J Wound Ostomy Continence Nurs. 2018;45(2):131-136.
Published by Lippincott Williams & Wilkins

Predictors of Pressure Injuries in a Critical Care Unit in Lebanon

Prevalence, Characteristics, and Associated Factors

Jihad El-Marsi ◆ Salah Zein-El-Dine ◆ Bana Zein ◆ Rita Doumit ◆ Lina Kurdahi Badr

ABSTRACT

PURPOSE: The purpose of this study was to identify factors associated with pressure injury in a medical-surgical intensive care unit (MSICU).

DESIGN: Retrospective review of medical records.

SUBJECTS AND SETTING: We reviewed the medical records of 145 patients who developed a new pressure injury in the MSICU of a 420-bed university medical center in Lebanon.

METHODS: Medical records of all patients cared for in the MSICU from December 2014 to June 2017 were reviewed by a research assistant using a standardized form. We extracted potential risk factors for pressure injury including sex, age, weight upon admission, weight at discharge, length of MSICU stay, episodes of hypotension, administration of inotropes/vasopressors, admitting diagnosis, comorbid conditions, and cumulative scores on the Braden Scale for Pressure Sore Risk. The outcome variable was development of any new pressure injury during their stay in our intensive care unit.

RESULTS: Forty-nine patents (33.7%) developed a new pressure injury. Bivariate analysis found statistically significant associations between pressure injury occurrences and administration of vasopressors (odds ratio [OR] = 0.42; 95% confidence interval = 0.29-0.87; $P = .02$), the administration of dopamine (OR = 0.20; 95% confidence interval = 0.04-0.94; $P = .04$), and hospital-acquired pressure injury. Among the continuous variables, analysis revealed significant relationships between weight at discharge ($t = 2.31$, $P = .02$), MSICU length of stay ($t = 5.30$; $P = .000$), cumulative Braden Scale score ($t = 3.06$; $P = .002$), hypotension ($t = -2.74$; $P = .007$), and development a new pressure injury. Multivariate analysis indicated that length of stay ($\beta = -.110$; $P = .002$), administration of vasopressors ($\beta = -.266$; $P = .029$), and total hours of hypotension ($\beta = -.53$; $P = .041$) were significant predictors of pressure injury.

CONCLUSIONS: Vasopressor use, hypotension, and length of stay were associated with an increased likelihood of pressure injury in adults managed in an MSICU. None of these factors is specifically evaluated during completion of the Braden Scale for Pressure Sore Risk. Based on these findings we recommend development of a pressure injury scale specific to critically ill adults.

KEY WORDS: Critical care, Pressure injury, Pressure ulcer, Risk factors, Vasopressors.

INTRODUCTION

The prevalence of pressure injuries (PIs) varies based on several factors including geographic locations, type of hospital surveyed, nurse staffing and patient acuity. Although reported prevalence rates overlap, high-income countries based on gross domestic product per capita such as Germany, Australia, and the United States generally report lower prevalence rates, 7% to 14%[1-3] as compared to reported rates of 8% to 66% in middle-income or developing countries such as Jordan, Brazil, and Indonesia.[4-6] Variability in reported prevalence rates may be influenced by the methods and calculations used in reporting (eg, whether prevalence was calculated at admission or during hospitalization and whether grade I was included) and when the data were collected.[7,8]

The National Pressure Ulcer Advisory Panel defines a PI as a localized injury to the skin or underlying soft tissue caused by pressure or sharing forces or related to use a medical device.[9] Advances in medical technology, the use of prevention programs and bundles of care based on clinical practice guidelines, have decreased the prevalence of PIs over the years; nonetheless, the problem remains of significant concern to health professionals and institutions.[3]

Pressure injuries in intensive care units (ICUs) are significantly higher than in non-ICU hospitalized patients, ranging between 8% and 56%, also varying between intuitions and countries.[10-13] A study in Australia found that patients cared for in the ICU were 3.8 times more likely to develop a PI compared to patients in other hospital units.[12] This differences

Jihad El-Marsi, RN, MSN, *Lebanese American University Medical Center, Beirut, Lebanon.*

Salah Zein-El-Dine, MD, *American University of Beirut Medical Center, Beirut, Lebanon.*

Bana Zein, RN, MSN, *Medical Surgical Unit, American University of Beirut Medical Center, Beirut, Lebanon.*

Rita Doumit, PhD, RN, *School of Nursing, Lebanese American University, Byblos, Lebanon.*

Lina Kurdahi Badr, PhD, RN, FAAN, *School of Nursing, Azusa Pacific University, Azusa, California.*

The authors declare no conflicts of interest.

Correspondence: *Salah Zein-El-Dine, MD, Internal Medicine, American University of Beirut Medical Center, Beirut, Lebanon (sz01@aub.edu.lb).*

DOI: 10.1097/WON.0000000000000415

are postulated to be primarily attributable to the acuity of the underlying illness and comorbid conditions, leading to the need for intubation and mechanical ventilation, administration of sedatives that diminish sensory perceptions, along with episodes of hypotension requiring administration of vasoactive drugs that alter peripheral blood flow.[14,15]

Critical care nurses must prevent PIs whenever possible, and promptly treat existing injuries to prevent them from evolving into higher stage wounds.[16] Although several screening tools such as the Braden, Waterlow, and Norton scales are used in clinical practice,[17-19] their predictive power in ICU patients is less than it is in other care settings.[20-25] A systematic review of 16 studies identified 7 factors associated with development of a facility-acquired PI in critically ill patients; they were age, prolonged stay in the ICU, diabetes mellitus, cardiovascular disease, hypotension, prolonged mechanical ventilation, and vasopressor administration.[26] Another systematic review of 12 studies[27] focusing on critically ill cardiac surgery patients found that vasopressor use, cardiopulmonary bypass time, and body temperature were associated with PI development. The purpose of this study was to identify factors associated with development of PIs in ICU patients in Lebanon. Specific objectives of this study were (1) to assess the rates and characteristics of hospital-acquired pressure injuries (HAPIs) in ICU patients, (2) to compare potential risk factors in patients who develop a HAPI and those who do not develop a HAPI, and (3) to identify factors other than those evaluated on the Braden Scale for Pressure Sore Risk that were most predictive of a HAPI in critically ill patients.

METHODS

We retrospectively reviewed medical records of patients admitted to our medical-surgical intensive care unit (MSICU) in order to determine risk factors associated with a PI. The study was conducted at a tertiary urban medical center in Lebanon, the American University of Beirut Medical Center (AUBMC). The AUBMC hospital is a 420-bed tertiary care center providing inpatient and outpatient services for the people of Lebanon and the Middle East. Our hospital is Joint Commission International accredited and magnet designated; it provides medical, surgical, and specialized services and admits around 30,000 patients a year. The MSICU has 12 beds, and approximately 650 admissions a year with a ratio of 1 nurse to 1 to 2 critically ill patients. All patients are placed on alternating mattresses to prevent PI, are turned every 2 hours, and are assessed via the Braden Scale for Pressure Sore Risk upon admission. We have 20 skin care champion nurses who receive extensive training on the staging of PIs and act as resource persons in assessing patients using the Braden Scale, and rates are regularly compared with the National Database of Nursing Quality Indicators. All RNs attend workshops that review new policies related to PI prevention, hands-on skill training, and competency validation.[20]

Medical records of patients admitted to the MSICU between December 2014 and June 2017 were audited using systematic selection process until a sample of 145 patients was reached. Based on a previous study[28] where an odds ratio (OR) of around 2 in favor of developing a PI in high-risk patients detected a significant difference using a logistic regression model with an α level of .05 and a power of 80% power, we determined that a minimum sample of 125 patients was sufficient to meet the purposes of this study. Additional patient records reviewed in case records revealed insufficient data to allow analysis. Inclusion criteria were patients 17 years or older cared for in our MSICU for more than 24 hours. Patients were excluded if they had burns or had died during their MSICU stay. Pressure injuries present on admission to the MSICU were not included in our analysis. However, patients with a PI on admission were included in our analysis if they developed a *new* PI during their ICU stay. The study was approved by the institutional review board of the American University of Beirut, protocol number NU04.

Instruments

We used the new National Pressure Ulcer Advisory Panel revised grading system to classify each PI, and recorded its anatomic location.[2] Pressure injury risk was assessed using the Braden Scale for Pressure Sore Risk.[20] The Braden Scale comprises 6 subscales: sensory perception, moisture, activity, mobility, nutrition, and friction and shear. Subscales are rated from 1 (least favorable) to 4 (most favorable), with the exception of friction and shear, which is rated from 1 to 3. The subscales are added to generate a cumulative score. Lower cumulative scores indicate a higher risk for PI. While the predictive power of the Braden Scale has proved robust in multiple care settings, it is less robust when applied to critically ill patients.[21-25]

Identification of Potential Risk factors

Based on previous studies in ICUs, we identified factors (variables) not included in the Braden Scale in order to determine their potential influence on HAPI occurrences.[15,22,23,29,30] They included gender, age, weight at discharge, length of stay in the MSICU, hypotension (operationally defined as total number of hours during the first 48 hours in the ICU that the patient had a systolic blood pressure <90 mm); this definition is consistent with criteria recommended by the National Heart, Lung, and Blood Institute of the US National Institutes of Health.[31] Additional factors identified were administration of inotropes/vasopressors such as phenylephrine, dobutamine, norepinephrine, dopamine, admitting diagnosis, and comorbid conditions such as diabetes mellitus and vascular disease.

Study Procedures

Medical records of all patients cared for in our MSICU from December 2014 to June 2017 were reviewed by a research assistant (B.Z.) every week until 220 records were reviewed. These records were not generated or stored in an electronic format. Records included in our analysis were systematically selected using every fifth medical record and all information was recorded on a standardized form. Data extracted included patient characteristics, stage and anatomic location of HAPIs, and presence of possible risk factors identified earlier.

Data Analysis

All data were entered on SPSS 24 (SPSS, Chicago, Illinois). Patient characteristics were descried using mean and standard deviations for continuous variables and number and percentages for categorical variables. The prevalence and location of HAPIs were described in numbers and percentages. Bivariate analysis using OR or χ^2 was conducted to assess the association of a PI with a categorical risk factor: gender, administration of inotropes/vasodilators (norepinephrine, dobutamine, and phenylephrine), administration of dopamine, and admitting diagnosis. Diagnosis was categorized into medical (respiratory disease, shock/trauma, sepsis, cardiovascular/cardiac arrest, and gastroenterology/hepatology) or general surgery. Comorbid

conditions were categorized as (1) no comorbid conditions or (2) one or more comorbid conditions. *t* Tests were used to compare continuous variables: age, weight upon arrival and discharge, MSICU length of stay, cumulative Braden Scale score upon arrival to the MSICU, and episodes of hypotension within the first 48 hours of admission to pour the ICU. Logistic regression modeling was completed using variables significant at *P* values < .05 in the bivariate analysis. The Hosmer-Lemeshow *r* test assesses the goodness of fit of the regression model; specifically, it evaluates whether the observed event rates match expected event rates in each of the subgroups.

RESULTS

The sample comprised 145 patients; their mean age—mean (standard deviation)—was 65.07 (19.91) years; 30 patients (43%) were between 60 and 80 years of age. Their mean weight upon admission was 76.2 (17.3) kg—168 (38) lb; their mean weight upon discharge was 77.15 (14.92) kg—170 (33) lb. The mean length of stay in our MSICU was 9.92 (10.2) days. Nearly three-quarters of patients (n = 103, 74%) had a Braden Scale score <10, indicating high or very high risk for developing a PI. Almost one-third of them had hypotensive episodes; the mean duration of these episodes was 2.16 (3.39) hours. Eighty-two patients (57%) did not receive inotrope/vasoactive drugs. The most common admitting diagnosis was cardiovascular diseases or cardiac arrest (40%, n = 58) followed by respiratory disease; 117 (81%) had one or more comorbid conditions. Demographic and pertinent clinical characteristics are summarized in Table 1.

HAPI Rates and Characteristics

Slightly more than one-third of patients (n = 49, 33.7%) developed a HAPI during their MSICU stay. Most (n = 34, 69.3%) were stage 2, 9 (18.4%) were stage 1, 2 were unstageable, 1 was stage 3, 1 was classified as a deep tissue pressure injury, and 2 patients had more than 1 HAPI. Twenty-five patients (51%) had 1 pressure injury, 19 (38.8%) had 2, and 5 patients (10.2%) had 3 pressure injuries. The sacral area was the most common anatomic site (n = 24, 50%), followed by the ischial tuberosity (n = 12, 24.5%), heel (n = 10, 20.4%), and nasal bridge (n = 3, 6.1%, Table 2).

Factors Associated With HAPI

Bivariate analysis of categorical (nominal) variables revealed statistically significant relationships between the administration of vasopressors (OR = 0.42, 95% confidence interval = 0.29-0.87, *P* = .02), dopamine (OR = 0.20, 95% confidence interval = 0.04-0.94, *P* = .04), and HAPI. Among the continuous variables, analysis revealed significant relationships between PI occurrences and weight at discharge (*t* = 2.31, *P* = .02), MSICU length of stay (*t* = 5.30, *P* = .000), cumulative Braden Scale score (*t* = 3.06, *P* = .002), hypotensive episodes (*t* = −2.74, *P* = .007, Table 3).

Multivariate analysis indicated that length of stay (β = −.110; *P* = .002), administration of vasopressors (β = −.266; *P* = .029), and total hours of hypotension (β = −.53; *P* = .041) were significant predictors of HAPI. Collectively, these factors explained 38% of the variance, R^2 = 0.376 (Table 4). The Hosmer-Lemeshow statistic was χ^2 1.52, *P* = .82, indicating adequate fit between the variables and the outcome.

TABLE 1.
Demographic and Clinical Characteristics of the Study Sample (N = 145)

Characteristic	Mean (SD)	n (%) Rounded
Gender		
Male		79 (54.5)
Female		66 (45.5)
Age, y	65.07 (19.91)	
Length of stay, d	12.21 (5.51)	
Weight upon admission	76.21 (17.34)	
Weight upon discharge	77.15 (14.92)	
Hypotension (SBP <90 mm Hg for at least 1 h to a maximum of 15 h)	2.16 (3.39)	
Total Braden score	11.32 (2.63)	
Administration of vasopressors/inotropic medications		
None		82 (57)
Norepinephrine		36 (25)
Dobutamine		2 (1)
Phenylephrine		3 (2)
Dopamine		13 (9)
Combination (norepinephrine + dobutamine or phenylephrine)		9 (6)
Intensive care admitting diagnosis		
Cardiovascular/cardiac arrest		35 (24)
Respiratory disease		23 (16)
Shock/trauma		17 (12)
Sepsis		13 (9)
Gastroenterology/hepatology		12 (8)
General surgical problems		43 (31)
Comorbid conditions		
None		28 (19)
Diabetes mellitus		25 (17)
Cardiovascular disease		27 (19)
Cancer		20 (14)
Infection/sepsis		16 (11)
Kidney disease		16 (11)
Vascular disease		13 (9)

Abbreviations: SBP, systolic blood pressure; SD, standard deviation.

DISCUSSION

Slightly more than one-third of patients (33.7%) developed a PI during their MSICU stay. This occurrence rate is higher than that reported in some studies conducted in critically ill patients in developed counties,[12,25,32] but consistent with several rates reported in developing or middle-income countries. Specifically, a study of critically ill patients in Saudi Arabia reported an occurrence rate of 39.3%[13] and a study of critically ill patients in Brazil reported a rate of 52.9%.[33] The influence of geographic region or economic status of a given country on HAPI rates

TABLE 2.
Sites for the HAPI

Site	n (%)
Sacral	21 (42.8)
Ischial tuberosity	11 (22.5)
Heel	9 (18.4)
Nasal bridge	2 (4.1)

is not entirely understood. The lower incidence rates of HAPI reported in the developed world may be influenced by legislation, which provides economic or quality penalties for their occurrences, nurse-to-patient staffing ratios, and frequency of preventive interventions.[34,35]

The most common anatomic locations of HAPIs in this study are consistent to most earlier reports in ICUs where around 40% to 60% are in the sacral area due to positioning in the supine position.[25,36,37] The majority of patients in this study (46%) had stage 2 PIs, which is consistent with results of some studies.[21,25,36] Nevertheless, other researchers reported stage 1 PIs as most common.[13,16,37] This variability may attributable to whether some studies reported stage 1 PIs.

Bivariate analysis identified 6 factors associated with a HAPI during a patient's MSICU stay: administration of dopamine, administration of vasopressors/inotropes, cumulative Braden Scale score, MSICU length of stay, weight at discharge, and episodes of hypotension. Our understanding of the influence of dopamine administration on PI development is limited.[15,30] Nijs and colleagues[30] observed that while dopamine administered as a dose of more than 15μg/kg/min was related to the occurrence of PIs in bivariate analysis, this relationship did not persist on multivariate analysis. In contrast, Cox and Roche[15] found that the total number of hours of low-dose dopamine (1-5 μg/kg/min) was associated with a higher rate of PI occurrences. Dopamine is a vasodilator at low doses and a vasoconstrictor at higher dosages.[38] The pharmacologic action of dopamine is more potent at β-2 versus α-receptors with the arteriolar wall; activation of β-2 receptors causes vasodilation whereas activation of α-receptors causes vasoconstriction. Therefore, when administered at lower doses, dopamine is likely to exert an effect on β-2 receptors in the vascular system. Nevertheless, cutaneous blood vessels mostly contain α-receptors with few or no β-2 receptors. As a result, dopamine is postulated to cause vasoconstriction at higher or lower doses, possibly influencing the patient's risk for PI.

TABLE 3.
Differences in Patients Who Did or Did Not Develop a HAPI

Independent Variables Categorical	No HAPI (n = 96) N (%)	Yes HAPI (n = 49) N (%)	OR (CI)/χ^2	*P* Value
Gender				
Male	40 (57)	37 (77)	0.75 (0.42-1.37)	.33
Female	30 (43)	33 (63)		
Vasopressor agents				
Yes	6 (9)	39 (56)	0.43 (0.29-0.87)	.00
No	54 (77)	19 (27)		
Dopamine				
Yes	2 (3)	10 (14)	0.20 (0.04-0.94)	.04
No	8 (11)	2 (3)		
Respiratory disease	10 (14)	11 (17)	χ^2= 3.63	.76
Shock/trauma	9 (13)	7 (11)		
Sepsis	10 (20)	11 (16)		
Cardiovascular/cardiac arrest	14 (23)	15(24)		
Gastroenterology/hepatology	7 (10)	5 (7)		
General surgical problems	20 (29)	21 (34)		
Comorbidities				
Yes	55 (79)	58 (83)		
No	15 (21)	12 (17)		
Independent Variables Continuous	**Mean (SD)**	**Mean (SD)**	***t* Test**	***P* Value**
Age	64.15 (15.2)	665.31 (15.4)	0.90	.37
Weight upon arrival to MSICU	76.31 (16.34)	77.42 (11.51)	0.81	.39
Weight upon transfer/discharge	76.63 (16.47)	80.79 (15.29)	2.31	.02
Length of stay in ICU	10.05 (3.68)	14.36 (2.98)	5.30	.00
Total Braden score upon arrival to ICU	12.43 (5.37)	8.82 (6.69)	3.06	.00
Hypotension	1.06 (1.39)	3.05 (2.67)	–2.75	.00

Abbreviations: CI, confidence interval; HAPI, hospital-acquired pressure injury; ICU, intensive care unit; MSICU, medical-surgical intensive care unit; OR, odds ratio; SD, standard deviation.

TABLE 4.
Multiple Regression for the Occurrence of a HAPI

Variable	β	SE	OR (CI)	*P* Value
Length of stay in the MSICU	−.110	0.035	0.46 (0.34-0.96)	.002
Weight upon transfer/discharge from the MSICU	−.171	0.931	0.86 (0.78-1.98)	.641
Total Braden score upon arrival to the MSICU	.137	0.113	1.48 (0.86-2.33)	1.474
Total number of hours in the first 48 h in the MSICU that the patient had a systolic blood pressure <90 mm Hg	−.053	0.078	0.45 (0.26-0.85)	.041
Administration of vasopressor/inotropic agents	−.266	0.131	0.77 (0.25-0.92)	.029

Abbreviations: CI, confidence interval; HAPI, hospital-acquired pressure injury; MSICU, medical-surgical intensive care unit; OR, odds ratio; SE, standard error.

Patients with more weight at discharge were more likely to develop a HAPI. Weight may increase the risk for PI due to pressure on the blood vessels and at bony prominences, diminishing local blood supply and oxygen delivery. Moreover, obese patients may have chronic impairment of perfusion to the skin and may be more difficult to turn every 2 hours, which increases their risk for PI.[15,39,40] In contrast, some studies find that underweight is associated with PI occurrences.[41,42] The inconsistencies in findings may be explained by the nonlinear relationship between body mass index and PI development[7]; additional studies are needed to provide conclusive evidence.

Cumulative Braden Scale scores were also related to HAPI. However, 74% of our patients were deemed at risk for PI with a cumulative Braden Scale score of 10 or less, while 33.8% developed a HAPI. Even though some studies find the Braden Scale to be predictive of HAPIs in critically patients,[15,37] our study is in line with others whose results suggest that the Braden Scale's ability to predict HAPI risk is limited in the ICU setting.[21,22,25]

Multivariate Analysis

The variables that remained significant in our multivariate analysis were administration of vasopressors, length of MSICU stay, and hypotension. The relationship between the administration of vasopressors and increased HAPI occurrences is consistent with several earlier studies.[15,26,30,43,44] In our facility, norepinephrine is typically the first vasopressor used to treat hypotension; it was given as a first-line vasopressor to 25% of our patients as compared with 4% who also received dobutamine and/or phenylephrine. Although vasopressors are frequently essential in the care of critically ill patients, they cause vasoconstriction, which may contribute to development of HAPI,[21] and we advocate their inclusion in any PI risk assessment specifically designed for critically ill patients.

The statistically significant relationship between hypotension and HAPI we found on multivariate analysis is consistent with results of several previous studies.[21,45] In addition, Man and Au-Yeung[46] found that a hypotensive episode (systolic blood pressure ≤90 mm Hg) was associated with PI occurrences in an ICU setting. Similarly, in a retrospective review, 345 ICU patients experiencing episodes of systolic blood pressure less than 90 mm Hg were more than 3 times likely to develop a PI than were patients who did not experience hypotensive episodes.[47] Ranzani and colleagues[25] reported that a mean arterial pressure less than 60 mm Hg at admission to the ICU was predictive of PI in a large sample of 9605 critically ill patients. The cut point of diastolic pressure and duration of hypotension remain unclear and warrant further study.

The third factor that emerged as significant on multivariate analysis was a longer MSICU stay; this finding is also consistent with several earlier studies.[26,36,47] In a prospective cohort study of 84 ICU patients in Saudi Arabia, Tayyib and colleagues[13] found that patients who developed a PI averaged a 4-day longer ICU course than did patients who did not develop a PI. Cremasco and associates[48] studied 160 ICU patients in Brazil and reported that patients who stayed more than 24 days in the ICU were more likely to develop a pressure injury when compared to those who stayed less than 9 days.

Limitations

There are limitations of the study. We collected data retrospectively and relied on nursing notes concerning the staging of HAPI. While nurses at our facility receive intensive training on PI assessment, documentation, and prevention, it is not possible to determine whether some PIs were missed on not documented on the patient's medical record. In addition, data were extracted from a single institution and generalization of findings to other ICUs is limited. We did not collect potential variables that may have emerged as significant such as days on mechanical ventilation, positioning, and mortality. Additional studies with large samples and multiple intensive care settings are recommended.

CONCLUSIONS

We evaluated patients managed in a medical and surgical ICU in Lebanon and identified 3 potential risk factors for PI development, length of stay in the ICU, episodes of hypotension, and vasopressor administration. These 3 variables should be taken into consideration as potential contributors to PIs in critically ill patients. Given the prevalence of these factors in critically ill patients, we advocate developing a risk assessment tool that includes variables associated with PIs in critically ill patients that can be used to alert nurses to carry out appropriate evidence-based prevention strategies.

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