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THE STUDY FOR MEDICAL DEVICE RELATED PRESSURE INJURY IN CRITICAL CARE UNIT IN VIETNAM

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Abstract

Medical device-related pressure injuries (MDRPIs) are a significant concern in Intensive Care Units (ICUs) due to the extensive use of medical devices. These injuries can lead to prolonged hospital stays, increased healthcare costs, and diminished quality of life for patients. Despite the prevalence of MDRPIs, there is limited research on this issue in Vietnam.

This study aims to investigate the incidence, level of injury and risk factors associated with MDRPIs in critically ill patients at the University Medical Center in Ho Chi Minh City, Vietnam.

A descriptive study was conducted from January to April 2024, including 146 ICU patients who met the inclusion criteria. Data on demographics, medical device use, and the incidence of MDRPIs were collected based on days period in ICU. Statistical analyses, including univariate and multivariate logistic regression, were performed to identify significant risk factors.

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The incidence of MDRPIs in the study was 28.77%, with 42 out of 146 patients developing at least one MDRPI. In the group with MDRPI, the average number of days for MDRPI to appear was 2.9 days. The average length of hospital stay was 17.7 days, with the shortest being 2 days and the longest being 67 days, and the number of mechanical ventilation patients were more than 90%. The most commonly affected areas were the tongue, lips, and nose, primarily caused by endotracheal tubes, nasogastric tubes, and urinary catheters. Among 42 cases of MDRPI, 44.6% were classified as Stage 1 and 33.9% Stage 2 pressure injuries, and 21.5% of mucosal MDRPI. Significant risk factors for MDRPIs in the multivariate logistic regression analysis included endotracheal tube holders (adjusted OR 1.72, 95% CI 1.24 – 2.4), HFNC cannula (adjusted OR 4.16, 95% CI 1.43 – 12.15), and sequential compression stocking (adjusted OR 0.79, 95% CI 0.64 – 0.99).

MDRPIs are prevalent among critically ill patients in the ICU, with several modifiable risk factors identified. Elderly patients are at higher risk of MDRPI than younger patients. Specifically, 3 variables predicted MDRPI, including ETT fixation, HFNC cannula, and sequential compression stocking. Implementing targeted interventions, such as regular assessment and timely repositioning, can mitigate the risk and improve patient outcomes. Further research is needed to develop comprehensive prevention strategies tailored to the Vietnamese healthcare context.

1. Introduction

1.1 Background Information

Medical device-related pressure injury (MDRPI) is defined as a localized injury to the skin or underlying soft tissue, including mucous membranes, resulting from the sustained pressure of a medical device (1). These injuries represent a critical and often underreported subset of hospital- acquired pressure injuries (HAPIs), with clinical configurations that typically mirror the shape and pattern of the causative equipment. In the global healthcare landscape, HAPIs impose a staggering economic burden, with annual costs estimated in the billions of dollars across various healthcare systems (2). The prevalence of pressure injuries in Intensive Care Units (ICUs) is particularly alarming, with recent studies highlighting that MDRPIs can account for more than 30% of all HAPIs identified in critical care settings (3).

The mortality and morbidity associated with MDRPIs are substantial. Critically ill patients, especially those requiring invasive interventions, face a significantly higher risk of developing these injuries due to physiological instability and prolonged exposure to rigid devices (4). These injuries lead to prolonged hospitalizations, increased pain, and a higher risk of secondary infections, thereby complicating the clinical trajectory of patients who are already

physiologically compromised. Despite their prevalence, MDRPIs are increasingly recognized not as an inevitable consequence of life-saving treatments, but as a preventable safety event requiring targeted clinical strategies (5).

1.2 The Need for Monitoring MDRPI in the ICU

In the complex milieu of the ICU, patients are exceptionally vulnerable to tissue damage due to a combination of extrinsic and intrinsic factors. Compared to general wards, the ICU environment necessitates a high density of life-sustaining medical devices, with patients often being subjected to multiple devices concurrently, such as ventilators, feeding tubes, and monitoring probes (6). The quintessence of this vulnerability lies in the patient's immobility, impaired sensory perception, and the frequent use of pharmacological agents such as sedatives and vasopressors, which further compromise peripheral tissue perfusion (7).

The benefits of systematic MDRPI monitoring are multifaceted, addressing both cutaneous and mucosal dimensions of patient safety. Mucosal pressure injuries, which occur on moist linings of the respiratory or gastrointestinal tracts, are particularly insidious as they cannot be staged using traditional systems (8). These injuries can manifest rapidly—often within hours of device application—and are predominantly associated with endotracheal and nasogastric tubes. Therefore, implementing dedicated assessment frameworks and preventive bundles is indispensable for early detection and for mitigating the severity of these complications in the ICU setting (9).

1.3 The Advent of Focused Nursing Interventions in Vietnam

In the evolving landscape of Vietnamese healthcare, the role of nursing professionals has become the cornerstone of patient safety and quality care. This transition is notably pronounced in the context of pressure injury prevention, where the implementation of evidence-based practices has emerged as a significant paradigm shift. Nurses, by virtue of their sustained and direct interaction with patients, are uniquely positioned to spearhead MDRPI surveillance, integrating skin assessments with the proactive management of medical equipment (10).

Identifying specific risk factors within the Vietnamese clinical context—such as the impact of age, comorbidities, and the specific duration of device use—is crucial for tailoring nursing interventions. Currently, many Vietnamese ICUs face challenges related to high patient-to-nurse ratios and varying levels of specialized wound care training. By investigating independent predictors of MDRPI, such as the use of endotracheal tube holders or high-flow oxygen cannulas, this study seeks to provide a localized evidence base. Such insights

will empower nurses to transcend traditional care models, fostering a more proactive and patient-centric approach to prevention and recovery in critical care (11).

Research Objectives and Methods

2.1. Research Objectives

This study was conducted with the primary aim of evaluating the current status and identifying the risk factors associated with Medical Device-Related Pressure Injuries (MDRPI) among critically ill patients at the University Medical Center, Ho Chi Minh City. Specifically, the study pursued two main objectives:

- **First,** to determine the incidence rate and classify the stages of MDRPI within the intensive care unit (ICU) patient population (12).

- **Second,** to analyze and identify independent risk factors—including demographic characteristics, clinical conditions, and specific types of medical devices—that are closely associated with the development of these injuries (13)

bf 2.2. Research Methods

A prospective descriptive cross-sectional design was employed for this study, conducted from January to April 2024. The study population consisted of 146 patients admitted to the Intensive Care Unit (ICU).

Participants and Sampling: A simple random sampling is a method in which each individual in the population under study has an equal and independent probability of being selected (14). Inclusion criteria required patients to be 18 years of age or older, utilizing at least one medical device, and having no pre-existing pressure injuries upon admission to the unit (2)

Data Collection Procedure: Patients were monitored continuously for the first 7 days of hospitalization—the typical timeframe for MDRPI onset (15). Data regarding demographics, Braden Scale scores (16) , Glasgow Coma Scale (GCS) , and a checklist of 17 types of medical devices (Endotracheal tubes, nasogastric tubes, central venous catheters) were recorded daily through electronic medical records and direct clinical observation.

The inclusion criteria for participation in the study

Age: Patients must be age 18 years old. Setting and Timeline: Patients must have been transferred to the Intensive Care Unit (ICU) of the University Medical Center (UMC) in Vietnam between January 2024 and March 2024.

Medical Intervention: Patients must have utilized at least one medical device during their stay in the ICU (17). The methodology for patient selection and recruitment.

Application of Exclusion Criteria: To maintain a clean baseline, the researcher excluded individuals who: Possessed a pre-existing MDRPI prior to their ICU admission. Declined to participate in the study. Were admitted

and subsequently discharged on the same calendar day, as this duration is insufficient to monitor for pressure injury development (2)

Ethical Considerations: The study protocol was approved by the Institutional Review Board (IRB) and the hospital's ethics committee, ensuring participant confidentiality and the protection of patient rights.

Outcome Measures

Primary Outcome: Incidence and Classification of MDRPI MDRPI Incidence: The occurrence of at least one pressure injury located on the skin or mucous membrane directly beneath or associated with a medical device in use.

Staging of Skin Injuries: Skin lesions were classified according to the National Pressure Injury Advisory Panel (NPIAP) grading system, ranging from Stage 1 (non-blanchable erythema of intact skin) to Stage 4 (full-thickness skin and tissue loss), including Unstageable and Deep Tissue Pressure Injury (17).

Mucosal Pressure Injuries: Due to the distinct anatomical structure of mucous membranes, these lesions were identified as a specific category of MDRPI that cannot be staged using the standard NPIAP system (17).

Secondary Outcomes: Temporal and Spatial Characteristics Time of Appearance: This was calculated as a continuous variable representing the number of days from ICU admission to the first clinical detection of a skin or mucosal lesion.

Anatomical Location: The specific body sites affected by the injury were recorded, with common locations including the tongue, lips, and nose.

Device Attribution: Each identified injury was linked to the specific medical device responsible for the pressure, such as endotracheal tubes, nasogastric tubes, or high-flow nasal cannulas (17).

Injury Burden: The total number of separate pressure injuries developed by each participant during the 7-day observation period was quantified (2).

3.5 Data Collection and Tools

3 .5.1. Research Instruments

The primary tool for this study was a data collection form, specifically designed and validated to capture the following core components:

Demographic Factors: This section includes basic patient data such as age, gender, Body Mass Index (BMI), and primary medical diagnosis. Clinical Characteristics and Comorbidities: Information regarding pre-existing conditions (Hypertension, Diabetes Mellitus, Chronic Obstructive Pulmonary Disease (COPD), hepatic disease, and cardiovascular disease) was recorded. Clinical Interventions: The form tracked interventions such as invasive or non-invasive mechanical ventilation and the use of prone positioning.

The Braden Scale: This validated tool was utilized to assess the risk of pressure injuries (PI) upon ICU admission. It evaluates six subscales: sensory perception, moisture, activity, mobility, nutrition, and friction/shear. Scores

range from 6 to 23, where lower scores indicate a higher risk of injury (16). Glasgow Coma Scale (GCS): Used to assess the patient's level of consciousness and neurological status (18).

Medical Device Monitoring: A total of 17 types of medical devices commonly used in the ICU (Endotracheal tubes, nasogastric tubes, central venous catheters, SpO2 probes, and compression hosiery) were monitored for type and duration of use.

3.5.2. Data Collection Procedure

The data collection followed a rigorous protocol:

1. Patient Screening: Inclusion criteria consisted of patients aged 18 or older admitted to the ICU at the University Medical Center (UMC) in Ho Chi Minh City between January and April 2024 who utilized at least one medical device.

2. Baseline data Acquisition: Demographic and clinical data were truthed and extracted from electronic medical records (EMR) upon admission.

3. Daily Longitudinal Monitoring: Each participant was observed daily for a 7-day period or until ICU discharge. A 7-day window was selected as it aligns with the typical development timeline for MDRPIs in critically ill patients.

MDRPI Identification and Classification: Research personnel performed daily skin and mucosal inspections at device-contact sites to detect early signs of injury. When an MDRPI was identified, the following data were documented:

+ Date of detection and total duration of device use prior to injury.

+ Anatomical location of the injury (stongue, lips, nasal area).

+ Staging of the injury according to NPIAP guidelines (Stage 1–4, Unstageable, Deep Tissue Injury, or Mucosal Injury).

The specific medical device identified as the causative agent.

Statistical Analysis: Data were processed using SPSS software, version 24.0. Univariate analyses were performed using t-tests and Chi-square tests. Subsequently, a multivariate logistic regression model was utilized to determine the independent predictors of MDRPI, with a significance level set at a 95% confidence interval.

4. Results

4.1 Participant Demographics

A total of 146 patients were recruited in this study. The participants included 74 males and 72 females. Their age ranged from 18 to 96 years old, with a mean of 65,16 (SD = 16.54). Among the comorbidities, hypertension and diabetes accounted the highest proportion, with 60.57% and 41.35% respectively, followed by cardiovascular disease with 36.54%, liver disease with 24.04% and COPD with the lowest percentage of 5.77%. The mean BMI was 22.41 kg/m2 (SD = 4.44), which was in the normal range (Table 2).

Table 1. Demographic characteristics of the participants (N= 146)

Mean ± SD	**All (n= 146)**	**MDRPI (n= 42)**	**Non- MDRPI (n= 104)**	**t/ χ^2**	**p value**
Age (year)	65.16 ± 16.54	70.31 ± 15.20	63.09 ± 16.67	2.43	0.02
BMI (kg/m^2)	22.41 ± 4.44	21.42 ± 5.01	22.81 ± 4.14	-1.73	0.09
Frequency (%)	**All (n = 146)**	**MDRPI (n= 42)**	**Non- MDRPI (n= 104)**	**t/ χ^2**	
Gender				0.7	0.47
Male	104 (71.23)	19 (42.24)	55 (55.88)		
Female	42 (28.77)	23 (54.76)	49 (47.12)		
Comorbidity					
Hypertension	86 (58.90)	23 (54.76)	63 (60.57)	0.42	0.58
Liver disease	32 (21.92)	7 (16.67)	25 (24.04)	0.95	0.38
DM	62 (42.47)	19 (45.24)	43 (41.35)	0.19	0.71
COPD	11 (7.53)	5 (11.90)	6 (5.77)	1.62	0.30
CVD	55 (37.67)	17 (40.48)	38 (36.54)	0.2	0.71
Others	83 (56.85)	23 (54.76)	60 (57.69)	0.11	0.85

Note. BMI: body mass index, COPD: chronic obstructive pulmonary disease, CVD: cardiovascular disease, DM: Diabetes mellitus

The participants were classified into two groups, MDRPI and non - MDRPI. As can be seen in Table 2, the MDRPI group was significantly older ($p = 0.02$). For other factors, there were no statistical difference.

4.2 Patient status and clinical characteristics on the first day of admission to the ICU

Table 2. Patient status and the clinical characteristic for the participants on the first day of ICU admission (N= 146)

Frequency (%)	MDRPI (n= 42)	Non-MDRPI (n= 104)	t/ χ^2	p value
Invasive MV	39 (92.86)	67 (64.42)	12.16	<0.001
Noninvasive MV	3 (7.14)	5 (4.81)	0.32	0.69
Prone position	3 (7.14)	3 (2.88)	1.38	0.36
Use of vasopressor	28 (66.67)	39 (37.50)	10.25	0.002
Use of sedation	26 (61.90)	41 (39.42)	6.09	0.02
Use of muscle relaxant	16 (38.10)	23 (22.12)	3.90	0.06
Mean ± SD	**MDRPI (n= 42)**	**Non-MDRPI (n= 104)**	**t/ χ^2**	
GCS	7.33 ± 4.72	10.00 ± 5.36	-2.28	0.006
Braden score	9.98 ± 2.60	11.78 ± 3.12	-3.31	0.001

Note. MV: Mechanical ventilation

Patient status included mechanical ventilation characteristics, the use of high-risk medications. In the mechanical ventilation, the non-MDRPI group had lower rate of non-invasive MV and patients treated by prone position, but the differences were not statistically significant. However, the MDRPI group had higher rate than the non-MDRPI group with p ¡ 0.001. In addition, there were significant between-group differences in the use of high-risk medications. The non-MRDPI group had a lower rate in use of vasopressor, sedation and muscle relaxant than the survivor group with a difference of 10.25 ($p < 0.001$); 6.09 ($p = 0.01$) and 3.90 ($p<0.05$).

In contrast, most of patients in the MDRPI group had lower level of consciousness characterized by an average GCS score of 7.33 and high risk of PI than non-MDRPI group which were statistical differences. Specifically, a significant proportion (45.89%) exhibited GCS scores below 8 points. This finding aligns with the clinical decision to initiate endotracheal intubation and me-

chanical ventilation in these patients. Furthermore, when categorized based on impaired consciousness (GCS score ¡ 13 points), the prevalence of this condition among MDRPI patients reached 60.39%. In addition, a significant proportion of patients in the study (32.88%) had Braden Scale scores below 9, indicating a very high risk of pressure ulcer development. Additionally, 37.67% of patients had scores between 10 and 12, which also places them in the high-risk category. These findings collectively demonstrate that over 70% of the patients were at high or very high risk of pressure ulcers. In contrast, only 29.45% of patients had Braden Scale scores of 13 or higher, indicating a medium or low risk of pressure ulcer development. The distribution of Braden Scale scores in this study highlights the elevated risk of pressure ulcer development among critically ill patients as the previous literature.

An analysis of device utilization patterns revealed that electrodes, pulse oximeters (SpO2), and Foley catheters were the most frequently employed devices, with an average usage duration of 5 days. This was followed by nasogastric (NG) tubes and central venous catheters (CVCs), with an average usage duration of 4 days, 3 days for ETT, ETT fixation and peripheral venous catheter.

The study found that the utilization time of medical devices in the MDRPI group was consistently higher than that in the non-MDRPI group for all types of devices. In the MDRPI group, there was a statistically significant difference in the following device types: ETT, oxygen cannula, ETT fixation, NG tube, Foley catheter, CVC, IBP, Sp02, electrode with $p < 0.001$ and peripheral catheter with $p < 0.05$.

4.4 Characteristics of Medical device-related pressure injuries

The most commonly affected organs were the tongue, lips, and nose. Less common were the face, pinna, glans penis, hands.

Out of 42 cases with MDRPI, 28.77% of patients developed MDRPI within 7 days of treatment in the ICU. They had at least one or more MDRPIs stages I to II or mucosal PI, totalling 65 pressure injuries. Upon analysing the characteristics of skin lesions according to the grading system, grade 1 lesion were the most common with 29 occurrences, followed by grade 2 lesions with 22 occurrences, and finally mucosal lesions with 19 occurrences.

4.5 Risk factors of MDRPI in the patients admitted to the ICU during 7 days

4.5.1. Univariate logistic regression

Each variable was included in the univariate logistic regression model with treatment outcome as the dependent variable to consider the individual impacts

Table 3. Clinical characteristics of using medical devices during 7 days in the ICU (N= 146)

Mean ± SD	MDRPI (n= 42)	Non-MDRPI (n= 104)	t/χ^2	p value
ETT	5.71 ± 2.17	2.99 ± 2.90	5.49	<0.001
Tracheostomy	0	0.25 ± 1.19	-1.36	0.18
NIV mask	0.17 ± 0.70	0.06 ± 0.31	1.32	0.19
Oxygen mask	0	0.09 ± 0.37	-1.51	0.13
HFNC cannula	0.17 ± 0.76	0.06 ± 0.36	1.17	0.24
Oxygen cannula	0.48 ± 0.89	1.23 ± 1.50	-3.03	0.003
Tracheostomy fixation	0	0.25 ±1.19	-1.36	0.18
ETT fixation	5.71 ± 2.17	2.97 ± 2.91	5.51	<0.001
NG tube	6.38 ± 1.40	4.13 ± 2.74	5.07	<0.001
Foley catheter	6.19 ± 1.86	4.57 ± 2.41	3.91	<0.001
CVC	5.55 ± 2.62	3.64 ± 2.90	3.69	<0.001
Peripheral catheter	4.55 ± 2.53	3.42 ± 2.29	2.60	0.01
IBP	3.9 ± 3.10	2.13 ± 2.51	3.60	<0.001
SpO2	6.52 ± 1.31	5.11 ± 1.92	4.39	<0.001
NIBP	2.45 ± 2.91	2.98 ± 2.39	-1.13	0.26
Electrode	6.36 ± 1.65	5.12 ± 1.91	3.70	<0.001
SCD	1.02 ± 2.28	1.38 ± 2.48	-0.81	0.42
Others	1.52 ± 2.73	1.88 ± 2.73	-0.72	0.47

Note. ETT: Endotracheal tube, NIV: non-invasive ventilation, HFNC: high flow nasal cannula, NG: nasal-gastric, CVC: central venous catheter, IBP: invasive blood pressure, NIBP: non-invasive blood pressure, SCD: Sequential

Table 4. Stages of Medical device-related pressure injuries (N=65)

Location of Injury	Severity Classification	Frequency (n)	Percentage (%)
Mucosal MDRPI	Non-stageable	14	21.5
Skin MDRPI	Stage 1	29	44.6
	Stage 2	22	33.9
Total		**65**	**100.0**

Table 5. Location of Medical device-related pressure injuries *(N=65)*

Location	Frequency (n)	Percentage (%)
Lips	28	43.1
Tongue	14	21.5
Nose	12	18.5
Face	3	4.6
Pinna (Ear)	2	3.1
Glans penis	2	3.1
Peripheral catheter site	2	3.1
Skin around CVC	1	1.5
Hands	1	1.5
Total	**65**	**100.0**

of factors on MDRPI (unadjusted odd ratio). The results are illustrated in Table 5, where older age (OR 1.03, p = 0.02), longer use of ETT, oxygen cannula, ETT fixation, NG tube, Foley catheter, CVC, peripheral catheter, IBP, SpO2, electrode, and low level of GCS (OR 0.91, p = 0.01), and low score of Braden (OR 0.78, p = 0.002) related to increased risk of MDRPI. Meanwhile, use of invasive MV (OR 0.14, p = 0.002), use of vasopressors and sedation (OR 0.30, p = 0.002), (OR 0.4, p = 0.02) decreased the risk of MDRPI. Nevertheless, these initial findings do not capture the entirety of the MDRPI phenomenon.

4.5.2 Multivariate logistic regression

Note.

For the multivariate logistic regression, all variables were included in the model using three steps. Step 1: All demographic variables were added in Model 1; all variables on the admission day were added in Model 2; demographic variables, variables on the admission day and all variables of medical device uses were added in Model 3, and finally, the significant variables in univariate regression were added in Model 4. The models were tested, and the significant results for each model are presented in Table 5.

Among the 4 models, Model 3 explained the highest total variance of 50.7% (Nagelkerke's R-squared), which yielded an χ^2 of 45.83 ($p < 0.001$). The model fit was checked using the Hosmer and Lemeshow test with p = 0.068. Specifically, 3 variables predicted MDRPI, including ETT fixation, HFNC cannula, and SCD (Table 7).

Table 6. Univariate logistic regression risk factors of MDRPI (N= 146)

Variable	Crude OR (95% CI), *p*-value
Pre-treatment day	1.03 (0.98 – 1.08), 0.21
Age	1.03 (1.01 – 1.06), 0.02
Gender	0.74 (0.36 – 1.51), 0.40
BMI	0.93 (0.85 – 1.01), 0.09
Hypertension	1.27 (0.16 – 2.62), 0.52
DM	0.85 (0.41 – 1.76), 0.67
Hepatitis	1.58 (0.63 – 4.00), 0.33
COPD	0.45 (0.13 – 1.57), 0.21
CVD	0.85 (0.41 – 1.76), 0.66
Others	1.13 (0.55 – 2.32), 0.75
ETT	1.46 (1.24 – 1.72), 0.000
Tracheostomy	0.002 (0), 1
NIV	1.60 (0.75 – 3.43), 0.22
Oxygen mask	0.000 (0), 1
HFNC cannula	1.44 (0.75 – 2.76), 0.27
Oxygen cannula	0.61 (0.43 – 0.86), 0.01
Tracheostomy fixation	0.002 (0), 1
ETT fixation	1.46 (1.24 – 1.72), 0.000
NG tube	1.65 (1.29 – 2.09), 0.000
Foley catheter	1.48 (1.18 – 1.85), 0.001

CVC	1.92 (1.11 – 1.50), 0.001
Peripheral catheter	1.23 (1.05 – 1.44), 0.01
IBP	1,23 (1.1 – 1.43), 0.001
SpO2	1.76 (1.31 – 2.56), 0.000
NIBP	0.92 (0.79 – 1.06), 0.26
Electrode	1.55 (1.20 – 2.00), 0.001
SCD	0.94 (0.8 – 1.10), 0.42
Others	0.95 (0.83 – 1.09), 0.47
Invasive_MV	0.14 (0.04 – 0.48), 0.002
Noninvasive_MV	1.52 (0.35 – 6.68), 0.58
Prone position	2.59 (0.50 – 13.38), 0.26
Vasopressor	0.3 (0.14 – 0.64), 0.002
Sedation	0.4 (0.19 – 0.84), 0.02
Relaxant	0.46 (0.21 – 1.00), 0.05
GCS	0.91 (0.85 – 0.97), 0.01
Braden	0.78 (0.66 – 0.91), 0.002

Table 7. Multivariate logistic regression results (N= 146)

Variable	Model 1			Model 2			Model 3			Model 4		
	β	OR	95% CI	β	OR	95% CI	β	OR	95% CI	β	OR	95% CI
Age (year)	0.02	1.02	0.97–1,08									
Invasive MV (yes)				-1.78	0.17	0.04-0.79						
Noninvasive (yes)				-1.94	0,14	0.02-0.98						
Vasopressor (yes)				-1.02	0.36	0.15-0.87						
ETT fixation (day)							0.54	1.72	1.24-2.40			
HFNC cannula (day)							1.43	4.16	1.43-12.15			
SCD (day)							-0.23	0.79	0.64-0.99			
Nagelkerke's R^2		15.4%			24.9%			50.7%			38.5%	

5. Discussion

5.1 Patient status and clinical characteristics on the first day of admission to the ICU

At the first day of admission to ICU, the majority of patients required invasive mechanical ventilation, with over 90% accounted in the MDRPI group. This rate is significantly higher compared to another study conducted in Turkey, where the proportion is only 52.3% (19). The high rate of invasive mechanical ventilation reflects the severity of the patients' conditions and the increased use of medical devices compared to patients who do not require invasive mechanical ventilation. In the current study, the distinct differences observed between the two groups suggested that these clinical characteristics may be associated with an increased risk of MDRPI.

Although a lower trend of non-invasive ventilation and prone position was found in the non MDRPI group which were not statistically significant with $p = 0.58$ and 0.24, respectively. While prone positioning was a major risk factor for MDRPIs in ICU patients with an OR of 24.71 (20), making it the most significant factor among the risk factors identified. In this study, the proportion of patients in the prone position was very low (around 4%), and evenly distributed between the two groups. Consequently, no statistically significant difference could be found and the result was the same as non-invasive ventilation.

It was undeniable that among 45.89% of patients used vasopressors and

sedation, up to 66.67% and 61.9% in the MDRPI group. At the first day of ICU admission, the trend of using high risk medication were the same. Perhaps these higher values in the MDRPI group were related to injury development which previous studies have also demonstrated (19-21). The mechanism could be understood that reduced blood flow caused by vasopressors can compromise the health of skin tissues, making them more susceptible to damage from pressure. Earlier studies have shown that the use of high dose of vasopressor was synonymous with certain adverse effects: vasoconstriction induced, myocardial damage, or arrhythmia (Andreis & Singer, 2016). In addition, medications used for sedation can induce drowsiness and impair a patient's ability to move or reposition themselves. This constant lying in one position increases pressure on specific areas of the skin. Patients under sedation may not be able to communicate discomfort or pain effectively. This makes it difficult for healthcare staff to identify early signs of pressure injury developing under medical devices. Sedative and muscle relaxant medications can potentially affect blood pressure and circulation reducing blood flow can further compromise the health of skin tissues, making them more susceptible to pressure damage. The Glasgow Coma Scale (GCS) is a measure of a patient's level of consciousness. In the MDRPI group, GCS scores were found to correlate with the use of sedative medications. As explained previously, reduced consciousness can lead to issues like impaired sensation and difficulty communicating discomfort to healthcare providers. A 3-point decrease in GCS scores revealed a significant difference in risk between the two patient groups.

This finding aligns with a previous meta-analysis, which indicated that a 1-point decrease in GCS is associated with a fourfold increased risk of MDRPI (20).

The Braden Scale may not be specifically designed for ICU patients, but numerous studies have demonstrated its effectiveness as a tool to assess skin injury risk, including MDRPIs (20, 21). Consistent with previous research, our study showed that lower Braden scores were associated with an increased risk of MDRPIs. In contrast, the result are still controversial when no statistical difference was found in the development of MDRPI (22). Some researchers argued that the Braden Scale doesn't directly assess the specific characteristics of medical devices that might contribute to pressure. Other factors not included in the Braden Scale, like the type and duration of device use, can also influence MDRPI risk.

Current study showed the consistent results with previous findings, the most common devices used in ICU settings and associated with MDRPIs were monitoring devices followed by invasive devices (21, 23). Across device categories with usage durations exceeding three days, the MDRPI group demonstrated a statistically significant increase in device usage time, which correlated with disease severity and sedative medication use or lower Braden scores. Particularly noteworthy are devices like endotracheal tubes (ETTs), ETT fixation devices,

and nasogastric (NG) tubes, which have been shown in previous studies to be associated with an increased risk of MDRPIs (22, 24).

Most of the injuries were stage I and II, mucosal injury accounting for more than 50%, and deeper stages were not detected in current study. This result was consistent with the results of previous studies that the lesions occurred but a numerous of them were not serious and had the potential to recover (22, 25). Similarly, the location of MDRPI were found in some certain locations such as the lips, mouth, nose or face of the patient, corresponding to the use of devices such as ETT or NG tube or oxygen cannulas (23).

In the multivariate logistic regression, only 1 model could explain 50.7% total variance providing three potential risk factors of MDRPI. Each day of having ETT fixation increased the risk of MDRPI to 1.72 times (OR 1.72, 95% CI 1.24 -2.40). This finding was consistent with previous studies that have shown that ETT fixation devices are the most common cause of MDRPI in ICUs (Galetto et al., 2019). These kinds of devices can cause injury to the face, lips, and oral mucosa. Additionally, the position of the endotracheal tube when using these fixation devices can also contribute to MDRPI. A previous study found that inappropriate ETT fixation increases the risk of MDRPI by 5.68 times.

While previous studies have confirmed the association between mechanical ventilation devices for patients and the risk of MDRPI, this study found a link between the use of HFNC and MDRPI (Duerst et al., 2022). Patients required HFNC cannula had the higher risk of MDRPI 4.16 times compared to patients without it. HFNC delivers a high-flow oxygen stream through the patient's nose, which increases the risk of mucosal dryness. Furthermore, the size of the HFNC cannula is larger than other types of oxygen tubes, making it more likely to cause nasal mucosal damage. The retaining strap of the HFNC cannula must also be tight enough, so the tighter it is tightened, the higher the risk of ulceration in the ear or head area. However, this can be difficult to differentiate, as nasogastric (NG) tube feeding is also very common in ICU patients. Nasal lesions can be difficult to determine whether they are caused by the HFNC cannula or the NG tube.

5.2 Significance of Findings

The study facilitates the early identification of high-risk groups (the elderly, low GCS scores) and independent device-related risk factors, such as endotracheal tube holders and HFNC cannulas, to implement targeted preventive measures. Enhancing Quality of Care: Given the relatively high incidence of MDRPIs (28.77%), this study provides clinical evidence to assist healthcare professionals in adjusting care protocols. It emphasizes the prioritization of close monitoring for vulnerable sites—specifically the lips, tongue, and nose—from the initial days of hospital admission."

Impact on Clinical Practice With a recorded MDRPI incidence of 28.77%, Vietnamese healthcare facilities should establish specialized prevention bundles incorporating prophylactic dressings and low-pressure fixation devices. Furthermore, clinical practice must evolve beyond the Braden Scale by integrating device- specific variables—such as device type and indwelling duration—to address the predictive limitations of traditional pressure injury assessment tools.

5.3 Strengths of the Study

This pioneering prospective study in Vietnam provides high-accuracy data on MDRPI incidence and specific risk factors through longitudinal monitoring and multivariate logistic regression. By identifying critical anatomical sites—notably the tongue and nasal mucosa—and high-risk devices like ETT holders and HFNC cannulas, the research offers a granular understanding of device- specific injuries. Furthermore, the rigorous application of validated tools (Braden and GCS) ensures a robust clinical comparison, establishing a vital baseline for targeted prevention protocols in Vietnamese critical care settings.

5.4 Limitations and Constraints

There are several limitations in current research. Firstly, this was a single central study so we cannot rule out selection bias and these results may not be generalizable to other populations. Second, because of the nature of the study, other potential factors associated with MDRPI in critically ill patients may not have been evaluated. Third, arbitrarily stratified intervals provide different information on incidence of MDRPI as well as risk factors. Finally, this observational study does not allow us to conclude causal relationships because there may be factors that we cannot measure that affect outcomes or interaction.

5.5 Implications and Recommendations

The study's 28.77% incidence rate underscores an urgent need for policy-driven improvements in nurse-to-patient ratios to facilitate proactive, per-shift monitoring of high-risk anatomical sites. Clinical protocols must evolve beyond the Braden Scale by integrating device-specific assessments to capture early-onset injuries, which typically emerge within the first 3.24 days. Ultimately, these findings necessitate a strategic shift in nursing priorities from reactive wound care to a comprehensive, preventative framework tailored to medical device management.

To ensure clinical excellence, healthcare facilities should implement standardized prevention bundles comprising prophylactic foam dressings, appro-

priate device sizing, and mandatory repositioning protocols. Special emphasis must be placed on focused respiratory care, prioritizing gas humidification and low-risk fixation to preserve mucosal and facial integrity for patients on HFNC or invasive ventilation. Furthermore, providing specialized ICU training on the unique pathophysiology of mucosal injuries is essential to bridge the knowledge gap between traditional skin lesions and device-specific pressure injuries.

6. Conclusion

The study identifies a high 7-day MDRPI prevalence (28.77%), with early onset typically presenting as Stage 1 (44.6%), Stage 2 (33.9%), or mucosal injuries (21.5%). Key clinical predictors for development include advanced age, low GCS and Braden scores, invasive mechanical ventilation, and high-risk medication administration. Multivariate analysis pinpointed endotracheal tube holders (OR 1.72) and HFNC cannulas (OR 4.16) as significant independent risk factors, while sequential compression stockings (OR 0.79) showed a protective correlation.

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