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RESEARCH ARTICLE

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Frequency of and risk factors for intensive care unit-acquired sacrum pressure injuries in critically ill patients: A multicenter cross-sectional study in China

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Abstract

Rationale, aims, and objectives: Hospital-acquired pressure injuries (HAPI) prolong hospital stays and are an important health problem worldwide. The aim of this study was to assess the frequency of and risk factors for intensive care unit (ICU)-acquired pressure injuries (IAPI) on the sacrum in critically ill patients in China.

Methods: We performed a multicenter, cross-sectional survey of IAPI on the sacrum in 23 adult ICUs in 19 hospitals in China. Data for 421 critically ill patients were collected on December 13, 2019, and January 13, 2020, including patient characteristics, physiological, and clinical information. Logistic regression was used to analyze the risk factors for IAPI on the sacrum in the ICU.

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Results: Forty-one patients presented sacrum pressure injuries in the ICU, with a frequency of 9.74%. Risk factors that significantly increased the risk of IAPI on the sacrum were lower body mass index (BMI, odds ratio [OR] = 1.115, confidence interval [CI]: 1.011-1.229, $P = .029$), chronic obstructive pulmonary disease (COPD, OR = 3.183, CI: 1.261-8.037, $P = .014$), multiple organ dysfunction syndrome (MODS, OR = 2.670, CI: 1.031-6.903, $P = .043$), and a lower Braden risk score (OR = 1.409, CI: 1.197-1.659, $P < .001$).

Conclusion: Lower BMI, COPD, MODS, and lower Braden risk score are independent risk factors for sacrum IAPI in China.

KEYWORDS

cross-sectional survey, frequency, intensive care unit, pressure injuries, risk factor, sacrum

1 | INTRODUCTION

Hospital-acquired pressure injury (HAPI) is a localized injury to the skin and/or underlying tissue during an inpatient hospital stay. HAPI is a major cause of inpatient morbidity and mortality, making it an important health problem worldwide.[1-3] Studies on HAPI have found the median incidence to be as high as 10.8%.[4] The intensive care unit (ICU) is the most common place for HAPI because of patients' poor nutritional status, impaired mobility, incontinence, complex underlying diseases, and complications, making them vulnerable to pressure injuries. It is estimated that up to 40% of patients develop pressure injuries during their stay in an ICU.[5] Previous studies have focused on the prevalence and risk factors of HAPI in a single disease or the incidence of pressure injuries in a certain setting.[6-8] The sacrum is the most common site of acquired pressure injuries in all hospitals and in both critically and noncritically ill patients.[9] However, there is little information on ICU-acquired pressure injuries (IAPI) on the sacrum, especially in China. Therefore, we designed a multicenter cross-sectional study to investigate the frequency of, and risk factors for, HAPI.

2 | METHODS

2.1 | Design and setting

This study used a multicenter, cross-sectional design in 23 ICUs of 19 hospitals in China. All patients admitted to the ICU on December 13, 2019, and January 13, 2020, who were aged ≥18 years, were included in the study. Data collection was performed by two nurses in each center, who were given training in data collection to ensure standardization. The study was approved by the First People's Hospital Institutional Review Board (CZH2019-003). All patients or their guardians provided written consent before enrollment.

Patients were excluded if they were <18-years-old, had a duration of ICU stay of <48 hours, or had existing pressure injuries. Patients who suffered IAPI in other locations but not the sacrum were also excluded. Eligible patients were divided into an IAPI group and a non-IAPI group depending on whether they incurred sacrum HAPI.

2.2 | Data collection and definition

The clinical data collected included gender, age, height, weight, body mass index (BMI), etiological factors, underlying diseases, complications, laboratory test results, and therapeutic schedule. In addition, other physiological and clinical information was collected and scored using the Sequential Organ Failure Assessment (SOFA) score and the Acute Physiology and Chronic Health Evaluation (APACHE) II criteria.

To assess a participant's risk of HAPI, the Braden scale was used. This scale has been used worldwide as a screening instrument for HAPI risk, both in hospital and community settings. The Braden scale measures six items: sensory perception, moisture, activity, mobility, nutrition, and friction/shear. Pressure injuries are divided into deep tissue injury, stage 1, stage 2, stage 3, stage 4, and unstageable.

BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Defecation frequency was defined as the number of defecations in the 3 days before the survey. It was also

TABLE 1 Distribution of IAPI in critically ill patients

Distribution	N (%)
Sacrum	41 (80.4)
Occipital bone	8 (15.7)
Back	2 (3.9)
Anterior superior spine	1 (2.0)
Heel	3 (5.9)
Ankle	2 (3.9)
Other	3 (5.9)

Abbreviation: IAPI, intensive care unit-acquired pressure injuries.

TABLE 2 Characteristics of the 421 patients

Characteristics	IAPI ($n = 41$)	Non-IAPI ($n = 380$)	Total ($n = 421$)	Test	*P*-value
Male, n (%)	31 (75.6)	275 (72.4)	306 (72.7)	0.196	.658
Age	71 (55-83)	61 (50-71)	62 (51-73)	4.787	.029
BMI	21.75 ± 0.61	23.39 ± 0.19	23.24 ± 0.18	−2.712	.007
Nurse:bed ratio	1.55 (1.5-1.55)	1.55 (1.55-1.60)	1.55 (1.55-1.60)	2.766	.097
Etiological factors (n, %)					
Brain trauma	7 (17.0)	216 (56.8)	223 (52.9)	17.535	.000
Sepsis	7 (7.0)	19 (5.0)	26 (6.9)	11.098	.005
Cancer	2 (4.8)	6 (1.5)	8 (1.9)	2.618	.153
Lung infection	7 (17.0)	31 (8.1)	38 (9.0)	4.666	.040
SAP	3 (7.3)	8 (2.1)	11 (2.6)	4.717	.065
Uremia	2 (4.8)	6 (1.5)	8 (1.9)	2.618	.153
AECOPD	1 (2.4)	10 (26.3)	11 (2.6)	0.001	.644
Other	12 (29.2)	84 (22.1)	96 (22.8)	1.970	.117
Underlying diseases (n, %)					
Diabetes	11 (26.8)	55 (14.8)	66 (15.7)	4.274	.039
CHD	16 (39.0)	84 (22.1)	100 (23.8)	5.849	.016
COPD	10 (24.4)	20 (5.3)	30 (7.1)	20.457	.000
HBP	22 (53.7)	164 (43.2)	186 (44.2)	1.005	.316
Complication (n, %)					
Sepsis	7 (17.1)	38 (10.0)	45 (10.7)	1.939	.164
MODS	10 (24.4)	32 (8.4)	42 (10.0)	10.508	.001
ARDS	14 (34.1)	140 (36.8)	154 (36.6)	0.903	.342
Other	7 (17.1)	152 (40.0)	159 (37.8)	8.276	.004
SOFA	9 (3-14)	6 (3–9)	6 (3-10)	11.201	.001
APACHE II	24 (16-30)	19 (15-24)	19 (15-24)	13.390	.000
RASS	−1.29 ± 0.35	−1.45 ± 0.10	−1.43 ± 0.10	0.467	.641
GCS	10.83 ± 0.66	11.14 ± 0.22	11.11 ± 0.21	−0.440	.660
LOS (d)	19.49 ± 4.57	14.97 ± 2.91	15.41 ± 2.66	0.502	.616
Duration of ICU stay (d)	10.0 (6-19.5)	5 (3-11)	5 (3–11)	6.707	.010
Duration of MV (h)	13.66 ± 4.60	8.89 ± 2.82	9.35 ± 2.59	0.546	.585
Defecation frequency	1.88 ± 0.55	1.71 ± 0.14	1.72 ± 0.14	0.360	.719
Position (n, %)				2.448	.310
Supine	24 (58.5)	261 (68.7)	285 (67.7)		
Lateral	15 (36.6)	96 (25.3)	111 (26.4)		
Prone	2 (4.9)	23 (6.1)	25 (5.9)		
CRRT (n, %)	4 (9.8)	32 (8.4)	36 (8.6)	0.084	1.000
ECMO (n, %)	0 (0)	2 (0.5)	2 (0.5)	0.217	1.000
WBC (10^9/L)	10.83 ± 0.66	11.93 ± 0.25	11.86 ± 0.24	−0.947	.344
ALB (g/L)	29.94 ± 0.64	34.14 ± 0.90	33.73 ± 0.82	−3.778	.000

Abbreviations: AECOPD, acute exacerbation of chronic obstructive pulmonary disease; ALB, albumin; APACHE II, Acute Physiology and Chronic Health Evaluation II; ARDS, acute respiratory distress syndrome; BMI, body mass index; COPD, chronic obstructive pulmonary disease; CRRT, continuous renal replacement treatment; ECMO, extracorporeal membrane oxygenation; GCS, Glasgow coma scale; IAPI, intensive care unit-acquired pressure injuries; LOS, length of stay; MODS, multiple organ dysfunction syndrome; MV, mechanical ventilation; RASS, Richmond agitation-sedation scale; SAP, acute severe pancreatitis; SOFA, sequential organ failure assessment; WBC, white blood cell.

noted whether patients received continuous renal replacement treatment or extracorporeal membrane oxygenation.

2.3 | Statistical analysis

All statistical analyses were performed using SPSS software version 24.0 for Windows (IBM Analytics, Armonk, New York). Continuous data with normal distributions are provided as the mean ± standard deviation (SD). Nonnormally distributed continuous data are presented as medians (25th, 75th percentiles). We used a *t*-test to analyze normally distributed data and the Mann–Whitney *U*-test for nonnormally distributed data. Qualitative data are expressed as frequencies (n) and percentages (%) and compared using a χ^2 test or Fisher's χ^2 test. A logistic regression analysis was performed to evaluate the risk factors for sacrum IAPI (forward stepwise likelihood ratio method). Model calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test statistic. A *P*-value of <.05 was considered statistically significant.

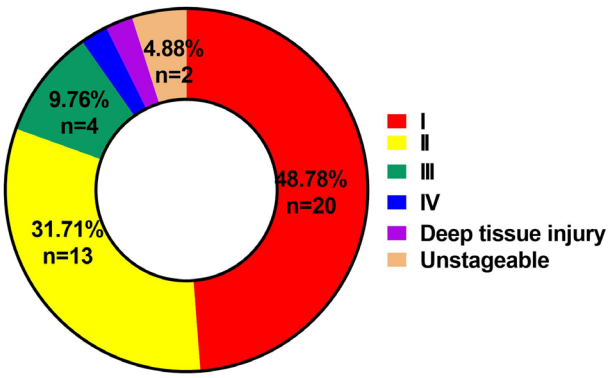

FIGURE 1 Stages of sacrum IAPI in critical ill patients.
Abbreviation: IAPI, intensive care unit-acquired pressure injuries

3 | RESULTS

3.1 | Demographic data and frequency of IAPI

A total of 431 patients were enrolled in this study; 51 patients suffered IAPI after ICU admission (11.83%), and 380 patients did not (88.17%). Among patients with IAPI, the majority had skin abnormalities on their sacrum (n = 41, 80.39%) and/or another location (n = 24, 47.06%). There were 14 cases with pressure injuries in multiple locations. Ten patients were not analyzed because they suffered IAPI in other locations but not the sacrum. Of the 421 remaining patients, 72.68% were male and the mean age was 62 years. The frequency of IAPI on the sacrum was 9.74%. The average number of days before IAPI development was 6.7. The distribution of IAPI is shown in Table 1.

The causes of sacrum pressure injuries might be different from injuries in other locations. Therefore, to make the results more accurate, the patients were divided into a sacrum IAPI group (n = 41) and a non-IAPI group (n = 380). In the sacrum IAPI group, 75.6% were male and the average age was 71. The demographic data for these groups are presented in Table 2.

Among the patients with sacrum IAPI, stages I and II accounted for 80.49% of all IAPI (20 in stage I and 13 in stage II). Stage III HAPI accounted for 19.05% (n = 4) and stage IV accounted for 4.76% (Figure 1). The ratio of surface pressure injuries (stage I and II) to severe pressure injuries was 33:8. As shown in Table 3, the IAPI group had a lower Braden risk score than the non-IAPI group (*P* < .05).

3.2 | Risk factors for sacrum IAPI in critically ill patients

After univariate analysis, the following risk factors were found to be associated with sacrum IAPI: age, weight, lower BMI, diabetes, chronic

TABLE 3 Braden risk scores for the sacrum IAPI group and the non-IAPI group in the ICU

Braden risk score	IAPI (*n* = 41)	non-IAPI (*n* = 380)	Total (*n* = 421)	Test	*P*-value
Sensory perception	2.05 ± 0.14	2.55 ± 0.05	2.50 ± 0.44	−3.438	.001
Moisture	3 (2–3)	3 (3–3)	3 (2.5-3)	4.168	.042
Activity	1 (1–1)	1 (1–1)	1 (1–1)	3.946	.048
Mobility	1.71 ± 0.14	2.19 ± 0.04	2.14 ± 0.04	−3.473	.001
Nutrition	2 (2–2)	2 (2-3)	2 (2-3)	4.589	.033
Friction/shear	1.32 ± 0.11	1.60 ± 0.04	1.57 ± 0.03	−2.408	.016
Total	10.80 ± 0.32	12.77 ± 0.15	12.58 ± 0.14	−4.313	.000

Abbreviation: IAPI, intensive care unit (ICU)-acquired pressure injuries.

TABLE 4 Results of multivariate logistic regression analysis

Clinical variables	*B*	SE	Sig.	Exp (β)	95% CI	
BMI	−1.158	0.472	0.029	1.115	1.011	1.229
COPD	0.982	0.485	0.014	3.183	1.261	8.037
MODS	0.343	0.083	0.043	2.670	1.031	6.903
Braden risk score	−0.109	0.050	<0.001	1.409	1.197	1.659

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; MODS, multiple organ dysfunction syndrome.

obstructive pulmonary disease (COPD), multiple organ dysfunction syndrome (MODS), SOFA score, APACHE II score, duration of ICU stay, Braden risk score, and albumin.

After multilogistic regression analysis, the following independent risk factors were found to be associated with sacrum IAPI (Table 4): lower BMI (OR = 1.115, CI: 1.011-1.229, $P = .029$), COPD (OR = 3.183, CI: 1.261-8.037, $P = .014$), MODS (OR = 2.670, CI: 1.031-6.903, $P = .043$), and lower Braden risk score (OR = 1.409, CI: 1.197-1.659, $P < .001$). Hosmer–Lemeshow tests showed $\chi^2 = 1.02$, $P = .995$.

4 | DISCUSSION

In the present study, we aimed to investigate the frequency of, and risk factors for, HAPI in China. ICU stay is an independent risk factor for HAPI,[2] possibly because ICU patients are more likely to have severe disease and greater complications. Studying the independent risk factors for IAPI in ICU patients could help us to identify those at risk of IAPI in advance and provide preventative interventions, such as regularly monitoring skin condition. In this multicenter, cross-sectional survey, we found that the frequency of sacrum IAPI was 9.74%, and lower BMI, COPD, MODS, and Braden score were independent risk factors.

Previous studies have shown that risk factors for HAPI differ between populations, countries, and hospitals. In Brazil, the risk factors in patients with traumatic brain injury were found to be a moderate or severe traumatic brain injury, the use of noradrenaline, and older age.[10] In Korea, multivariate logistic regression analysis found that hospitalization due to pressure injuries was strongly associated with being male and older, having a low socioeconomic status, severe disease, and plegia comorbidity.[11] In a systematic review, age, mobility/activity, perfusion, and vasopressor infusion emerged as important risk factors for pressure injury development among critical care patients.[12] In nursing homes and hospitals in Germany, more women were underweight and at pressure injury risk.[13] Among Chinese community–dwelling older people, pressure injury was shown to be associated with age, disability, incontinence, cancer, and dementia.[14]

The sacrum is the most common site of acquired pressure injury in all patients (both critically ill and noncritically ill).[9] Most damage occurring to the sacrum is attributed to pressure, shear, excessive moisture, or a combination of these factors. In the present study, the sacrum was the most common site of IAPI, consistent with a systematic review by Moore et al.[4]

BMI is an important risk factor for HAPI. In general, a lower BMI often indicates malnutrition or serious illness. Obesity is due to excessive accumulation of fat, causing pathological and physiological changes in the human body. Ness et al[15] concluded that both being underweight (BMI <18.5 kg/m^2) and morbidly obese (BMI ≥40 kg/m^2) greatly increased the risk of HAPI. In our study, patients with a BMI of <18.5 kg/m^2 were predisposed to IAPI.

Critically ill patients with poor underlying condition are at greater risk of IAPI. We found that COPD was often co-present with IAPI possibly because these patients had a longer ICU stay and MODS. These findings are in line with another study, which found that comorbidities with COPD were associated with IAPI.[16] This may be because patients with COPD receive more mechanical ventilation. Manzano et al[17] identified pressure injury as a significant independent predictor of mortality in mechanically ventilated patients (adjusted hazard ratio 1.28; 95% CI 1.003-1.65; $P = .047$).

Our study found that MODS is also an independent risk factor of IAPI. The development of MODS in critically ill patients often requires longer hospital stays, more invasive procedures, analgesic sedation, and so on. A worldwide observational study showed that organ support (eg, renal replacement and mechanical ventilation on ICU admission) and ICU stay >3 days were independently associated with IAPI.[16]

Braden scores are commonly used as a risk assessment scale for pressure injuries,[18,19] but there is not enough evidence about whether this scale is valid for critically ill patients in the intensive care setting. We showed that low Braden scores indicate a risk of IAPI in the ICU, which is consistent with a previous study.[20] Thus, Braden scores apply to ICU patients not only common in-patients.

This study has limitations. First, although we investigated the frequency of and risk factors for IAPI in ICUs, we ignored the effects of IAPI on the patients, such as outcomes and financial burden. Secondly, our hospital focused on southern China, meaning that the results obtained from this study are not generalizable to the rest of China.

In conclusion, the present study found that lower BMI, COPD, MODS, and lower Braden risk score were independent risk factors for sacrum IAPI in critically ill patients in China. Future studies could investigate more areas to provide further data.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

TRANSPARENCY STATEMENT

Xingui Dai affirms that this manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted, and that any discrepancies from the study as planned have been explained.

AUTHORS' CONTRIBUTIONS

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Writing—review and editing: Xiaofang Li and Xingui Dai

All authors have read and approved the final version of the manuscript.

Xingui Dai (corresponding author) had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

DATA AVAILABILITY STATEMENT

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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