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Determination of Pressure Injury Risk Factors in COVID-19 Patients Hospitalized in the Intensive Care Unit

Yoğun Bakım Ünitesinde Yatan COVID-19 Hastalarının Basınç Yaralanması Risk Faktörlerinin Belirlenmesi

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ABSTRACT

Objective: This study aimed to determine the risk factors for pressure injury in COVID-19 in intensive care unit.

Materials and Methods: A retrospective study was conducted using COVID-19 Intensive Care Unit archive data from April 2020 to July 2022. The study included patients aged 18 and over, with no pre-existing pressure injury, at high risk (Braden Score not between 6-12), and hospitalized in the ICU for at least 24 hours.

Results: A pressure injury developed in 25.2% of the patients. Among those who developed a pressure injury, 79.4% were classified as Stage I, characterized by redness, and 36.8% of the injuries occurred in the sacral region. A significant difference was observed in relation to age, length of stay, Braden score, albumin levels, hemoglobin levels, oxygen levels, and medications used between patients with pressure injuries and those without ($p < 0.05$). The Braden scale was used for risk assessment. Factors independently associated with pressure injury were hemoglobin (1.398 [1.122-1.742]), hemoglobin (0.067 [0.007-0.643]), high-dose steroids (0.026 [0.002-0.317]) and oxygen (0.108 [0.012-0.964]).

Conclusions: It was found that stage I developed in patients, and the most pressure injuries were in the sacrum. The risk of pressure injury was associated with the Braden score, hemoglobin, high-dose steroids, and oxygen. Nurses should evaluate the risk of developing pressure injury in the intensive care unit. They should minimize the conditions that will threaten the safety of patients at risk.

Keywords: COVID-19, intensive care unit, pressure injury, risk factors

ÖZ

Amaç: Bu çalışmanın amacı yoğun bakım ünitesinde COVID-19'a bağlı bası yarası risk faktörlerini belirlemektir.

Materyal ve Metot: Nisan 2020 ile Temmuz 2022 tarihleri arasında COVID-19 yoğun bakım arşiv verileri kullanılarak retrospektif bir çalışma gerçekleştirildi. Çalışmaya 18 yaş ve üzeri, önceden mevcut basınç yarası olmayan, yüksek risk altında olan (Braden Skoru 6-12 puan arasında olmayan) ve en az 24 saat yoğun bakımda yatan hastalar dâhil edildi.

Bulgular: Bir basınç yarası, hastaların %25.2'sinde gelişti. Basınç yarası gelişenlerin %79.4'ü, kızarıklıkla karakterize edilen Evre I olarak sınıflandırıldı ve yaraların %36.8'i sakral bölgede meydana geldi. Basınç yarası olan ve olmayan hastalar arasında yaş, yatış süresi, Braden skoru, albümin seviyesi, hemoglobin düzeyi, oksijen seviyesi ve kullanılan ilaçlarla ilgili anlamlı bir fark gözlendi ($p<0.05$). Risk değerlendirmesi için Braden ölçeği kullanıldı. Basınç yaralanmasıyla bağımsız olarak ilişkili faktörler (1,398 [1,122-1,742]), hemoglobin (0,067 [0,007-0,643]), yüksek doz steroid (0,026 [0,002-0,317]) ve oksijen (0,108 [0,012 -0,964]) bulundu.

Sonuç: Hastalarda evre I geliştiği ve en fazla basınç yaralanmasının sakrumda olduğu bulundu. Basınç yaralanması riski Braden skoru, hemoglobin, yüksek doz steroid ve oksijen ile ilişkiliydi. Hemşireler yoğun bakım ünitesinde basınç yaralanması gelişme riskini değerlendirmelidir. Risk altındaki hastaların güvenliğini tehdit edecek koşulları en aza indirmelidirler.

Anahtar Kelimeler: Basınç yaralanması, COVID-19, risk faktörleri, yoğun bakım ünitesi

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INTRODUCTION

Coronavirus 2019 (COVID-19) was characterized by severe respiratory infection (severe pneumonia), acute respiratory distress syndrome (ARDS), sepsis, septic shock, myocarditis, arrhythmia and cardiogenic shock, and multiple organ failure.[1] Disease management was also very challenging due to decreased oxygenation and the risk of infection in COVID-19.[2] The inability to frequently change patients' position due to the severity of the disease, their medical characteristics, practices related to treatment interventions, and health personnel-related reasons impaired oxygenation and tissue perfusion.[2,3] Therefore, prolonged disease management also caused pressure injuries (PIs) in the patient.[2] Healthcare professionals may have overlooked PI as they often focused on the hemodynamic responses of COVID-19 patients who had severe respiratory problems in the ICU (Intensive Care Unit).[4,5]

In a study conducted in New York, it was found that the prevalence of PIs in COVID-19 patients who needed ICU was three times higher than in patients without a COVID-19 diagnosis who needed ICU.[6] The pathophysiology of COVID-19 and the risk of developing PI were evaluated at the European Pressure Ulcer Advisory Panel Virtual Meeting held in September 2020. In this evaluation, inflammation and medical device-related tissue damage were stated as the causes of PIs.[5,6] Patient-related medical conditions (low oxygenation due to lung involvement, anemia, malnutrition, hypovolemia, etc.) needed to be assessed in patients who had COVID-19 and were admitted to the ICU. In addition, the use of devices related to diagnosis, treatment, and care and diagnostic conditions (non-invasive mechanical ventilation (NIMV), immobilization, oxygen treatment methods, prone position, etc.) needed to be assessed, too.[6,7]

Prone positioning improves mortality in ARDS by optimizing oxygen recruitment, reducing lung strain, and improving oxygenation. While the benefits of prone positioning far outweighed the risks, placing patients with COVID-19 in a prone position was likely to put them at risk of other complications, including PIs of the soft tissues and skin.[5,8] However, prone positioning was widely used to reduce ventilator-induced lung injury and improve oxygenation in patients with severe COVID-19.[5,9-11]

Practices performed depending on the patient's medical condition and diagnosis, therapeutic interventions[1,5] needed to be considered as risk factors that accelerated the development of PI and delayed wound healing in some cases,[6,9-11] and risks needed to be minimized using preventable holistic nursing interventions (e.g., supporting the PIs region, frequent positioning, skin monitoring, etc.).[4,11,12] In this context, this study was carried out to determine the risk factors for PIs in ICU patients diagnosed with COVID-19.

MATERIALS AND METHODS

Ethics Committee Approval: Written approval to conduct the study was obtained from the Non-Interventional Clinical Research Ethics Committee of Cukurova University Faculty of Medicine (Date: 13.05.2022, decision no: 52). The requirement for individual patient consent was waived by the Clinical Research Ethics Committee due to the retrospective and anonymous nature of the study. The study was conducted in accordance with the tenets of the Declaration of Helsinki.

Study Design and Sample: This was a retrospective observational study. This study was conducted with 270 COVID-19 patients in the ICU between April 2020 and July 2022. The study was carried out retrospectively by using patients' records. The records of 2,110 patients diagnosed with COVID-19 from April 2020 to July 2022 were analyzed. Only 348 of the patients were admitted to the ICU, and therefore, the remaining 1762 records were excluded. The study setting was the 9-bed COVID-19 ICU of a university hospital. Patient files that met the inclusion criteria were recorded. Patients aged 18 and over, patients who did not have an existing PIs, who were patients at high risk for PIs (Braden Score 6-12 points) on admitted to the ICU, and who were hospitalized in the intensive care unit for at least 24 hours were included in the study.

Data Collection Tools: Patient characteristics were required to compile data from electronic records, so we created a Patient Descriptive Information Form. We also used the Braden Pressure Injury Risk Assessment Scale.[13,14]

Patient Descriptive Information Form (PDIF): This form consisted of 17 questions about patients' descriptive and medical characteristics, including age, length of stay in the ICU, gender, chronic disease, body mass index (BMI), skin status, nutrition status, serum albumin level, oxygen level, hemoglobin level, smoking status, vasopressor medicines treatment and high-dose steroids (at least 40 mg of equivalent prednisone per day), the duration of sedation, the duration of the prone position, and systemic infection.

Braden Pressure Injury Risk Assessment Scale (BPIRAS): The scale was developed in 1989,[13] and its validity and reliability study in our country was performed in 1997.[14] The scale consists of 6 subscales: sensory perception, activity, mobility, skin moisture, nutrition, and friction and shear. The six subscales reflect critical determinants of pressure and factors that influence the pressure tolerance of

the skin and supporting structures. Each item is scored between 1 and 3 or 4, and the total scale score ranges from 6 to 23. The lower the score is, the higher the patient's risk of PIs is. A lower Braden score indicates higher levels of risk for PI development. Scores from 6 to 12 indicate a very high risk.

Data Collection: We obtained the data from patients' records between April 2020 and July 2022. The data were reviewed by the researcher, and it took approximately 20-25 minutes to review each patient file.

Data Analysis: The SPSS (IBM-Statistical Package for Social Sciences for Windows, Version 24.0) was applied to analyze the data of the study. Descriptive analysis included frequency, percentage, mean, standard deviation, minimum, and maximum values. The Kolmogorov-Smirnov test was used to determine whether the data were normally distributed. Parametric tests were applied as the data were normally distributed. Categorical variables were expressed as percentages and compared using the chi-square or Fisher exact test. After applying multivariate logistic regression (LR), the variables associated with the risk of developing PI were analyzed. According to our findings from univariate analysis, we included variables that were significant at the $p<0.2$ threshold into the forward model and performed a stepwise-decreasing analysis that removed variables with a $p>0.05$ threshold from the model. The link between estimators was assessed by examining the Variance Inflation Factor. $p<0.05$ was considered significant in all tests.

RESULTS

Table 1 compares PI development based on patients' descriptive and clinical characteristics. The average age of patients was 64.12±14.55 years, with 60.9% being male, and the average ICU stay was 12.28±7.07 days. No significant differences were found in gender, BMI, chronic diseases, or smoking status between patients with and without PI. However, significant differences were observed in albumin levels, hemoglobin levels, oxygen treatment, age, ICU stay length, and Braden total scores ($p<0.05$).

Table 1. Comparison of PI development according to the descriptive and clinical characteristics of the patients

Descriptive and clinical characteristics	**PI Mean±SD (n=68)**	**Non-PI Mean±SD (n=202)**	**Test/p**
Age (years)	64.12±14.55	59.11±16.15	t=2.472/ **p=0.019**
Length of ICU stay (days)	12.28±7,07	8.02±4.94	t=4.484/ **p=0.000**
Scale for the evaluation of the risk of PI (BRADEN)	8.19±2.53	11.47±4.04	t=-7.831/ **p=0.000**
Albumin	2,21±1,12	3,20±2,63	t=-4.398/ **p=0.000**
Length of MV (days)	9.84±5,17	6.05±3.24	t=-4.926/ **p=0.000**
Hemoglobin	9.34±3.42	11.94±6.14	t=-6.430/ **p=0.000**
Length of steroids (days)	9.48±2.56	10.86±3.31	t=-5.102/ **p=0.000**
Length of vasopressors (days)	4,88±2,71	3,00±0,00	t=-.451/ p=0.596
Sedation duration (hours)	3,79±2,10	3,96±2,98	t=-.369/ p=0.713
Prone position duration (n=40)/hours	9,08±3,31	8,79±3,33	t=.564/ p=0.517
	n(%)	**n(%)**	
Gender			
Male	38 (55.9)	123 (60.9)	x^2=0.530/
Female	30 (44.1)	79 (39.1)	p=0.467
BMI			
Less than 18.5 kg/m2: Underweight	13 (19.1)	7 (20.8)	
18.5-24.9 kg/m2: Normal	0 (0.0)	6 (3.0)	x^2=2.232/
25-30 kg/m2: Overweight	26 (38.2)	73 (36.1)	p=0.526
≥30 kg/m2: Obese	29 (42.6)	81 (40.1)	
Chronic Disease*			
Yes	62 (91.2)	159 (78.7)	x^2=0.241
No	6 (8.8)	43 (21.3)	p=0.621
Smoking			
Yes	28 (41.2)	91 (45.0)	x^2=0.310/
No	40 (58.8)	111 (55.0)	p=0.578
Oxygen Treatment			
MV [a]	57 (83.3)	92 (45.5)	
NIMV	8 (11.8)	23 (11.4)	x^2=36.578/
Mask	2 (2.9)	35 (17.3)	**p=0.000**
Nasal	1 (1.5)	24 (11.9)	
HFT[a**]	0 (0.0)	28 (13.9)	

*: DM, Heart Diseases; HT: Hypertension; Respiratory diseases- COPD, ARDS, PNEUMONIA; **: HFT, high flow therapy; SD: Standard Deviation; t: Independent groups t-test, test; a: Groups causing significance according to Bonferonni test; High-dose steroids: >40 mg of equivalent prednisolone per day.

Multivariate LR analysis is shown in Table 2. According to the findings obtained from the univariate analysis, we included age, length of ICU stay (days), albumin, oxygen therapy, hemoglobin, Braden Scale score, and high-dose steroid use in the advanced model, and performed a stepwise backward elimination analysis that excluded variables with a p-value > .05. The factors independently associated with oxygen levels (OR:0.108 [95% Cl:0.012,p=0.964]), PI in the scale for the evaluation of the risk of PI (Braden) (OR:1.398 [95% Cl:1.122- p=1.742]), hemoglobin levels (OR:0.067 [95% Cl:0.007, p=0.643]) and high-dose steroids (OR:0.026 [95% Cl:0.002, p=0.317]). Collinearity between these four variables was low, with the variable inflation factor ranging between 1.0 and 1.2. BMI, chronic disease, smoking, low albumin level, nutrition and skin condition were not associated with PIs.

PIs were identified in 25.2% of the patients. Among those affected, the majority (79.4%) had stage I injuries, followed by 17.6% with stage II and 2.9% with stage III injuries. The anatomical distribution of PIs, detailed in Table 3, shows that the most frequently affected sites were the sacral region (36.8%) and the gluteal region (35.3%).

Table 2. Multivariate analysis of the factors associated with pi among COVID-19 patients hospitalized in the ICU.

Variable	Odds ratio	95% Confidence interval		p-value
		Lower	Upper	
Oxygen levels*	0.108	0.012	0.964	**0.046**
Hemoglobin levels	0.067	0.007	0.643	**0.019**
Scale for the evaluation of the risk of PI (BRADEN)	1.398	1.122	1.742	**0.003**
High-dose steroids	0.026	0.002	0.317	**0.004**

*oxygen-treatment: MV, NIMV, Mask, Nasal, HFT.

Table 3. PIs characteristics (n=270).

PI characteristic	n (%)
Total Number of Patients	**270 (100)**
Total PI	**68 (25.2)**
Stage of PIs*	**68 (100)**
Stage I: redness	54 (79.4)
Stage II: partial-thickness skin loss	12 (17.6)
Stage III: full-thickness skin loss	2 (2.9)
Location of PIs*	**68 (100)**
Sacrum	25 (36.8)
Gluteal	24(35.3)
Face	10 (14.7)
Heel	5 (7.4)
Scapula	4 (5.9)

*Regardless of the total number of patients, the location of PI and Stage of PI were considered as n=68, %=100.

DISCUSSION AND CONCLUSION

PIs were likely to be overlooked since health professionals usually focused on the hemodynamic responses of patients with COVID-19 in the ICU who had severe respiratory problems.[4,5] There were various risk factors for PIs due to decreased physical activity in the ICU,[15] and necessary precautions had to be taken to prevent PIs development in case of risks.[16]

The mean age of patients who had developed PIs was determined as 64.12±14.55 in this study and 67.5±17 in the study by Kıraner et al.[12] With aging, patients are prone to PIs development due to changes, such as delayed infiltration of macrophages and lymphocytes, decreased secretion of growth factors,[16] and decreased partial O2 pressure.[17] In elderly patients with severe respiratory failure, weakening of the immune system and slowing of respiratory functions may increase PIs by impairing tissue perfusion.

Albumin levels are as important as oxygenation in ensuring tissue perfusion.[18,19] In this study, 91% of patients with PIs were found to have low levels of albumin. Some studies conducted with patients in the ICU have shown that low albumin levels may cause PIs development.[18-21] In the transition from the early to late phase of COVID-19, the breakdown of the extracellular matrix caused fluid to accumulate in the lungs, impairing the oxygenation capacity over time,[21] and preventing the passage of nutrients

and oxygen to damaged tissues.[20,21] The decrease in the albumin level caused edema, which led to PIs development by impairing tissue perfusion due to decreased oxygen transmission.

According to our results, we found that LR yielded the best model to predict that oxygen, hemoglobin, the Braden Risk Assessment Scale, and high-dose steroid treatment played a role in PIs. Our study yielded results similar to those of studies in the literature,[21-25] and we determined that a statistical approach (LR- oxygen, hemoglobin and high-dose steroid treatment) similar to that of the Braden risk assessment scale existed.

Patients with COVID-19 were often applied mechanical ventilation (MV) or non-invasive mechanical ventilation (NIMV) due to the treatment of acute respiratory failure and acute pulmonary edema, and maintenance of oxygenation.[24-26] In our study, MV was applied to 83% of the patients to maintain oxygenation. Since patients with COVID-19 experienced an atypical form of ARDS,[27] according to its prognosis, it was likely to lead to hypoxia and ischemia unless the oxygen need for peripheral tissues in the human body was met.[26] It is known that prolonged MV of about >96 hours is a known risk factor for PIs in the general ICU population; however, the decrease in oxygenation required for the prevention of tissue damage would inevitably pave the way for PIs development.

In our study, PIs had developed in 97.1% of the patients with low hemoglobin levels, and we determined that hemoglobin levels were a risk factor. While Akan and Sayın[22] determined that hemoglobin levels did not affect the prevention of PIs, Kıraner et al.[12] found that low hemoglobin and albumin levels increased the risk of PIs. In addition, there are different studies in the literature showing that low hemoglobin levels increase PIs development.[12,20] Low hemoglobin and decreased oxygen transport may be risk factors for the development of injury by causing hypoxia and impaired tissue perfusion.

One of the most important risk factors for the development of PIs are the use of high-dose steroids and vasopressors.[20,24,28] We found that high-dose steroids were associated with PIs (OR:0.026 [%95 Cl:0.002,p=0.317]). Labeau et al. defined the use of corticosteroids and vasopressors as risk factors for ICU-related PIs.[29] High-dose steroids and vasopressors are thought to cause PIs development because they impair tissue perfusion in patients at risk for tissue ischemia.

In this study, it was found that approximately 25.2% of the patients with COVID-19 hospitalized in the ICU had PIs and that this was associated with various risk factors (Table 1 and Table 2). This rate was found as 56.8% by Kıraner et al[12] and 57.5% by Şengül et al.[4] ın our study, approximately 25% of the patients had developed stage I (redness) and stage II (partial-thickness skin loss) injuries and the most common injury site was the sacrum (Table 3). Similarly, some studies conducted with COVID-19 patients in the literature indicated that approximately half of the patients had developed deep tissue injury and stage II injuries and that the most common injury site was the sacrum.[4,12,28] As a result, the peak interface pressure at the sacrum increased, and it resulted in an increased risk of sacral PIs. Also, since the majority of PIs were on the sacrum, it seems that the most critical time interval for PIs risk was when the patient was not placed in a prone position. Some studies conducted with COVID-19 patients indicated that PIs were usually tool-induced or were due to the prone position, and also occurred in the facial area.[4,5,7,11,12,15,29] However, in this study, we found that[20-22,24,30] they were more prevalent in the sacrum and gluteal regions. Healthcare professionals were likely to neglect PIs as they often focused on the hemodynamic responses of COVID-19 patients.[4,7] In addition, we think that healthcare workers were reluctant to provide care for patients due to the delay in positioning because of staff shortage, the necessity of wearing PPE, and the high rate of patient contamination. These findings suggest that the sacral and gluteal regions are particularly vulnerable to pressure injuries, likely due to prolonged immobility and sustained pressure in these areas during critical care. This highlights the need for targeted preventive measures focused on these high-risk anatomical sites.

In our study, patients who developed PIs were placed in the prone position for a mean of 9.08±3.31 hours, and no significant difference was found for PIs development (Table 1). As stated in studies conducted with patients with severe ARDS and COVID -19 in the literature, prolonged prone position caused PIs.[4,6,7,29,30] Patients with COVID-19 were placed in a prone position for long periods between 12 and 24 hours, depending on their medical condition, to improve oxygenation.[4,29,30] The reason for the development of PIs in this position may have been due to the medical characteristics of the patient or the prevention of frequent position changes due to having to stay in this position for a long time.

In our study, 14.7% of the patients developed PIs in the facial region, and this rate was approximately 30% in studies in the literature.[4,12,16] In the literature, medical device-related PIs development in COVID-19 patients was reported to be mostly due to respiratory devices such as NIMV masks and tracheal tubes.[1,4,12,16] In studies conducted in the ICU, medical device-related PIs development was reported to range between 30% and 79.4%.[4,12,30] The pressure created by the medical device and the inadequate oxygenation increased the risk of PIs in patients with

COVID-19.

In conclusion, the results of this study have limitations of record studies (such as the reliability of records) as they are based on data from records on risk assessment in patients with PIs cared for during the COVID-19 pandemic in a single center. The study found that 25.2% of patients developed PIs, of which 79.4% were stage I (redness). The most common sites were the sacrum (36.8%) and gluteal region (35.3%). Risk factors for PIs included oxygen level, Braden score, hemoglobin levels and high-dose steroids. Stage I injuries were more common in the sacrum and gluteal regions. PIs were often overlooked as healthcare professionals focused on severe respiratory problems in ICU patients with COVID-19. Risk factors such as prolonged ICU stay, low hemoglobin, low albumin and corticosteroid use were consistent with findings from other studies. Nurses should regularly assess the risk of PIs and apply evidence-based interventions to prevent complications and enhance patients' quality of life.

Ethics Committee Approval: Written approval to conduct the study was obtained from the Non-Interventional Clinical Research Ethics Committee of Cukurova University Faculty of Medicine (Date: 13.05.2022, decision no: 52). The requirement for individual patient consent was waived by the Clinical Research Ethics Committee due to the retrospective and anonymous nature of the study. The study was conducted in accordance with the tenets of the Declaration of Helsinki.

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

Author Contributions: Concept – IT, FÜ; Supervision – IT, FÜ, SE; Materials – IT, FÜ, SE; Data Collection and/or Processing – IT, FÜ; Analysis and/or Interpretation – IT, FÜ, SE; Writing – IT, FÜ, SE.

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