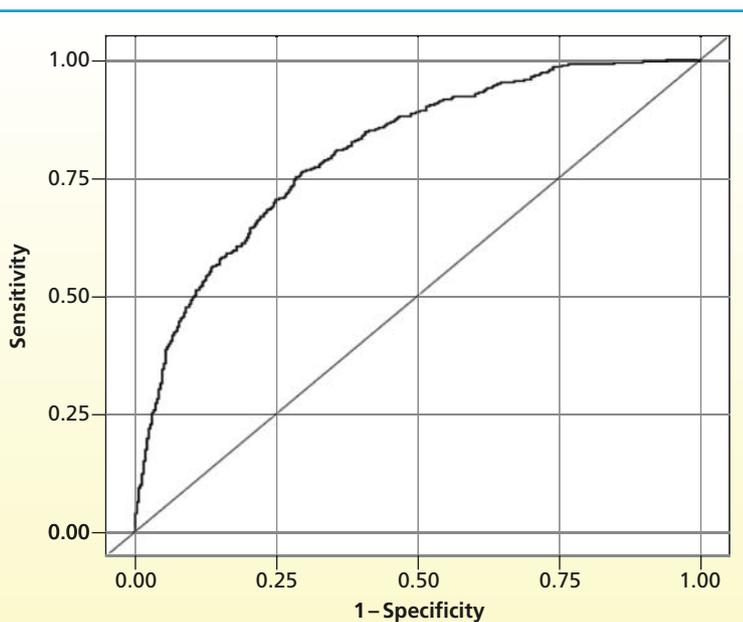


Figure 2 Receiver operating characteristic curve for the final multivariate logistic regression model derived from the patient and hospital process predictors of pressure ulcers (Table 3). Area under the curve = 0.81.

by 0.97. When all other factors in the model were controlled for, the odds ratio for the Braden score at admission was 0.89. This value indicates that for each additional point in the Braden score, the patient was 0.89 times less likely to acquire a pressure ulcer. Age was not a significant predictor of pressure ulcers.

The receiver operating characteristic curve (Figure 2) constructed from data in the final multiple logistic regression had an area of 0.81, indicating that the model closely reflected the data and was predictive of the development of pressure ulcers. The Hosmer-Lemeshow goodness-of-fit test for the

final model was not significant, also indicating a good model fit ($\chi^2 = 12.5$, $df = 8$; $P = .13$).

Discussion and Implications

The purpose of this study was to determine the impact of patients' and process characteristics on the development of a pressure ulcer. Our findings suggest that both types of characteristics play a significant role in the development of pressure ulcers in surgical patients. For process characteristics, total operating time and overall number of surgical procedures were significant predictors of pressure ulcers. When a patient is immobilized, the risk for pressure ulcers increases.¹¹ Lindgren et al²¹ found that 14.3% of surgical patients acquired a pressure ulcer during the time from surgery to 12

weeks after surgery, confirming the results of other studies.²²⁻²⁴ Specifically, Schoonhoven et al²⁴ found that total operating room time was significantly associated with the occurrence of pressure ulcers. For every 30 minutes the surgery went beyond 4 hours, the risk for a pressure ulcer increased by approximately 33%. In addition, further surgeries (ie, more than a single surgery) may result in more episodes of increased pressure on the capillaries when a patient is immobile because of sedation. This increase may in part be related to the amount of time a patient is completely immobile and unable to relieve pressure on bony prominences. During surgical procedures, the capillaries supplying the skin and subcutaneous tissues may be compressed enough to impede perfusion, leading ultimately to tissue necrosis (>32 mm Hg of pressure placed on the capillaries).²⁵

Use of vasopressors was also a significant predictor of pressure ulcers. Patients who receive vasopressors usually have an unstable hemodynamic status and compromised tissue perfusion, a situation that can lead to pressure ulcers.²⁶ According to Bliss,²⁷ circulation at the periphery is controlled in part by sympathetic vasoconstrictor impulses from the brain and secretions from localized endothelial cells. This control is impaired during illness, a situation that puts patients at greater risk for ischemia (ie, pressure ulcers).

When this impaired control is combined with administration of a vasoconstrictive drug, the risk for pressure ulcers increases.

Other patient-specific characteristics also increased the risk for pressure ulcers among surgical patients. The Braden score at admission was a significant independent predictor of pressure ulcers. To date, few studies²⁸⁻³⁰ in surgical patients have included investigation of the Braden score on admission as a possible predictor of pressure ulcers; our findings confirm that the score is useful in identifying high-risk patients. Lewicki et al²⁹ and Stordeur et al³⁰ reported that a Braden score at admission might be indicative of a high risk for pressure ulcers in surgical patients. Our results confirmed that patients with lower BMI scores, as noted by others,³¹ were also at greater risk for pressure ulcers than were patients with higher scores.

Van Gilder et al³² reported that pressure ulcers were more prevalent among patients with a lower BMI (25%; $P < .001$) than among patients in other BMI categories. Of interest, the mean BMI of patients in that study³² was 29.0 (SD, 9.0), slightly higher than the mean BMI in our study. In both the study of Van Gilder et al³² and our study, patients with low BMI values were still considered overweight (on average). We also found that pressure ulcers were more likely to occur in patients with the highest risk for mortality than in patients with lower risks. This finding again most likely is related to patients' unstable hemodynamic status, which sometimes results in poor tissue perfusion and organ failure, and to the inability to implement strategies (eg, turning) known to prevent pressure ulcers. In addition, patients in our study with a history of diabetes were at significantly greater risk for pressure ulcers than were patients without diabetes. This finding is in agreement with previous research³¹ and may also be related to poor perfusion.

In our study, age was not a significant predictor of pressure ulcers. This finding has been reported by other investigators,^{22,30} although other research^{28,33,34} has indicated a relationship between age and pressure ulcers. Stordeur et al³⁰ found that mean ages were 64 years (SD, 11.5) in patients who did not acquire a pressure ulcer and 67.1 years (SD, 10.7) in patients who did acquire an ulcer ($P = .06$). Although not significant, the mean age for patients in our study who acquired a pressure ulcer was greater than 60 years, a finding supported by Frankel et al.³⁵

Limitations

A limitation to our study was that only care units with a fully functional system for electronic medical records were included in the analysis. Therefore, surgical patients admitted to other areas of the institution (without the capacity to generate electronic

Patients who developed pressure ulcers were more likely to have diabetes and receive vasopressors.

During surgery, subcutaneous capillaries may be compressed, impeding perfusion, leading to tissue necrosis.

medical records) were not represented in the sample. In addition, generalizations from our findings are limited to similar populations of patients and do not reflect patients admitted for medical conditions. Finally, we included the development of stage I pressure ulcers in our outcomes analysis. This inclusion is in line with our idea that early identification of pressure ulcers (regardless of stage) leads to earlier treatment.

Implications for Nursing Practice

Efforts to prevent pressure ulcers in surgical patients starts at the time the decision is made that surgery is needed. Early identification can aid in the development of specific preoperative interventions to prevent the development of pressure ulcers during and immediately after surgery.³¹ Our findings suggest that the Braden score at admission is indicative of risk for pressure ulcers. In addition, other patient and hospital characteristics must be considered when an intervention plan is developed to reduce development of pressure ulcers. Surgical patients should receive a thorough skin assessment as well as an assessment of known risk factors for pressure ulcers (eg, history of diabetes, expected long procedure time, elderly age, low BMI) before surgery. This information should then guide the plan of care, including implementation of interventions (both during and after surgery) that can minimize the risk for pressure ulcers. These interventions should include, but are not limited to, turning patients every 2 hours, avoiding wrinkles in the linen under a patient, avoiding excessive linen between the patient and the bed, and identifying and managing any sources of moisture.³⁶ In addition, special padding may be considered for the intraoperative period if the surgical procedure is expected to be long,³⁶ or special mattresses can be ordered to ensure patients are immediately placed on a bed that minimizes risk of skin deterioration.

Development of a standard of care with a focus on early detection and prevention and a supportive documentation system are imperative for a well-developed program to prevent pressure ulcers. The National Pressure Ulcer Advisory Panel³⁶ and the European Pressure Ulcer Advisory Panel³⁷ both support this strategy. The first step is to ensure correct and uniform skin assessment on admission. We found that the score on the Braden Scale at admission was effective in flagging patients at increased risk for pressure ulcers. Review of specific subscales is necessary to determine specific interventions. Appropriate measures to prevent skin breakdown should be implemented, maintained, and reassessed on an ongoing basis.

Conclusion

Pressure ulcers continue to affect the lives of patients. Continued research is needed to fully understand this phenomenon and to form additional strategies for its prevention. We identified risk factors for the development of pressure ulcers in surgical patients. Understanding both patient- and process-related risk factors can assist nurses and the surgical team in determining which surgical patients are at higher than normal risk for pressure ulcers. Early identification and recognition of a patient's risk factors allow nurses across the continuum of care to implement prevention strategies at the earliest possible time to help prevent and decrease the development of pressure ulcers.

ACKNOWLEDGMENTS

We thank Ms S. Diccion-Macdonald for her support and Mr J. Gombert for providing access and technical support. We acknowledge the contributions of Ms K. McIlroy and other reviewers in preparing the manuscript.

FINANCIAL DISCLOSURES

Dr Talsma was funded by the Robert Wood Johnson Foundation Nurse Faculty Scholar Fellowship during the time this study took place.

eLetters

Now that you've read the article, create or contribute to an online discussion on this topic. Visit www.ajconline.org and click "Submit a response" in either the full-text or PDF view of the article.

SEE ALSO

For more about pressure ulcers, visit the *Critical Care Nurse* Web site, www.ccnonline.org, and read the article by Alderden et al, "Risk Profile Characteristics Associated With Outcomes of Hospital-Acquired Pressure Ulcers: A Retrospective Review" (August 2011).

REFERENCES

1. Russo CA, Steiner C, Spector W. Hospitalizations Related to Pressure Ulcers, 2006. HCUP Statistical Brief #64. December 2008. Rockville, MD: Agency for Healthcare Research and Quality, 2008. <http://www.hcup-us.ahrq.gov/reports/statbriefs/sb64.pdf>. Accessed January 5, 2012.
2. Institute for Healthcare Improvement. Prevent pressure ulcers. <http://www.ihl.org/IHI/Programs/Campaign/PressureUlcers.htm>. Accessed December 7, 2011.
3. Ayello EA, Baranoski S, Lyder CH, Cuddigan J. Pressure ulcers. In: Baranoski S, Ayello EA, eds. *Wound Care Essentials: Practice Principles*. 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007:254-286.
4. Institute for Clinical Systems Improvement. *Pressure Ulcer Prevention and Treatment Protocol*. 2nd ed. Bloomington, MN: Institute for Clinical Systems Improvement; April 2010:1-68.
5. European Pressure Ulcer Advisory Panel and the National Pressure Ulcer Advisory Panel. Pressure ulcer prevention: quick reference guide. http://www.npuap.org/Final_Quick_Prevention_for_web_2010.pdf. Published 2009. Accessed December 7, 2011.
6. National Pressure Ulcer Advisory Panel. Pressure ulcer stages revised by NPUAP. <http://www.npuap.org/pr2.htm>. Published 2007. Accessed December 7, 2011.
7. Baugh N, Zuelzer H, Meador J, Blankenship J. Wounds in surgical patients who are obese. *Am J Nurs*. 2007;107(6):40-50.

8. Russo CA, Steiner C, Spector W. *Hospitalizations Related to Pressure Ulcers Among Adults 18 Years and Older, 2006*. Rockville, MD: Agency for Healthcare Research and Quality; December 2008:1-9. HCUP Statistical Brief No. 64.
9. Centers for Medicare and Medicaid Services. Medicare and Medicaid move aggressively to encourage greater patient safety in hospitals and reduce never events [press release]. July 31, 2008. <https://www.cms.gov/apps/media/press/release.asp?Counter=3219&intNumPerPage=10&checkDate=&checkKey=&srchType=1&numDays=0&srchOpt=0&srchData=&keywordType=All&chkNewsType=1%2C+2%2C+3%2C+4%2C+5&intPage=&showAll=1&pYear=1&year=2008&desc=false&cbOrder=date>. Accessed January 5, 2012.
10. Karadag M, Gumuskaya N. The incidence of pressure ulcers in surgical patients: a sample hospital in Turkey. *J Clin Nurs*. 2006;15:413-421.
11. Lindgren M, Unosson M, Fredricksson, Ek AC. Immobility—a major risk factor for development of pressure sores among adult hospitalized patients: a prospective study. *Scand J Caring Sci*. 2004;18:57-64.
12. Agency for Health Care Policy and Research. *Pressure Ulcers in Adults: Prediction and Prevention*. Rockville, MD: Agency for Health Care Policy and Research, US Dept of Health and Human Services; May 1992. Clinical Practice Guideline, No. 3. Report No. 92-0047.
13. Schultz A. Home study program: predicting and preventing pressure ulcers in surgical patients. *AORN J*. 2005;81(5):986-1006.
14. Walton-Geer PS. Prevention of pressure ulcers in the surgical patient. *AORN J*. 2009;89(3):538-548.
15. Centers for Disease Control and Prevention. Body mass index calculator. <http://www.cdc.gov/healthyweight/assessing/bmi/>. Updated September 13, 2011. Accessed December 7, 2011.
16. Braden B, Bergstrom N. A conceptual schema for the study of the etiology of pressure sores. *Rehabil Nurs*. 1987;12:8-16.
17. Bergstrom N, Braden B, Kemp M, Champagne M, Ruby E. Predicting pressure ulcer risk: a multisite study of the predictive validity of the Braden Scale. *Nurs Res*. 1998;47(5):261-269.
18. Bergstrom N, Braden B, Laguzza, Holman V. The Braden Scale for predicting pressure sore risk. *Nurs Res*. 1987;36:205-210.
19. Bergstrom N, Demuth PJ, Braden BJ. A clinical trial for the Braden Scale for predicting pressure ulcer sore risk. *Nurs Clin North Am*. 1987;22:417-428.
20. Hughes J. Development of the 3M All Patient Refined Diagnosis Related Groups (APR DRGs). Agency for Healthcare Research and Quality Web site. <http://www.ahrq.gov/qual/mortality/Hughes3.htm>. Published February 2009. Accessed December 8, 2011.
21. Lindgren M, Unosson M, Krantz AM, Ek AC. Pressure ulcer risk factors in patients undergoing surgery. *J Adv Nurs*. 2005;50(6):605-612.
22. Kemp MG, Keithley JK, Smith DW, Morreale B. Factors that contribute to pressure ulcers in surgical patients. *Res Nurs Health*. 1990;13:293-301.
23. Hoshowsky V, Schramm C. Intraoperative pressure sore prevention: an analysis of bedding materials. *Res Nurs Health*. 1994;17:333-339.
24. Schoonhoven L, Defloor T, Grypdonck MH. Incidence of pressure ulcers due to surgery. *J Clin Nurs*. 2002;11(4):479-487.
25. Landis EM. Micro-injection studies of capillary blood pressure in human skin. *Heart*. 1930;15:209.
26. Lyder CH, Preston JA, Ahearn D, et al. *Medicare Quality Indicator System: Pressure Ulcer Predication and Prevention Module Final Report*. Bethesda, MD: Health Care Financing Administration; November 1998.
27. Bliss MR. Hyperaemia. *J Tissue Viability*. 1998;8(4):4-13.
28. Pokorny, ME, Koldjeski D, Swanson M. Skin care intervention for patients having cardiac surgery. *Am J Crit Care*. 2003;12:535-544.
29. Lewicki LJ, Mion L, Splane KG, Samstag D, Secic M. Patient risk factors for pressure ulcers during cardiac surgery. *AORN J*. 1997;65(5):933-942.
30. Stordeur S, Laurent S, D'hoore W. The importance of repeat risk assessment for pressure sores in cardiovascular surgery. *J Cardiovasc Surg*. 1998;39(3):343-349.
31. Lyder CH, Ayello EA. Pressure ulcers: a patient safety issue. In: Hughes RG, ed. *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville, MD: Agency for Healthcare Research and Quality; 2008:chap 12. <http://www.ncbi.nlm.nih.gov/books/NBK2650>. Published April 2008. Accessed December 8, 2011.
32. VanGilder C, MacFarlane G, Meyer S, Lachenbruch C. Body mass index, weight, and pressure ulcer prevalence: an analysis of the 2006-2007 international pressure ulcer prevalence surveys. *J Nurs Care Qual*. 2009;24(2):127-135.
33. Bergstrom N, Braden B, Norvell K, Lenaghab P, Boynton P. Diminished tissue tolerance: influence on pressure sore development in the institutionalized elderly. *Appl Nurs Res*. 1988;1(2):96.
34. Jesurum J, Joseph K, Davis JM, Suki R. Balloons, beds, and breakdown: effects of low-air loss therapy on the development of pressure ulcers in cardiovascular surgical patients with intra-aortic balloon pump support. *Crit Care Nurs Clin North Am*. 1996;8(4):423-440.
35. Frankel H, Sperry J, Kaplan L. Risk factors for surgical ulcer development in a best practice surgical intensive care unit. *Am Surg*. 2007; 73(12):1215-1217.
36. National Pressure Ulcer Advisory Panel. Pressure Ulcer Prevention Points. http://www.npuap.org/PU_Prevention_Points.pdf. Revised 2007. Accessed December 9, 2011.
37. European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel. Prevention and treatment of pressure ulcers: quick reference guide. Washington, DC: National Pressure Ulcer Advisory Panel; 2009. http://www.epuap.org/guidelines/Final_Quick_Prevention.pdf. Published 2007. Accessed January 5, 2012.

To purchase electronic or print reprints, contact The InnoVision Group, 101 Columbia, Aliso Viejo, CA 92656. Phone, (800) 899-1712 or (949) 362-2050 (ext 532); fax, (949) 362-2049; e-mail, reprints@aacn.org.

CE Test Test ID A1221021: Patient-Specific and Surgical Characteristics in the Development of Pressure Ulcers.

Learning objectives: 1. Identify 4 patient characteristics that increase the surgical patient's risk of developing a pressure ulcer during hospitalization. 2. Describe the stages of pressure ulcers according to the National Pressure Ulcer Advisory Panel. 3. Discuss the importance of early pressure ulcer risk identification and incorporation in the surgical plan of care.

1. What is the annual cost of treating pressure ulcers in hospitalized patients reported by the Agency for Healthcare Research and Quality?

- a. \$80 000
- b. \$600 000
- c. \$2.5 million
- d. \$11 billion

2. How many stages are included in the National Pressure Ulcer Advisory Panel grading system?

- a. 3
- b. 5
- c. 6
- d. 7

3. When soft tissue is compressed between a bony prominence and an external surface for an extended period, which of the following is the result?

- a. Increased delivery of nutrition to the tissue
- b. Increased ischemia in the tissue
- c. Increased oxygen delivery to the cells
- d. Increased blood flow to the tissue

4. A patient with a body mass index (BMI) of 23 would be classified as which of the following?

- a. Underweight
- b. Normal weight
- c. Overweight
- d. Obese

5. Which of the following risk factors for pressure ulcers is not part of the Braden Scale?

- a. History of diabetes
- b. Impaired nutritional status
- c. Decreased activity
- d. Increased shear

6. Which of the following characteristics was the least significant in predicting pressure ulcers in this study?

- a. Low BMI
- b. Use of vasopressors
- c. Age
- d. History of diabetes

7. Which of the following was a limitation in the study?

- a. The entire hospital did not have electronic documentation.
- b. Medical and surgical patients had the same classification.
- c. Pressure ulcers were only included if they were stage II or higher.
- d. There was a control group included in the study.

8. Which of the following risk factors should be included in the assessment for pressure ulcers on the preoperative patient?

- a. Anticipated procedure time of 1 hour
- b. BMI of 24
- c. Age of 85 years
- d. Admission Braden score 22

9. The patient has a 3 cm localized area on her sacrum with visible subcutaneous fat noted. How would the nurse stage this area?

- a. Unstageable
- b. Stage IV
- c. Stage III
- d. Stage II

10. The patient has a brown, firm, 4 cm localized area on his hip. How would the nurse stage this area?

- a. Unstageable
- b. Stage IV
- c. Stage III
- d. Stage II

11. Which of the following categories of Risk of Mortality was associated with the highest risk of developing pressure ulcers in this study?

- a. 1
- b. 2
- c. 3
- d. 4

Test ID: A1221021 Contact hours: 1.0 Form expires: March 1, 2014. Test Answers: Mark only one box for your answer to each question. You may photocopy this form.

- | | | | | | | | | | | |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|--------------------------------|--------------------------------|
| 1. <input type="checkbox"/> a | 2. <input type="checkbox"/> a | 3. <input type="checkbox"/> a | 4. <input type="checkbox"/> a | 5. <input type="checkbox"/> a | 6. <input type="checkbox"/> a | 7. <input type="checkbox"/> a | 8. <input type="checkbox"/> a | 9. <input type="checkbox"/> a | 10. <input type="checkbox"/> a | 11. <input type="checkbox"/> a |
| <input type="checkbox"/> b | <input type="checkbox"/> b |
| <input type="checkbox"/> c | <input type="checkbox"/> c |
| <input type="checkbox"/> d | <input type="checkbox"/> d |

Fee: AACN members, \$0; nonmembers, \$10 Passing score: 8 correct (73%) Category: A, Synergy CERP A Test writer: Marylee Bressie, RN, MSN, CCRN, CCNS, CEN.

AMERICAN
ASSOCIATION
of CRITICAL-CARE
NURSES

For faster processing, take this CE test online at www.ajconline.org ("CE Articles in This Issue") or mail this entire page to: AACN, 101 Columbia, Aliso Viejo, CA 92656.

Program evaluation

- | | Yes | No |
|--|--------------------------|--------------------------|
| Objective 1 was met | <input type="checkbox"/> | <input type="checkbox"/> |
| Objective 2 was met | <input type="checkbox"/> | <input type="checkbox"/> |
| Objective 3 was met | <input type="checkbox"/> | <input type="checkbox"/> |
| Content was relevant to my nursing practice | <input type="checkbox"/> | <input type="checkbox"/> |
| My expectations were met | <input type="checkbox"/> | <input type="checkbox"/> |
| This method of CE is effective for this content | <input type="checkbox"/> | <input type="checkbox"/> |
| The level of difficulty of this test was: | | |
| <input type="checkbox"/> easy <input type="checkbox"/> medium <input type="checkbox"/> difficult | | |
| To complete this program, it took me _____ hours/minutes. | | |

Name _____ Member # _____

Address _____

City _____ State _____ ZIP _____

Country _____ Phone _____ E-mail address _____

RN License #1 _____ State _____

RN License #2 _____ State _____

Payment by: Visa M/C AMEX Check

Card # _____ Expiration Date _____

Signature _____

The American Association of Critical-Care Nurses is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation. AACN has been approved as a provider of continuing education in nursing by the State Boards of Nursing of Alabama (#ABNP0062), California (#01036), and Louisiana (#ABN12). AACN programming meets the standards for most other states requiring mandatory continuing education credit for relicensure.

Copyright of American Journal of Critical Care is the property of American Association of Critical-Care Nurses and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.