

# The incidence of pressure ulcer in old patients undergoing open heart surgery and the relevant factors

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## Abstract

**Introduction:** The proportion of old inpatients in cardiac intensive care units (CICUs) is increasing.

**Objectives:** This study was conducted to determine the relationship of hemodynamic and oxygenation status with the risk of pressure ulcers following open heart surgery in old patients.

**Patients and Methods:** The present descriptive study was conducted over three months in 2016 on 48 patients selected using convenience sampling. The data collection tools included a three-part demographic information checklist, hemodynamic clinical data collection forms, oxygenation clinical data collection forms and the Braden scale. The data collected were analyzed in SPSS using descriptive tests, the independent *t* test and Pearson's correlation coefficient.

**Results:** Of the 48 patients, 28 (58.3%) were male and 20 (41.7%) were female. The mean age of the patients was  $68.16 \pm 5.53$  years and their mean length of stay was  $2.95 \pm 0.96$  days. All the pressure ulcers were stage 1 and 2. The incidence of pressure ulcers in these patients was found to have statistically significant relationships with the mean heart rate on the second day ( $P=0.01$ ), the mean arterial carbon dioxide level on the fourth day ( $P=0.02$ ), diabetes ( $P=0.01$ ) and smoking ( $P=0.001$ ), while it lacked statistically significant relationships with the other hemodynamic and oxygenation variables studied.

**Conclusion:** Old patients undergoing open heart surgeries are at a high risk of the incidence and development of pressure ulcers. Thus, factors such as diabetes, smoking, heart rate and arterial carbon dioxide level affect the incidence of these ulcers.

## Introduction

Pressure ulcers are skin integrity disorders in which a soft tissue forms between bony appendages and an outer surface due to the skin compression. Ineffective tissue perfusion causes these ulcers which progressively destruct their underlying layers and consequently cause the loss of cells (1). Pressure ulcers are a cause of physical, economic and emotional pressure on patients and an indicator for investigating the quality of healthcare provided in health centers (2). These ulcers prolong hospitalization, increase healthcare costs, undermine quality of life (3) and are associated with adverse consequences including pain, reduced performance and independence, increased risk of infection and sepsis, delayed recovery and a need for additional surgeries (4). Moreover, over one million inpatients are annually infected with pressure ulcers, around 7%-8% of whom die due to the complications of these ulcers (5). Billions of dollars are also spent every year in healthcare centers around the world to prevent and treat pressure ulcers, particularly in

## Core tip

Old patients undergoing open heart surgeries are at a high risk of the incidence and development of pressure ulcers. Consequently, factors such as diabetes, smoking, heart rate and arterial carbon dioxide level affect the incidence of these ulcers.

patients with prolonged hospitalization (2). According to a report, the cost of pressure ulcer care accounts for around 1% of the total healthcare budget of the Netherlands (6). Despite advances in modern technology and preventive equipment, unfortunately, the prevalence of pressure ulcers has not been reduced in inpatients (7). Numerous risk factors contribute to forming and developing pressure ulcers (5), including peripheral vascular disease, infections and aging (8). Given the progressively growing population of older adults in many countries, healthcare requirements of this population seem to be growing today (9). Different studies suggest significantly positive

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relationships between the incidence of pressure ulcers and patient age (8). Around, 70% of pressure ulcers form in patients over 70, 60% occur during hospitalization, 18% in aged care homes and the remaining at home (10).

Nowadays, a significant proportion of the patients hospitalized in intensive care units (ICUs), are old (11). Given the many changes in the cardiovascular system caused by hospitalization or bed-rest (12), these patients are always at risk of hemodynamic and oxygenation disorders (7). Furthermore, surgery and its prolongation may cause pressure ulcers owing to restricting motor skills and changing hemodynamics of these patients (13), including those undergoing open heart surgery (14). Studies reported an incidence rate of 9.8% for pressure ulcers in surgery patients (15), reaching 32% in cardiac surgery patients (16). The incidence of pressure ulcers in Iranian cardiac surgery patients was also reported as 21.3% (14).

Given the growing population of older adults both in Iran and across the world, the increasing proportion of inpatients in cardiac care units (CCUs) and currently unclear relationship of the hemodynamic and oxygenation status with the risk of developing pressure ulcers in old patients undergoing cardiac surgery, predicting the incidence of the ulcers and identifying these patients with the risk of developing pressure ulcers are essential using studies on cardiac surgery.

## Objectives

The present study was therefore conducted to determine the relationship of the hemodynamic and oxygenation status with the risk of developing pressure ulcers following cardiac surgery in old patients.

## Patients and Methods

### Study population

The present descriptive cross-sectional study was conducted in the cardiac surgery ward of Bu-Ali-Sina teaching hospital, Qazvin, Iran on patients undergoing non-emergency open heart surgery, aged at least 60 years and with the desire to participate in the study. This study was conducted for three months in 2016 and approved by the hospital's authorities and the Ethics Committee of the University. The patients were briefed on the study objectives and process, ensured of the confidentiality of their information and asked to sign informed consent forms. A total of 48 patients were included using convenience sampling and those having pressure ulcers upon admission to the operating room were excluded.

A three-part checklist was used in this study to collect the patients' data. The first part of this demographic checklist included age, gender, time of admission to the recovery room, a history of diseases such as diabetes, hypertension, hyperlipidemia and stroke, a history of surgeries, body mass index (BMI), smoking status, intraoperative pump status and having pressure relief mattresses. The second part of the checklist comprised hemodynamic variables such as heart rate, central venous pressure, systolic and

diastolic blood pressure, mean arterial pressure as well as clinical data associated with oxygenation variables such as oxygen saturation, partial pressure of oxygen, partial pressure of carbon dioxide and oxygen content. The Braden scale, which was used as a predictor of pressure ulcers in the third part, comprises six subscales of activity, mobility, sensory perception, nutrition and moisture, each of which scored between 1 and 4, as well as friction and shear with a score of 1-3 (17,18). The total score of this scale is therefore 6-23 and the lower the score obtained, the higher the risk of developing pressure ulcers.

The present study applied the Braden scale before the patients' entrance to the operating room and when areas of the patients' body were more prone to developing pressure ulcers. Patients who have pressure ulcers at the time of admission were excluded. Demographic information recorded in this stage included age, gender, date of admission, presence of diabetes, hypertension, hyperlipidemia, stroke and previous surgeries as well as BMI and smoking status. Data related to having pressure relief mattresses and intraoperative pump status were recorded upon the patient's entrance to the recovery room. The data collection tool used in the first stage was also used in the second stage when the patient's consciousness level (GSC) reached a minimum of 8 at the CCU. The patient's skin and areas prone to pressure ulcers were investigated daily before discharge and the data associated with the incidence or healing of pressure ulcers were recorded in the patient's profile. The patient's affliction with the ulcers was recorded in this stage based on the six-step international guideline. Daily averages of clinical data associated with the main variables, including heart rate, central venous pressure, systolic and diastolic blood pressure, mean arterial pressure, oxygen saturation, partial pressure of oxygen, partial pressure of carbon dioxide and oxygen content were included in the patients' profiles. The Braden scale was used for the first time upon patient discharge from the recovery room.

### Ethical issues

1) The research followed the tenets of the Declaration of Helsinki and its later amendments; 2) informed consent was obtained; and 3) Permission of the ethical review committee of Qazvin University of medical science was obtained prior to execution of the study.

### Statistical analysis

This study used descriptive tests including frequency and relative frequency to analyze qualitative variables such as having pressure ulcers, having diabetes, a history of previous surgeries, hypertension, a history of stroke and hyperlipidemia, smoking status, gender and having pressure relief mattresses. Mean and standard deviation were also used to analyze quantitative variables including age, length of stay, day of developing pressure ulcers, day of pressure ulcer healing, the Braden scale score, BMI, systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, central venous pressure,

oxygen saturation, partial pressure of oxygen, partial pressure of carbon dioxide and oxygen content. Moreover, the independent *t*-test was used to evaluate dichotomous variables and Pearson's correlation coefficient and Fisher's exact test, to investigate the relationship of independent variables with the dependent variable. Independent *t* test was also used. The statistical significant level of *p* was set at 0.05.

## Results

### Demographic variables

The patients' age ranged 60-78 years (mean;  $68.16 \pm 5.53$  years), their length of stay was 2-6 days (mean;  $2.95 \pm 0.96$  years) and their BMI was 20.50-40.82 kg/m<sup>2</sup> (mean;  $26.58 \pm 4.94$  kg/m<sup>2</sup>). Table 1 presents the other demographic variables. The prevalence of pressure ulcers in the patients was found to be 50%; 24 patients developed stage-1 pressure ulcers, 22 on the first day and 2 others on the second day. Two cases of stage-2 pressure ulcer were observed on the second day in patients with stage-1 ulcer on the first day. Both of these patients still suffered this type of ulcer upon discharge. The results of the chi-square test found the incidence of pressure ulcers to have statistically significant relationships with diabetes ( $P=0.01$ ) and smoking ( $P=0.001$ ). Table 2 shows the results associated with the relationship between developing pressure ulcers and demographic variables.

Independent *t* test found statistically significant relationships between pressure ulcer development and moisture ( $P=0.02$ ), activity ( $P=0.04$ ), mobility ( $P=0.04$ ) at the first time of applying the Braden scale, sensory perception ( $P<0.001$ ), activity ( $P=0.03$ ), mobility ( $P=0.02$ ) as well as friction and shear ( $P=0.01$ ) at the second time and moisture ( $P=0.01$ ), mobility ( $P=0.04$ ) and nutrition ( $P=0.01$ ) at the third time of applying this scale (upon patient discharge).

**Table 1.** Frequency distribution of demographic variables in the study patients

Variable	Frequency	Relative frequency	
Gender	Male	28	58.3
	Female	20	41.7
Diabetes	Yes	29	60.4
	No	19	39.6
Hypertension	Yes	37	77.7
	No	11	22.9
Hyperlipidemia	Yes	12	25.0
	No	36	75.0
A history of surgeries	Yes	21	43.8
	No	27	56.2
A history of stroke	Yes	12	25.0
	No	36	75.0
Pressure relief mattresses	Yes	8	16.7
	No	40	83.3
Intraoperative balloon pump	Yes	43	89.6
	No	5	10.4
Smoking	Yes	20	41.7
	No	28	58.3

The results of the *t* test found pressure ulcer development in old patients undergoing cardiac surgery not to have significant relationships with the mean systolic blood pressure, the mean diastolic blood pressure, the mean arterial pressure and the mean central venous pressure during hospitalization (Tables 3 and 4). Pressure ulcer development was however found to have statistically significant relationships with the mean heart rate of the second day in these patients ( $P=0.01$ ). Table 5 presents the relevant results in detail.

The analytical results of the *t* test associated with the oxygenation variables found pressure ulcer development to be significantly associated with the mean partial pressure of carbon dioxide on the fourth day as the blood carbon dioxide levels were lower in the patients with pressure ulcers this day. No statistically significant relationships were found between the other oxygenation variables during hospitalization and pressure ulcer development. Table 6 contains more detailed results.

## Discussion

Pressure ulcer is associated with disability and age, and 70% of pressure ulcers form in people over 70. Pressure ulcer development increases the risk of infections, affects quality of life in older adults and finally leads to an increased rate of mortality and morbidity (19). Literature suggests that pressure ulcers increase the risk of death by 2-4 times in old patients hospitalized in CICUs (20). The findings of the present study indicated that old patients hospitalized in CICUs are at high risk of developing stage 1 and 2 pressure ulcers and factors such as the mean heart rate on the second day, the mean arterial carbon dioxide level on the fourth day, diabetes and smoking increase the

**Table 2.** Comparison of demographic variables distribution in the two groups

Variable	With ulcers	Without ulcers	<i>P</i>	
Age	$69.04 \pm 5.90$	$67.29 \pm 5.11$	0.19	
BMI	$26.29 \pm 4.95$	$26.87 \pm 5.01$	0.77	
Length of stay	$3.20 \pm 1.14$	$2.70 \pm 0.69$	0.027	
Diabetes	Yes	19	10	0.01
	No	5	14	
Gender	Male	14	14	1.000
	Female	10	10	
A history of surgeries	Yes	13	8	0.24
	No	11	16	
Smoking	Yes	16	4	0.001
	No	8	20	
Intraoperative pump status	Yes	24	19	0.05
	No	0	5	
Hypertension	Yes	20	17	0.49
	No	4	7	
Hyperlipidemia	Yes	7	5	0.74
	No	17	19	
A history of stroke	Yes	6	6	1.000
	No	18	18	
Pressure relief mattresses	Yes	2	6	0.24
	No	22	18	

**Table 3.** Comparison of the mean systolic, diastolic and arterial blood pressure

Variable	Hospitalization day	With ulcers	Without ulcers	P
Systolic	First	123.29±12.70	121.78±11.45	0.65
Diastolic	First	73.46±9.44	76.56±10.16	0.54
Mean arterial	First	90.09±9.69	91.47±9.41	0.67
Systolic	Second	123.79±15.25	121.08±12.76	0.52
Diastolic	Second	75.20±9.49	75.01±9.45	0.55
Mean arterial	Second	91.26±10.64	90.33±9.57	0.53
Systolic	Third	122.30±13.08	126.20±15.52	0.50
Diastolic	Third	76.72±10.38	78.92±8.24	0.30
Mean arterial	Third	92.41±10.22	94.67±9.73	0.82
Systolic	Fourth	116.77±9.53	106.11±7.34	0.36
Diastolic	Fourth	73.43±10.50	72.38±7.23	0.38
Mean arterial	Fourth	87.87±9.74	83.62±6.89	0.38

**Table 4.** Comparison of the mean central venous pressure in the two groups

Variable	Hospitalization day	With ulcers	Without ulcers	P
Central venous pressure	First	11.27±3.31	10.53±2.23	0.39
	Second	14.49±1.10	11.35±4.16	0.09

**Table 5.** Comparison of the mean heart rate in the two groups

Variable	Hospitalization day	With ulcers	Without ulcers	P
Heart rate	First	89.06±11.38	82.68±11.12	0.97
	Second	90.50±10.46	83.41±15.22	0.01
	Third	89.08±11.03	86.78±16.61	0.23
	Fourth	87.51±15.19	96.87±5.53	0.14

**Table 6.** Comparing the mean partial pressure of oxygen, oxygen saturation, partial pressure of carbon dioxide and oxygen content in the two groups

Variable	Hospitalization day	With ulcers	Without ulcers	P
Partial pressure of oxygen	First	117.01±24.33	111±21.65	0.50
Oxygen saturation	First	96.86±1.92	96.99±1.62	0.33
Partial pressure of carbon dioxide	First	31.82±2.80	31.12±2.00	0.13
Oxygen content	First	14.69±0.93	14.50±1.83	0.24
Partial pressure of oxygen	Second	121.98±39.10	118.82±33.33	0.33
Oxygen saturation	Second	95.06±2.72	95.79±2.62	0.97
Partial pressure of carbon dioxide	Second	32.82±3.42	31.49±3.51	0.76
Oxygen content	Second	14.80±0.93	14.88±1.39	0.18
Partial pressure of oxygen	Third	110.35±27.15	127.56±19.24	0.25
Oxygen saturation	Third	95.07±3.04	95.96±2.11	0.08
Partial pressure of carbon dioxide	Third	31.36±3.21	31.72±2.51	0.57
Oxygen content	Third	15.07±1.06	15.11±0.68	0.12
Partial pressure of oxygen	Fourth	105.19±25.14	131.50±47.37	0.22
Oxygen saturation	Fourth	97.10±1.82	95.99±2.06	0.95
Partial pressure of carbon dioxide	Fourth	30.57±0.72	33.50±2.12	0.02
Oxygen content	Fourth	15.70±1.000	15075±0.35	0.26

risk of developing pressure ulcers.

Casimiro et al reported a prevalence of 35.7% in old patients hospitalized in Spanish hospitals (21). The present study investigated the prevalence of pressure ulcers in immobile and confined-to-bed patients undergoing open heart surgery and more susceptible to pressure ulcers. The present study did not find significant relationships between developing pressure ulcers and systolic blood pressure, diastolic blood pressure, the mean arterial pressure and the

central venous pressure, which is consistent with the study conducted by Donnelly et al (22). Lindgren et al also found the relationship between pressure ulcer development and diastolic blood pressure to be insignificant (23). Pancorbo Hidalgo and Fernandez found the relationship of risk of developing pressure ulcers with systolic and diastolic blood pressures to be significant (24). Hypertension seems to increase the risk of pressure ulcers owing to increasing the risk of damaging endothelium. Abnormally low

blood pressure also increases the risk of pressure ulcers owing to disrupting the blood supply to the skin surface tissues. The present study found statistically significant relationships between the incidence of pressure ulcers and the mean heart rate on the second day. Karayurt et al found no significant difference of heart rate between two groups with and without pressure ulcers, which is inconsistent with the present study as far as daily figures are concerned (25). The difference in the results might be associated with the increased mean proportion of days, patients underwent mechanical ventilation in this study. The relationship between the incidence of pressure ulcers and the mean heart rate on the second day was found to be significant since heart rate is a hemodynamic factor that is more quickly affected by clinical and psychological condition of patients compared to other hemodynamic factors. On the first day after the surgery, patients in the CCU are provided with more care. They normally undergo mechanical ventilation for up to 12 hours and they are less affected by the environment and conditions within the recovery room. These patients, however, face quite unfamiliar conditions of the recovery room on the second day after the surgery. The present study found the incidence of pressure ulcers to have significant relationships with the mean arterial carbon dioxide on the fourth day. While, lower levels of arterial carbon dioxide were found in the patients, however, no statistically significant relationships were observed between the incidence of pressure ulcers and the other oxygenation variables during hospitalization. Bly et al reported significant relationships between oxygen saturation and the incidence of pressure ulcers (26). Their finding was inconsistent with the present study, as the mean duration of hospitalization was 11 days, which influences the effective factors on pressure ulcers. Moreover, they included all age groups, while we recruited only the old patients. Pressure ulcers are caused by numerous factors including immobility, reduced sensory perception, reduced consciousness level, carrying orthopedic devices such as plaster, malnutrition, anemia, cachexia, obesity, infection, peripheral vascular disease, age, psychological status, smoking, pressure and friction force and moisture (27-31). Older adults are however at higher risk of developing these ulcers owing to aging, urinary and fecal incontinence, incorrect status change, preoperative diseases, hypertension, low Braden scores, diabetes mellitus, medications and age-related changes in body systems (32-36). According to the present study, mobility, activity, sensory perception, friction, moisture and nutrition, as mentioned in the Braden scale, are the factors with demonstrated effects on developing pressure ulcers. Reduced consciousness levels and the consequent reduced sensory perception were found to be associated with developing pressure ulcers in the study patients. Moreover, the lower the mobility and ability to change positions in bed, the higher the patient's susceptibility to pressure ulcers. Moore et al also found mobility and activity to be the causes of patient disability for changing positions in bed, which causes constant pressure and prolonged

immobilization (35). The patient's nutritional status constitutes a key factor at play in the skin's health and ulcer healing. Different studies reported the effects of nutrition on the incidence of pressure ulcers. Proper nutrition is also a significant factor that affects the progression of pressure ulcers, increases the body's energy and reduces susceptibility to infections, which is consistent with the study conducted by Holm et al (36). Moreover, the effect of moisture on developing pressure ulcers is demonstrated in literature. Moisture makes the skin soft and thin, thereby reducing the skin resistance against physical factors such as pressure and the shear force, which is consistent with the study conducted by Keelaghan et al (37). Another potentially effective factor on pressure ulcers is a variety of diseases that may coincide with other underlying comorbidities. The present study found diabetes to be significantly associated with developing pressure ulcers, which is consistent with the study conducted by Nixon et al (38). Another study, however, found no significant correlation between diabetes and developing pressure ulcers (39). Vascular function failure in diabetics makes them more vulnerable to pressure ulcers than other patients. The present study found significant relationships between smoking and developing pressure ulcers in patients, which is consistent with the study conducted by Compton et al (40), but inconsistent with the findings obtained by Donnelly et al (22). No statistically significant relationships were observed in the present study between using pressure relief mattresses and the prevalence of pressure ulcers, which may be affected by the short duration of hospitalization as a limitation of the present study.

### Conclusion

The present study intended to investigate the risk of developing pressure ulcers and the relevant factor in old patients hospitalized in the CCU. Based on the findings, this group of patients is at high risk of developing pressure ulcers, of which physicians and nurses working in these wards should be aware and take the necessary measures for preventing this type of ulcers. Using preventive protocols and identifying high-risk patients can be helpful in this regard. Given the few studies found in literature, further studies are recommended to be conducted on this group of patients.

### Limitations of the study

Small sample size and convenience sampling were the limitations of the present study.

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### Authors' contribution

MS, JA and HR coined the study idea and methodology. MA, HR, JA, MH and FA were involved in devising the questionnaire, collecting data, entering it on SPSS and analyzing it. MA and HR drafted the

manuscript, did the literature review and critically reviewed and edited the article. JA and HR supervised the study.

### Conflicts of interest

The authors declare no conflict of interest.

### Ethical considerations

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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