

Factors Affecting the Time to Occurrence of Hospital-Acquired Pressure Ulcers Using EHR Data

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Abstract

This study examined factors affecting the time to occurrence of hospital-acquired pressure ulcers using electronic health records (EHR) data in a critical care setting. The subjects were 202 patients who were admitted to a tertiary hospital between January 2015 and May 2016 and developed pressure ulcers. In total, 61 risk factors for pressure ulcers were extracted from nine different report forms and analyzed using univariate and multiple linear regression analyses. The univariate analysis identified 33 significant factors, and 11 factors remained significant in the multiple regression analysis. Patients with decreased consciousness and those on ventilators tended to develop pressure ulcers during the early stage of hospitalization. Patients taking sedative-hypnotics, anti-inflammatory drugs, steroids, and anticoagulants, those in renal failure, and those who consulted a nutritionist, or had a gastrointestinal or tracheostomy tube or diarrhea tended to develop pressure ulcers at a later stage of hospitalization.

Keywords:

Pressure Ulcer; Electronic Health Records; Risk Factors

Introduction

Hospital-acquired pressure ulcers (HAPUs) are a threat to patient health [1]. HAPUs may prolong the hospital stay and lead to increased medical costs [2, 3]. Therefore, it is important to prevent pressure ulcers. It is also important to treat patients with pressure ulcers properly to prevent complications, such as infection [4].

The incidence rates and time to the occurrence of HAPUs in a critical care setting vary across studies. The incidence of HAPUs ranges from 12.8 to 16.6% among patients in critical care settings [5-7], from 14.3 to 43.2% among intensive care unit (ICU) patients [8-10], and from 20.3 to 38.5% among trauma patients [11-13].

Regarding the time to HAPU occurrence, 59.1% of patients in a neurological ICU developed HAPUs within 3 days of their admission [14], and 28.8% of the patients admitted to a tertiary hospital developed them within 7 days of admission [15].

Many studies have examined the risk factors affecting pressure ulcer development. However, few studies have tried to identify risk factors related to the time to HAPU occurrence; one study explored the times to occurrence and closure and risk factors in patients with spinal cord injuries [16], and another study

explored risk factors for pressure ulcers among elderly patients early in the hospital stay [17].

With this background, we considered the factors affecting the time to HAPU occurrence among patients in a critical care setting with diverse diagnoses during their hospital stay. We also considered whether electronic health records (EHR) data could be used to answer this question.

Research Objectives

This study explored risk factors affecting the time to HAPU occurrence among adults admitted to a critical care setting.

Methods

Study design

This was a retrospective study that used EHR data to identify factors affecting the time to HAPU occurrence among patients admitted to an acute care hospital.

Setting and study subjects

The subjects were admitted to six wards in the neurology, neurosurgery, hemato-oncology, and oncology departments at a tertiary teaching hospital in Korea. The subjects were 202 adults who developed HAPUs from January 2015 to May 2016 in the study hospital. Patients with HAPUs were identified from pressure ulcer incident reports. For those patients who developed HAPUs more than once during their hospital stays, only the first HAPU was included in the study.

Data extraction from EHR

A literature review identified 61 pressure ulcer risk factors. To identify these risk factors in the EHR, nine documents were reviewed: the Braden Scale form, initial nursing assessment, clinical observation record, severity classification system, nursing activity sheet, nurses' notes, surgery record, doctors' order sheet, and laboratory test results. Risk factors were grouped based on how often each was measured and how variable the values were. For variables that were recorded only at admission (e.g., route of admission) or most frequently recorded at admission (e.g., body weight), data recorded at admission were extracted. For variables that were recorded after admission with values that do not vary by day or by shift (e.g., surgery or diagnosis), data recorded at the time when an event that occurred between admission and pressure ulcer occurrence were extracted. For variables that were recorded more than once and whose values varied by day or by shift, data recorded most recently before the pressure ulcer occurred were extracted. We

set the maximum data extraction allowance time by computing the average time difference between the last time the risk factor was recorded and the time of HAPU occurrence. For example, reports of pain appeared in the clinical observation records or nurses' notes. If a HAPU occurred, then the time difference between the most recent record of pain in the clinical observation record or nurses' notes and the time when the HAPU occurred was extracted, and the mean time difference was computed across patients. The mean time difference was 1 day. Thus, if pain was recorded within 1 day before the onset of a pressure ulcer, pain was considered to be present; otherwise, pain was considered to be absent.

If data were recorded in more than one form within the maximum data extraction time, data from the most recently completed form were selected. Data were extracted from the clinical data warehouse based on data-extraction guidelines prepared by the authors. Data quality was validated by reviewing the records of 10 patients selected randomly.

The recorded frequencies of the risk factors were counted, and factors with a relative frequency of less than 0.1% were not included in this study (e.g., diagnosis of narcotic intoxication, malnutrition, sepsis, and hypotension). Table 1 shows the data recording times and data sources by risk factors.

Analytical plan

The statistical analysis was performed with SPSS ver. 18.0 for Windows.

1. Descriptive analyses with the frequency, mean, and standard deviation were used to examine the characteristics of surgical and medical patients.
2. Univariate analyses were used to study factors affecting the time to HAPU occurrence.
3. Multiple stepwise regression analysis was performed to identify factors affecting the time to HAPU occurrence.

Results

Characteristics of the study subjects

The study included 202 patients with HAPUs: 128 surgical patients and 74 medical patients.

Table 2 presents the gender, age, diagnosis, Braden scale score on admission, time to HAPU occurrence from admission, place of occurrence, and body site for the surgical and medical patient groups.

Table 1 - Data recording time and data sources by risk factors

Data recording time	Risk Factors	EHR data source								
		1	2	3	4	5	6	7	8	9
On admission	Gender, age, smoking, route of admission, body weight	√								
	Braden scale score on admission		√							
Any time between admission and pressure ulcer occurrence	Surgery									√
	Diagnosis (cancer, fracture, diabetes mellitus, nervous system disease, urogenital disease, head injury, spinal cord injury, renal failure, cardiovascular disease, mental illness, respiratory disease)			√						
Until 1 day before pressure ulcer onset	Endotracheal tube, tracheostomy tube, oxygen therapy, restraint, gastrointestinal tube, motor disorder				√	√	√	√		
	Skin condition, immobilization devices							√		
	Hygiene management					√	√	√		
	Pain				√			√		
	Friction and shear		√							
	Albumin									√
Until 3 days before pressure ulcer onset	Nothing by mouth, edema, weakness							√		
	Cognitive impairment				√			√		
	Decreased consciousness				√		√	√		
	Foley catheter				√	√	√	√		
	Ventilator				√	√		√		
	Activity disorder						√	√		
Until 5 days before pressure ulcer onset	Malnutrition, skin moisture							√		
	Incontinence				√		√	√		
	Diarrhea				√			√		
	Nutrition consultation, medication (cardiac stimulants, sedative-hypnotics, analgesics, anti-inflammatory drugs, steroids, anxiolytics, or anticoagulants)			√						

EHR data sources: 1. Initial nursing assessment; 2. Braden Scale form; 3. doctors' order sheet; 4. clinical observation record; 5. nursing activity sheet; 6. severity classification system; 7. nurses' notes; 8. laboratory test result report; and 9. surgery record

Table 2 - Comparison of characteristics of surgical and medical patients

Characteristics	Surgical patients (n = 128)		Medical patients (n = 74)	
	n	%	n	%
Gender				
Male	76	59.4	43	58.1
Female	52	40.6	31	41.9
Age, mean $\pm$ SD (years)	59.45 $\pm$ 15.75		65.62 $\pm$ 15.25	
Diagnosis				
Cancer	47	36.7	44	59.5
Nervous system disease	56	43.8	33	44.6
Cardiovascular disease	21	16.4	19	25.7
Diabetes mellitus	8	6.3	6	8.1
Renal failure	10	7.8	4	5.4
Spinal cord injury	8	6.3	2	2.7
Head injury	4	3.1	4	5.4
Mental illness	3	2.3	4	5.4
Fracture	5	3.9	2	2.7
Respiratory disease	3	2.3	2	2.7
Urogenital disease	1	0.8	1	1.4
Braden Scale score on admission				
Mild to very high risk	35	27.3	48	64.9
No risk	93	72.7	26	35.1
Time to HAPU occurrence (days)				
0-3	58	45.4	12	16.2
4-15	35	27.3	35	47.3
≥ 16	35	27.3	27	36.5
Place where pressure ulcer developed				
Operating room	73	57.0	0	0.0
Not the operating room	55	43.0	74	100.0
Body site of pressure ulcer				
Back of head	4	1.9	1	1.4
Cheek	11	5.1	0	0.0
Chest	28	13.0	0	0.0
Vertebra	14	6.5	2	2.8
Coccyx	42	19.4	49	69.0
Hip	20	9.3	18	25.4
Thigh	12	5.6	3	4.2
Lower leg	10	4.6	2	2.8
Ankle	14	6.5	0	0.0
Heel	11	5.1	0	0.0

Both groups had more males than females. The mean ages of the medical and surgical patients were 65.62 and 59.45 years, respectively. Of the surgical patients, 43.8% were diagnosed with nervous system diseases, and 59.5% of the medical patients were diagnosed with cancers. Most of the medical patients (64.9%) were classified as at risk on admission, whereas only 27.3% of the surgical patients were identified as at risk on admission. Surgical patients developed HAPUs during the early stage of the hospital stay, with 45.4% occurring within 3 days of admission. Medical patients developed HAPUs at a later stage of their hospital stays compared with surgical patients, with 47.3% developing at 4-15 days.

More than half of the surgical patients (57.0%) developed HAPUs in the operating room during surgery. The most common body site of the pressure ulcer for both surgical and medical patients was the coccyx. The second most common body site for pressure ulcers was the chest for surgical patients and the hip for medical patients.

Factors related to the time to HAPU occurrence

The univariate analyses identified 33 factors as significantly ($p < 0.05$) affecting the time from admission to HAPU occurrence (Table 3).

Cardiac stimulants, weight, Foley catheter, endotracheal tube, ventilator, oxygen therapy, nothing by mouth, restraint, decreased consciousness, cognitive impairment, hygiene management, pain, and surgery were negatively related to the length of time to HAPU occurrence from admission. This means that patients with these factors tended to develop HAPUs earlier in their hospital stays. Route of admission, Braden Scale score on admission, sedative-hypnotics, analgesics, anti-inflammatory drugs, steroids, anxiolytics, anticoagulants, renal failure, cancer, cardiovascular disease, incontinence, diarrhea, tracheostomy tube, gastrointestinal tube, weakness, nutrition consultation, malnutrition, activity disorder, and edema were positively related to the length of time to HAPU occurrence from admission. Patients with these factors tended to develop HAPUs later in their hospital stays.

Of the 33 factors included in the multiple stepwise regression analysis, 11 were significant, with combined explanatory power of 69.5% (Table 4). Patients with decreased consciousness and those on a ventilator developed HAPUs at an early stage of their hospital stays. Patients with sedative-hypnotics, anti-inflammatory drugs, steroids, anticoagulants, renal failure, nutrition consultation, diarrhea, gastrointestinal tube, and tracheostomy tube developed pressure ulcers at a later stage of their hospital stays.

Discussion

We divided our subjects into surgical and medical patient groups based on the fact that patients who are rendered immobile, such as those undergoing surgery, may be at greater risk. There were 128 surgical patients (63.4%). Of the 128 surgical patients, 73 (57.0%) developed pressure ulcers in the operating room. Surgery is an important risk factor for HAPU development in many studies [18-21]. This is likely because the patients are immobile during their surgery, and anesthesia prevents them from feeling the pain caused by compression [18]. In addition, blood loss, lowered body temperature, skin moisture due to irrigation, and warming therapy during

surgery are important factors in the development of pressure ulcers among surgery patients [21].

Table 3 - Factors significantly affecting the time to HAPU occurrence

Categories	Factors
Negatively related to the time to HAPU occurrence (13)	Ventilator, cognitive impairment, restraint, nothing by mouth, decreased consciousness, endotracheal tube, Foley catheter, pain, surgery, oxygen therapy, weight, hygiene management, cardiac stimulants
Positively related to the time to HAPU occurrence (20)	Nutrition consultation, sedative-hypnotics, analgesic, diarrhea, gastrointestinal tube, weakness, anxiolytics, anti-inflammatory, tracheostomy tube, anticoagulant, cancer, edema, route of admission, incontinence, cardiovascular disease, steroid, renal failure, admission Braden Scale score, malnutrition, activity disorder

The time to pressure ulcer occurrence after admission averaged 15.2 days. About one third of the pressure ulcers ($n = 70$, 34.7%) occurred within 3 days of admission. This is much lower than the value reported in a previous study, which found that 59.1% of neurological patients in ICU developed pressure ulcers within 3 days of admission [14]. This could be due to the fact that our subjects were more diverse and from many different wards.

Of the 70 patients who developed pressure ulcers within 3 days, 58 were surgical patients, and 12 were medical patients. The surgical patients were more likely to develop pressure ulcers during the initial stage of hospitalization compared with the medical patients. In our hospital, most surgical patients undergo surgery on the first or second day of admission, so surgical patients develop pressure ulcers in the early stage of hospitalization. In a previous study, most of the patients who underwent surgery were found to have developed pressure ulcers on the day of or within 2 days after surgery [20].

Among the surgical patients, 28 (13.0%) and 11 (5.1%) developed pressure ulcers on the chest or cheeks, respectively, whereas no medical patients had pressure ulcers on the chest or cheeks. Patients with a pressure ulcer on the chest, clavicle, or rib were those who had surgery in the prone position. Patients with pressure ulcers on the face were those who wore a medical device, such as an oxygen mask, during anesthesia [22].

The multiple regression analysis showed that decreased consciousness and being on a ventilator were the most significant factors affecting the development of pressure ulcers in the initial stage of admission. Decreased consciousness and being on a ventilator are directly related to general anesthesia. In another study, all of the surgical patients with pressure ulcers had general anesthesia [23]. In addition, the use of cardiac stimulants, such as vasopressors, during surgery was a significant factor affecting the development of pressure ulcers during the initial stage of admission. Postoperative pain and fasting for various tests or surgery were also related to the occurrence of pressure ulcers in the early stage of hospitalization.

Table 4 - Results of the multiple linear regression

Variable	β	T	p	Durbin-Watson	Adj. R ²
(constant)		14.050	<0.001		
Nutrition consultation	0.270	5.605	<0.001		
Ventilator	-0.309	-6.266	<0.001		
Sedative-hypnotics	0.183	3.934	<0.001		
Anti-inflammatory	0.175	4.211	<0.001		
Diarrhea	0.153	3.549	<0.001	1.905	0.695
Steroid	0.205	4.837	<0.001		
Renal failure	0.131	3.166	0.002		
Gastrointestinal tube	0.112	2.206	0.029		
Anticoagulant	0.107	2.484	0.014		
Decreased consciousness	-0.110	-2.267	0.025		
Tracheostomy tube	0.099	2.077	0.039		

Sedative-hypnotics, steroids, and anticoagulants were factors affecting the development of pressure ulcers at a later stage of hospitalization. Sedative-hypnotics include sleeping pills prescribed for medical patients, and dexamethasone-like steroids and anticoagulants for heparin therapy were used to treat neurological diseases.

A nutrition consultation also was an important factor in the development of pressure ulcers at a later time during hospitalization. Nutrition consultations are rarely requested for patients in the early stage of hospitalization, and are mainly requested for patients with nutritional deficiencies admitted to a long-term ward. Impaired nutritional intake was an important factor in the development of pressure ulcers in a study of medical patients [24].

A tracheostomy tube was a risk factor for pressure ulcer development at a later stage of hospitalization. Tracheostomy tubes are mainly used in patients with long-term hospitalization, whereas patients with surgical procedures have endotracheal tubes for ventilator applications, which was a risk factor affecting pressure ulcer development at an early stage of hospitalization.

In summary, most of the patients who developed pressure ulcers early in their hospitalization were patients who had general anesthesia during surgery. Patients who are admitted for surgery have a high risk of developing pressure ulcers due to surgery, although they were assessed as low risk for pressure ulcers on admission.

In this study, we did not use the incident report as a data source to identify risk factors for pressure ulcers, but the incident reports can be connected with EHR to deepen the analysis of risk factors.

Conclusions

This study examined the factors affecting the time to HAPU occurrence during the hospital stay. These findings can be

used to help nurses to develop nursing interventions to recognize and prevent HAPUs.

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