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Root Cause Analysis and Prevalence of Pressure Injuries a Neurointensive Care Unit

Basınç Yaralarının Sıklığı ve Kök Neden Analizi: Nöroloji Yoğun Bakım Örneği

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ABSTRACT *Objective:* This study determined the prevalence and causes of the pressure injuries (PIs) in patients hospitalized our neurology intensive care unit (NICU).
Materials and Methods: Planned as a cross-sectional, descriptive design, this study was conducted in training and research hospital NICU. The population of the study consisted of 338 patients. We retrospectively collected data from the hospital information management system that included the study period from January 1, 2020 to December 31, 2020.
Results: Most 338 patients (54.4%) were male, the mean age of the patients was 68.44±15.5. Most patients were found to have comorbidities that may have contributed to the development of the PIs. The prevalence of the PI first appeared to be 15.4%, but since the PIs of 11 patients were found to have developed before admission to the NICU, yet with no stage progression, the prevalence of the PI was finally specified as 12.1% (n=41).
Conclusion: It is of great importance to note that since the patients in the NICUs are at high risk of the PIs, close follow-up is accordingly necessary in terms of the PIs until discharge, it is necessary that nurses be informed as regard current guidelines to ensure offering appropriate nursing care.
Keywords: Intensive care unit, nursing care, pressure injury, root cause analysis

ÖZ *Amaç:* Bu çalışmada hastanemiz nöroloji yoğun bakım ünitesinde (NYBÜ) yatan hastalarda basınç yarası (BY) sıklığı ve nedenlerinin belirlenmesi amaçlandı.
Gereç ve Yöntem: Kesitsel ve tanımlayıcı olarak planlanan bu çalışma bir eğitim ve araştırma hastanesi NYBÜ'de gerçekleştirildi. Araştırmanın evrenini 338 hasta oluşturmuş olup, 1 Ocak 2020 ile 31 Aralık 2020 arasındaki çalışma dönemini içeren veriler hastane bilgi yönetim sisteminden elde edildi.
Bulgular: Üç yüz otuz sekiz hastanın çoğunluğu (%54,4) erkek olup, hastaların yaş ortalaması 68,44±15,5 idi. Hastaların çoğunluğunun BY gelişimine katkıda bulunabilecek komorbiditeye bulunmaktaydı. BY prevalansı ilk başta %15,4 idi, ancak 11 hastanın BY'nin NYBÜ'ye kabul edilmeden önce geliştiği ve herhangi bir evre ilerlemesi olmadığı tespit edildiğinden, BY nihai prevalansı %12,1 olarak belirlendi (n=41).
Sonuç: NYBÜ'deki hastalar BY açısından yüksek risk altında olduğu için, hastaların BY açısından taburcu olana kadar yakın takip gerekliliği unutulmamalı, hemşirelerin uygun hemşirelik bakımının sunulabilmesi için güncel kılavuzlar hakkında bilgilendirilmesi gerekmektedir.
Anahtar Kelimeler: Yoğun bakım ünitesi, hemşirelik bakımı, basınç yarası, kök neden analizi

Introduction

Pressure injury (PI) is a localized damage over a visible bony prominence or in the skin and/or underlying soft tissue, in relation to the use of medical or other devices (1,2). PI refer to a very costly complication that triggers substantial problems in patient care and an important indicator for patient safety and health care quality (2,3). The PI classification is used to describe the extent of tissue loss and the physical appearance of the injury as a result of pressure and/or shear. The National Pressure Injury Advisory Panel and the European Pressure Ulcer Advisory Panel have added two further classifications to the PI framework that range from stage I to IV depending on the depth of the lesion (4-6). These classifications are known as unstageable

and suspected deep tissue injury. Since intensive care units (ICUs) are complicated health care facilities that provide treatment for critically ill and unstable patients who have undergone numerous medical interventions, those who are hospitalized there are especially at risk of acquiring PIs (7,8). ICU nurses need to be mindful of PI formation and treatment for this reason. Mobility/activity, perfusion, skin condition, skin moisture, age, hematological parameters, diet, body temperature, and sensory perception are some of its main risk factors (9). The risk of developing a PI is typically higher in individuals who are sedentary, older adults, have low serum albumin and body mass index, have had surgery, or have received ICU treatment (5). Other factors such as diabetes, smoking, peripheral vascular disease and hypoproteinemia are also likely to contribute to the formation of such ulcers (2,10). Research has shown that one of the most common factors that lead to prolonged hospitalization of the patients after surgery is the PIs with a rate of 3.4-66% (2). It has been reported that the incidence of pressure injuries varies between 1.9% and 35%, with the prevalence ranging between 11.1% and 31% (11). In a similar sense, the incidence of pressure injuries in the ICUs has been reported to be 4.7-15%, a rate reaching up to 56% (12,13).

In the event of a PI, a root cause analysis (RCA) should be performed to explore the underlying causes of the problem, without focusing only on the apparent cause (14). RCA is a systematic process used to identify the source of the problem, address problems or non-conformity (15). In Turkey, there are standards expressing the necessity of performing RCA as included in Health Quality Standards and Health Accreditation Standards (16,17). The purpose of a RCA is to identify, discuss and question the practices and habits of any given institution. Instead of dealing with "what happened" and "how it happened", it is aimed to find an answer to the question of why it happened, as well as to reveal the factors that caused it, and prevent the reoccurrence of any undesirable experience (18-20).

Neurological diseases with a progressive course those are among chronic diseases as well, differ from other diseases due to the burden they bring to caregivers and society (21). Cerebrovascular diseases (CVDs), which ranks first among the causes of mortality in the world (22) and is the most common among neurological diseases. CVDs are in the second place among the causes of morbidity in Turkey (23). While intensive care need appears in the acute period of neurological diseases; the need for intensive care can increase in the later stages of motor neuron diseases (24). With the establishment of neurological ICUs, it has been observed that many patients, who were thought to be difficult to cope with, were brought back to life with quality health care delivery (21). We focused to determine the characteristics of the patients hospitalized in neurology intensive care units (NICUs), and performed RCA to find out the causes those leading to formation of pressure injuries.

Materials and Methods

Planned as a cross-sectional and descriptive design, this study was carried out in a Hospital, NICU. The NICU has 10 beds and has been registered as a tertiary ICU. Patient data were obtained from the hospital information management system (HIMS). The evolution of study consisted of 52 patients, a sample of 338 patients. We collected data retrospectively from the HIMS which including the study period from 1 October 2020 to 31 December 2020.

The data of age, gender, diagnosis, hospitalized days, Acute Physiology and Health Evaluation-II (APACHE-II) scores, Nutritional Screening Tool-2002 (NRS2002) scores, Braden risk scores, comorbidity, nutrition, haemoglobin levels, albumin levels, discharging condition of patients was obtained.

Braden risk assessment scale: Developed by Braden and Bergstrom, the Braden scale is frequently used in the PI assessment, and its validity and reliability in Turkey was confirmed in 1997. The scale had six subscales, including friction, shear, wetness, activity, mobility, nutrition, and sensory perception (25). The risk level is classified as being either high risk (12 points or less), medium risk (13 points to 14 points), or low risk (15 points to 16 points, with 15 points to 18 points for those over 75) (25-29).

APACHE-II: For critically ill patients, scoring systems can assist forecast how long they will stay in the hospital and their outcome. The measure for determining the severity of acute diseases that is most well-known and frequently used is the APACHE-II score. There are three primary parts to this scoring system: Age points, chronic health points, and acute physiology points (30,31).

NRS2002: NRS2002 is system for screening of nutritional risks developed by Kondrup et al. (32) in 2002 with the support of Danish Society of Parenteral and Enteral Nutrition. It is a method that is scored on three factors: age (0-1 point), disease severity (0-3 point), and inadequate nutritional

status (0-3 point). Extra one score is added for aged 70+ patients. The patients those have ≥3 scores is determined under nutritional risk. The Turkish validity and reliability of the system was determined by Bolayır 2014 (32,33).

Study was approved by the Clinical Research Ethics Committee of the University Health Sciences Turkey, Antalya Training and Research Hospital (decision no: 14/4, date: 16.09.2021). Because of it is a retrospective study, data usage permission was obtained from the ethics committee and the hospital management.

Statistical Analysis

Continuous data were presented with mean ± standard deviation or median (interquartile range: 25-75th percentile). Categorical variables were presented with frequency (n) and percentage (%), and analysed with Pearson chi-square and Fisher's Exact test. The normality assumptions were controlled by the Shapiro-Wilk test. Independent t-test and Mann-Whitney U test were used for comparing the numerical data between two groups, as appropriate. One-Way ANOVA was used for comparing the parametric variables among Braden risk groups and Tukey HSD test was used as a post-hoc test for significant cases. Comparison of non-parametric variables among Braden risk groups was performed using Kruskal-Wallis test and Bonferroni-Dunn test was used as a post-hoc test for significant cases. Statistical analysis was made using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Armonk, NY). Two-sided p-value less than 0.05 was considered statistically significant.

Results

A total of 338 patients were hospitalized in the NICU in 2020. The majority of 338 patients (54.4%) were male, and the mean age of all patients was 68.44±15.5 with the mean hospital stay of 4 days. Of all the patients, 59.8% of them were hospitalized with the diagnosis of CVD, while 21.3% of them with the diagnosis of hemiplegia. The majority of the patients (74%) were found to have comorbidities [diabetes mellitus (DM), hypertension (HT) or both] that may have contributed to the development of pressure injuries. The mean score in Braden risk assessment scale was 14, and 36.4% of the patients were in the high-risk group. When the prevalence of the PIs was examined, 52 (15.4%) patients appeared to have the PI, but 11 of them were found to have developed it outside the hospital before hospitalization in the NICU, though with no stage progression. The frequency of the PIs in the NICU was found as 12.1% (n=41). The average length of stay (23 days) of the patients with the PIs was longer than those without. A statistical significance was found between the two groups (p<0.001). In 80.8% of the patients who developed the PIs, the albumin level seemed quite low, with a mean value of 2.92±0.58, indicating statistical significance when compared with the patients who did not develop any PIs (p<0.001). Furthermore, 88.5% of the patients who developed pressure injuries had low hemoglobin levels, with a mean value of 10.74±2.18, signifying statistical significance when compared with those who did not (p<0.001). All patients who developed the PIs were in the high-risk group in terms of their NRS2002 scores, being statistically significant between the two groups (p<0.001). Of all the patients, 50.3% were discharged, but 46.2% died. Statistical significance was found between the two groups (p=0.011) (Table 1).

Having examined pressure injuries according to their stages, it appeared that 91.7% of the patients who developed a PI in the sacrum region were at stage 2, 77.8% of which developed in the hospital, yet with no statistical significance. It is apparent that 63.9% of the patients with the PIs developed them 10 days after hospitalization, and there was a statistically significant difference between the stage of the PI and the length of hospital stay (p=0.002) (Table 2).

The mean age of the patients in the high-risk group was 72.15, and 54.5% of them were female, according to the Braden risk assessment scale score. Age and gender differences among the risk groups were statistically significant (p<0.001, p=0.017). We determined that patients in the high-risk group in terms of Braden risk assessment scale score had a longer hospital stay, lower albumin and hemoglobin levels, indicating statistical significance. We also found that the vast majority of the patients (82.1%) in the high-risk group according to the Braden risk assessment scale score were likewise in the risk group as to the NRS2002 score due to their high scores, indicating statistical significance. The patients in the high-risk group had higher APACHE-II scores with a statistically significant difference (p=0.001). No statistically significant difference was found between the Braden risk assessment scale score and the diagnosis of hospitalization. Though not statistically significant, comorbidities such as HT and DM were found in the majority of patients with the PIs (Table 3).

Table 1. Patient characteristics				
Variables	**No PIs (n=286)**	**PIs (n=52)**	**All patients (n=338)**	**p**
Age (years), mean ± SD	67.87±15.57	71.58±14.91	68.44±15.5	0.113
Gender, n (%)				
Female	127 (44.4)	27 (51.9)	154 (45.6)	0.317
Male	159 (55.6)	25 (48.1)	184 (54.4)	
Diagnosis, n (%)				
DM with neurological complications	2 (0.7)	0 (0)	2 (0.6)	0.517
Middle cerebral artery syndrome and cerebrovascular disease	6 (2.1)	2 (3.8)	8 (2.4)	
Cerebrovascular disease	172 (60.1)	30 (57.7)	202 (59.8)	
Hemiplegia	62 (21.7)	10 (19.2)	72 (21.3)	
Parkinson's disease	1 (0.3)	1 (1.9)	2 (0.6)	
Epilepsy	5 (1.7)	2 (3.8)	7 (2.1)	
Other	38 (13.3)	7 (13.5)	45 (13.3)	
Length of hospital stay (days), median (IQR)	3.5 (1-9)	23 (6-43)	4 (2-12)	<0.001
Comorbidity, n (%)				
HT	80 (28)	15 (28.8)	95 (28.1)	0.897
DM	35 (12.2)	6 (11.5)	41 (12.1)	0.887
Heart disease	51 (17.8)	8 (15.4)	59 (17.5)	0.669
Neurological disease	21 (7.3)	7 (13.5)	28 (8.3)	0.168
Other	19 (6.6)	8 (15.4)	27 (8)	0.048
Albumin, mean ± SD	3.58±0.58	2.92±0.58	3.48±0.63	<0.001
Albumin category, n (%)				
Normal	189 (66.1)	10 (19.2)	199 (58.9)	<0.001
Low	97 (33.9)	42 (80.8)	139 (41.1)	
Hemoglobin, mean ± SD	12.1±2.17	10.74±2.18	11.89±2.23	<0.001
Hemoglobin category, n (%)				
Normal	79 (27.6)	6 (11.5)	85 (25.1)	0.014
Low	207 (72.4)	46 (88.5)	253 (74.9)	
APACHE-II score, median (IQR)	13.5 (8-20)	16 (10.5-20.5)	14 (8-20)	0.048
NRS2002 score, median (IQR)	2 (2-3)	3 (3-4)	3 (2-4)	<0.001
NRS2002 score category, n (%)				
Normal	152 (53.1)	0 (0)	152 (45)	<0.001
High	134 (46.9)	52 (100)	186 (55)	
Braden score, median (IQR)	14 (12-16)	11 (7-12)	14 (12-15)	<0.001
Braden score category, n (%)				
No risk	19 (6.6)	0 (0)	19 (5.6)	<0.001
Low risk	100 (35)	0 (0)	100 (29.6)	
Moderate risk	94 (32.9)	2 (3.8)	96 (28.4)	
High risk	73 (25.5)	50 (96.2)	123 (36.4)	
Result				
Referred	5 (1.7)[a]	0 (0)[a]	5 (1.5)	0.011
Discharged	152 (53.1)[a]	18 (34.6)[b]	170 (50.3)	
Left the hospital on his/her own will	1 (0.3)[a]	0 (0)[a]	1 (0.3)	
Partially recovered	63 (22)[a]	10 (19.2)[a]	73 (21.6)	
Ex	65 (22.7)[a]	24 (46.2)[b]	89 (26.3)	

Independent t-test, Mann-Whitney U test, Pearson chi-square test, Fisher's Exact test. Same letters in a row denote the lack of statistically significant difference. NRS2002: Nutrional Risk Screening, APACHE-II: Acute Physiology and Health Evaluation-II, DM: diabetes mellitus, HT: hypertension, SD: standard deviation, PI: pressure injury, IQR: interquartile range, Ex: exitus

Table 2. Features of patient with pressure injuries according to the stage				
Variables	**Stage 1**	**Stage 2**	**Stage 3**	**p**
Location, n (%)				
Sacrum	11 (91.7)	33 (91.7)	3 (75)	0.402
Heels	1 (8.3)	6 (16.7)	2 (50)	0.205
Back	0 (0)	3 (8.3)	0 (0)	0.658
Legs	1 (8.3)	3 (8.3)	1 (25)	0.402
Place of developing the PIs, n (%)				
Home	5 (41.7)	8 (22.2)	0 (0)	0.198
Hospital	7 (58.3)	28 (77.8)	4 (100)	
Which day? n (%)				
<10 days	7 (58.3)[a]	6 (16.7)[b]	2 (50)[a,b]	0.002
>10 days	1 (8.3)[a]	23 (63.9)[b]	2 (50)[b]	
Pre-existing condition	4 (33.3)[a]	7 (19.4)[a]	0 (0)[a]	

PI: pressure injury. Fisher's Exact test. Same letters in a row denote the lack of statistically significant difference.
*Some patients had more than one pressure injury

Table 4 presents the detailed information regarding 52 patients (27 women, 25 men) with the PIs, most of whom were found to be in stage II, with the majority (90.4%) having developed it in the sacrum region, and 75% of them were found to develop it during their stay in the hospital. We determined that 50 patients who developed the PIs were in the high-risk group according to the Braden risk score, that all patients had a high-risk score of NRS2002 and received enteral nutrition, and that most of the PIs developed in the sacrum region, though they were found in more than one region. Based on the evaluation of the PI RCA, sufficient data could not be found in only 8 patients, whereas in others, RCA results revealed advanced age, nutritional deficiency, prolonged hospital stay, low albumin and hemoglobin levels, and comorbidities as the root causes resulting in the PIs. It appeared that 27 of the 52 patients who developed the PIs had at least one comorbidity and more than half of them had two. Stage progression was detected in only 2 of the patients with the PI developing outside the hospital (Table 4). In the light of such data, it is clear that the factors belonging to the patients are predominant in the analysis of the root cause in the formation of the PIs. In our study, advanced age, any kind of disease that may cause limitation of movement, comorbidities, nutritional deficiency and prolonged stay appeared to be influential factors in the development of the PIs (Table 4).

Discussion

Although there are conflicting statistics available about the incidence of PIs, the pace of their development appears to be higher in ICUs as compared to other healthcare units (34-38).

Prevelance and Feature Risk of PIs

In this study, the prevalence of the PIs was found to be 12.1%. Research conducted on the PI incidence and prevalence has shown that the rate of the PIs in the NICU 10.9% (38) and 15% hospital-wide NICU (36). These variations may have been caused by a variety of variables, such as the size of the hospital where the study was done, whether it was a public or private university hospital, the type of ICU, whether the researcher was an employee of the organization, the exclusion of the PIs in stage I from the study, and the variation in the ability of ICU nurses to assess and be aware of PIs. This study's significance comes from the fact that it was carried out in the NICU, where elderly patients with chronic illnesses who typically have limited mobility were present, and from the fact that the RCA of the patients' components and other factors were presented simultaneously.

Although the sacrum, trochanter, and heels are listed as the areas where PIs are frequently observed (29), it has been shown in a number of studies that it most frequently occurs in the sacrum (29,37,39-41). Similar to this, we discovered

that the sacrum region was where PIs most frequently developed, which is consistent with the literature. The PIs in the sacrum region in the ICU patients may be caused by the increase in pressure applied to the sacral region, with the heads of the patients elevated to prevent aspiration pneumonia and ventilator-associated pneumonia (41). With frequent positioning, pressure and cutting time can be reduced. For example, if both the head and foot end of the bed are raised 30 degrees when the semi-fowler position is given, the lowest contact pressure occurs at this angle

Table 3. Patient characteristics according to the Braden score

Variables	No risk-low risk (n=119)	Moderate risk (n=96)	High risk (n=123)	p
Age (years), mean ± SD	63.45±16.78[a]	69.85±14.19[b]	72.15±13.97[b]	<0.001
Gender, n (%)				
Female	43 (36.1)[a]	44 (45.8)[a.b]	67 (54.5)[b]	0.017
Male	76 (63.9)[a]	52 (54.2)[a.b]	56 (45.5)[b]	
Diagnosis, n (%)				
DM with neurological complications	0 (0)	1 (1)	1 (0.8)	0.482
Middle cerebral artery syndrome + cerebrovascular disease	3 (2.5)	1 (1)	4 (3.3)	
Cerebrovascular disease	62 (52.1)	60 (62.5)	80 (65)	
Hemiplegia	27 (22.7)	22 (22.9)	23 (18.7)	
Parkinson's disease	1 (0.8)	0 (0)	1 (0.8)	
Epilepsy	4 (3.4)	1 (1)	2 (1.6)	
Other	22 (18.5)	11 (11.5)	12 (9.8)	
Hospital stay (days), median (IQR)	2 (1-5)[a]	4.5 (2-13.5)[b]	7 (3-28)[c]	<0.001
Comorbidity, n (%)				
HT	29 (24.4)	25 (26)	41 (33.3)	0.261
DM	14 (11.8)	12 (12.5)	15 (12.2)	0.986
Coronary disease	18 (15.1)	21 (21.9)	20 (16.3)	0.392
Neurological disorders	10 (8.4)	8 (8.3)	10 (8.1)	0.997
Other	10 (8.4)	7 (7.3)	10 (8.1)	0.954
Albumin, mean ± SD	3.64±0.53[a]	3.54±0.66[a]	3.27±0.63[b]	<0.001
Albumin category, n (%)				
Normal	84 (70.6)[a]	62 (64.6)[a]	53 (43.1)[b]	<0.001
Low	35 (29.4)[a]	34 (35.4)[a]	70 (56.9)[b]	
Hemoglobin, mean ± SD	12.33±2.12[a]	11.77±2.16[a.b]	11.57±2.33[b]	0.022
Hemoglobin category, n (%)				
Normal	36 (30.3)	22 (22.9)	27 (22)	0.277
Low	83 (69.7)	74 (77.1)	96 (78)	
APACHE-II score, median (IQR)	12 (6-19)[a]	12 (8-18)[a]	16 (10-22)[b]	0.001
NRS2002 score, median (IQR)	2 (2-3)[a]	2 (2-3)[a]	3 (3-4)[b]	<0.001
NRS2002 score category, n (%)				
Normal	78 (65.5)[a]	52 (54.2)[a]	22 (17.9)[b]	<0.001
High	41 (34.5)[a]	44 (45.8)[a]	101 (82.1)[b]	

One-way ANOVA, Kruskal-Wallis test, Pearson chi-square test, Fisher's Exact test. Same letters in a row denote the lack of statistically significant difference.
NRS2002: Nutritional Risk Screening, APACHE-II: Acute Physiology and Health Evaluation-II, DM: diabetes mellitus, HT: hypertension, SD: standard deviation, IQR: interquartile range

(42). Due to such reasons, it is necessary to monitor and protect the parts under pressure to avoid any PI formation by changing positions at certain intervals. In the ICU where the study was conducted, all patients were recorded by changing their positions every 2 hours.

There are many factors that can lead to the PI formation, such as moisture status of the skin, age, nutrition, inactivity, anaemia, albumin level, and comorbidities (2,5,35).

It was determined that PIs developed in a shorter time in patients who could not get enough calories and protein than those who did (43).

The PI risk is higher in patients over the age of 65, and risk factors increase in those over the age of 51, indicating that the risk of developing the PIs increases with age (42). Research shows that the mean age of the patients in the previous studies was 64.9 (38), 63 (44) and 72.5 years (40). The mean age of the patients who developed the PIs was 71.6 in our study.

PIs Causes

According to the pertinent literature evaluation, patients with low albumin levels (3.5 g/dL) are more likely to develop PIs. In another study, the mean serum albumin values of patients who developed the PIs were reported as 3.41±0.58 gr/dL (45,46). Haematological and biochemical parameters should be closely monitored in ICU patients, and it should be kept in mind that the PIs may develop, especially in patients with low hemoglobin and albumin levels, and necessary precautions must be taken.

It has been stated that the comorbidity accompanying the neurological diagnosis affects the formation of the PIs, in addition to other factors (47). In our study, although no significant correlation was found between comorbid chronic diseases such as HT, DM, heart disease, and the PI formation, such disorders turned out to be more common in the majority of patients with the PIs. In our study, despite the fact that we found the APACHE-II score of the group with the PIs as higher than that of the group that did not, a statistical significance was found at the border (p=0.048).

A popular method for determining the risk of pressure injuries is the Braden scale. According to the meta-analysis study, the Braden scale demonstrated a modest level of predictive power (48). The Braden risk assessment scale score found as 11.0±2.64 is regarded in the high-risk group (49). In our study, the Braden risk assessment score of the patients who developed the PIs was likewise found to be 11. It should be noted that it is very important to monitor the patients in the risk group in terms of Braden risk score, and especially those hospitalized in the ICU should be closely monitored by the ICU nurses in order not to overlook stage I, in particular.

It is known that the PIs five times prolong the hospital stay of patients. Research shows that the length of hospitalization in PI patients has been reported as 25.14±9.87 days (50), 20.2±18.3 (38). The average length of hospital stays of the patients who developed the PIs was 23 days in our study.

A study in the literature focusing on thirty-two cases of PIs in order to perform root cause analyses, reported malnutrition as the most important cause (51). In our study, patient-related factors such as age, comorbidities, nutritional status, and length of hospital stay were by far the most important causes. Nonetheless, apart from the given reasons, it should be noted that there may be a lack of sufficient medical materials or personnel, or a defect in the PI evaluation method. Figure 1 presents the reasons for the PIs in the form of a fishbone diagram based on our study data.

In the ICU, where we performed this study on the prevention of the PIs, the following measures are taken: all patients are recorded by changing their lying positions every 2 hours, and they are given daily body hygiene, air mattresses are used, the bed linens are changed daily, ensuring that they stay tight, Braden risk scores are evaluated at each shift change once any PIs are detected, skin care is provided (such as keeping the skin dry), barrier cream is used, position pads in different sizes are used to reduce pressure, necessary treatment (enteral/parenteral) is initiated in cooperation with the nutrition team based on the results of the evaluation regarding the patients' nutritional care, and the dressings are routinely changed as part of nursing interventions. The study has stressed that PI rates can be greatly decreased from 13.86% to 10.41% by employing basic precautionary measures (52). When a patient is being discharged from the ICU, it is crucial for the ICU nurse to instruct the patient and/or the patient's family members and caregivers on how to avoid and treat PIs (26). It is necessary that patients be evaluated at their admission to the hospital, and that continuity of care be ensured by planning and monitoring the care to be given in the ongoing process (25).

Table 4. Details of patients with pressure injuries

Patient no	Age	Sex	HSD	Albumin	Hemoglobin	Nutrition risk	Braden risk	Comorbidity	PI stage	PI location	Where PI Develops	PI development	Root cause found?	Was it avoidable?	Nutrition
1	44	F	1	L	L	Yes	High	None/ unknown	Stage II	Sacrum	Home	Available/No phase progress	Sequence of events	No, patient had this PI on admission	Enteral
2	65	M	1	N	L	Yes	High	None/ unknown	Stage II	Sacrum	Home	Available/No phase progress	Sequence of events	No, patient had this PI on admission	Enteral
3	53	M	6	N	L	Yes	Moderate	None/ unknown	Stage I	Leg + Heel	Hospital	Within 10 days	Sequence of events	Yes	Enteral
4	54	M	44	N	N	Yes	High	DM	Stage II	Sacrum	Home	Available/Yes phase progress	Yes	No, patient had this PI on admission	Enteral
5	81	F	41	N	L	Yes	High	HT, CAD	Stage II	Sacrum + Back	Hospital	After 10 days	Yes	Yes	Enteral
6	69	M	40	L	L	Yes	High	None/ unknown	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
7	76	M	12	N	L	Yes	High	None/ unknown	Stage II	Sacrum	Home	Available/Yes phase progress	Yes	No, patient had this PI on admission	Enteral
8	84	M	16	N	L	Yes	High	None/ unknown	Stage III	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
9	73	F	11	N	L	Yes	High	None/ unknown	Stage II	Sacrum + Heel	Hospital	After 10 days	Yes	Yes	Enteral
10	86	F	11	L	L	Yes	High	None/ unknown	Stage II	Leg + Heel	Hospital	After 10 days	Yes	Yes	Enteral
11	61	M	2	N	L	Yes	High	None/ unknown	Stage II	Sacrum + Heel	Home	Available/No phase progress	Sequence of events	No, patient had this PI on admission	Enteral
12	48	F	4	N	L	Yes	High	None/ unknown	Stage I	Sacrum	Home	Available/No phase progress	Sequence of events	No, patient had this PI on admission	Enteral
13	77	M	42	N	L	Yes	High	None/ unknown	Stage II	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral
14	60	M	41	N	L	Yes	High	DM	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
15	91	M	2	N	L	Yes	High	BPH	Stage I	Sacrum	Home	Available/No phase progress	Yes	No, patient had this PI on admission	Enteral

Table 4. Details of patients with pressure injuries

Patient no	Age	Sex	HSD	Albumin	Hemoglobin	Nutrition Risk	Braden risk	Comorbidity	PI stage	PI location	Where PI Develops	PI development	Root cause found?	Was it avoidable?	Nutrition
16	79	F	10	L	L	Yes	High	Malignancy	Stage II	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral
17	80	M	21	N	L	Yes	High	None/ unknown	Stage II	Sacrum + Heel	Hospital	After 10 days	Yes	Yes	Enteral
18	93	F	13	N	L	Yes	High	None/ unknown	Stage II	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral
19	64	F	64	N	L	Yes	High	Epilepsy	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
20	80	F	25	N	L	Yes	High	None/ unknown	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
21	71	F	75	N	L	Yes	High	HT	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
22	88	F	2	L	L	Yes	High	HT	Stage II	Sacrum	Home	Available/No phase progress	Yes	No, patient had this PI on admission	Enteral
23	52	M	44	N	L	Yes	High	None/ unknown	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
24	64	F	4	N	L	Yes	High	HT, DM	Stage II	Sacrum	Hospital	Within 10 days	Sequence of events	Yes	Enteral
25	87	F	9	N	N	Yes	High	Parkinson's, dementia	Stage I	Sacrum + Back	Hospital	Within 10 days	Yes	Yes	Enteral
26	95	F	1	L	L	Yes	High	None/ unknown	Stage II	Sacrum	Home	Available/No phase progress	Yes	No, patient had this PI on admission	Enteral
27	56	F	3	N	L	Yes	Moderate	DM, asthma	Stage I	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral
28	74	M	3	L	N	Yes	High	Asthma, CVD	Stage I	Sacrum	Home	Available /No phase progress	Yes	No, patient had this PI on admission	Enteral
29	64	F	52	L	L	Yes	High	None/ unknown	Stage III	Leg + Heel	Hospital	After 10 days	Yes	Yes	Enteral
30	76	F	70	N	N	Yes	High	None/ unknown	Stage I	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
31	88	F	25	N	L	Yes	High	None/ unknown	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
32	84	F	41	N	L	Yes	High	HT, DM, CVD, CHF	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
33	31	M	6	N	L	Yes	High	None/ unknown	Stage I	Sacrum	Home	Available /No phase progress	Sequence of events	No, patient had this PI on admission	Enteral

Table 4. Details of patients with pressure injuries

Patient no	Age	Sex	HSD	Albumin	Hemoglobin	Nutrition Risk	Braden risk	Comorbidity	PI stage	PI location	Where PI Develops	PI development	Root cause found?	Was it avoidable?	Nutrition
34	85	M	10	N	L	Yes	High	CVD, HT	Stage II	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral
35	56	M	30	L	L	Yes	High	HT	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
36	85	F	45	N	L	Yes	High	None/ unknown	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
37	46	M	39	L	L	Yes	High	None/ unknown	Stage III	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral
38	80	M	69	L	L	Yes	High	BPH	Stage II	Sacrum + Hell	Hospital	After 10 days	Yes	Yes	Enteral
39	79	F	9	L	L	Yes	High	HT, CVD, CAD	Stage I	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral
40	91	F	30	N	L	Yes	High	HT	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
41	86	F	6	N	L	Yes	High	HT, bypass	Stage I	Sacrum	Home	Available/No phase progress	Yes	No, patient had this PI on admission	Enteral
42	65	M	7	L	L	Yes	High	None/ unknown	Stage III	Sacrum	Hospital	Within 10 days	Sequence of events	Yes	Enteral
43	81	F	1	L	L	Yes	High	None/ unknown	Stage II	Leg + Heel	Home	Available/No phase progress	Yes	No, patient had this PI on admission	Enteral
44	72	M	13	N	L	Yes	High	DM, CAD, HF	Stage I	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral
45	45	M	183	N	L	Yes	High	None/ unknown	Stage II	Leg + Heel	Hospital	After 10 days	Yes	Yes	Enteral
46	81	F	41	L	L	Yes	High	HT, CAD, CHF	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
47	54	M	165	N	N	Yes	High	Asthma, CAD, HT	Stage II	Sacrum + Back	Hospital	After 10 days	Yes	Yes	Enteral
48	83	M	83	N	N	Yes	High	HT	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
49	64	M	63	L	L	Yes	High	HT, CAD, COPD	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
50	74	M	28	N	L	Yes	High	CHF, HT, COPD	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
51	83	F	31	L	L	Yes	High	HT, Alzheimer	Stage II	Sacrum	Hospital	After 10 days	Yes	Yes	Enteral
52	64	F	96	N	L	Yes	High	HT	Stage I	Sacrum	Hospital	Within 10 days	Yes	Yes	Enteral

PI: Pressure injury, HT: hypertension, DM: diabetes mellitus, CAD: coronary artery disease, COPD: chronic obstructive pulmonary disease, CHF: chronic heart failure, HF: heart failure, CVD: cardiovascular disease, BPH: benign prostate hyperplasia, M: male, F: female, HSD: hospital stay days, L: low, N: normal

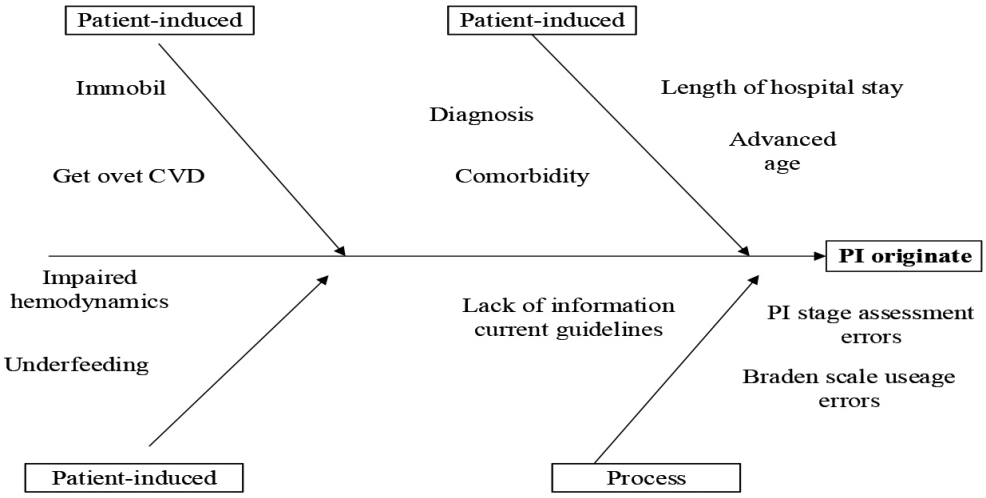

Figure 1. Root cause analysis of pressure injuries
PI: Pressure injury, CVD: cerebrovascular disease

As the study was conducted only a tertiary training and research hospital in a single NICU makes it difficult to generalize the results. On the other hand, it is considered important that it is one of the largest public hospitals in the service universe in the province of Antalya, where the study was conducted. Another limitation is that the study data only covers a one-year period.

Conclusion

We observed that the patients in the NICU were in the high-risk group in terms of PI development. Immobilization, age, length of stay and nutritional status during their stay in the ICU are risk factors for the PI formation. It should be highlighted that PIs in hospitalized patients are only being evaluated as a first step in the prevention of PI formation.

In conclusion, since the patients with mechanical ventilator support (in terms of a PI caused by a medical device), as well as those who are unconscious, those with oedematous skin, those fed by enteral nutrition, those getting 12 points or less from Braden pressure sore risk assessment scale, those with infection, and those with low levels of albumin and hemoglobin are at high risk for the PI development, it is necessary that the patients -especially those hospitalized in the ICUs- are periodically evaluated considering the risk factors and that appropriate nursing interventions are provided to prevent any PI development. In this context, the evaluation of patients in terms of PI risk is important in both way the the quality of care and the patient safety. There is a need for more comprehensive multi-center studies that reveal other causes of PIs (such as health personnel-related, material-related) with a holistic approach.

In future studies, there is a need for comprehensive and long-term data covering multi-centre intensive care and clinics, in which the opinions of intensive care nurses are taken, and not only patient-related causes, but also health professionals and equipment-related reasons (like socio-economic, home care and nutritional problems) of PIs.

Ethics

Ethics Committee Approval: This study was aproved by the Clinical Research Ethics Committee of the University Health Sciences Turkey, Antalya Training and Research Hospital (decision no: 14/4, date: 16.09.2021).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: H.E., C.Ö., Concept: H.E., C.Ö., Design: H.E., C.Ö., Data Collection and Process: H.E., C.Ö., Analysis or Interpretation: H.E., C.Ö., Literature Search: H.E., C.Ö., Writing: H.E., C.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

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