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# Pressure Injury Risk Assessment and the Use of Intraoperative Polyurethane Foams to Prevent the Pressure Injuries

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## Abstract

**BACKGROUND:** Patients undergoing surgery are at risk of developing pressure sores up to 72 h after surgery. The incidence of pressure injury can affect patient outcomes and quality of care. Pressure injuries have many risk factors and causes. The Munro Pressure Ulcer Risk Assessment Scale for Perioperative Patients was used to assess risk factors for developing a pressure injury. One of the interventions to prevent pressure injuries during and after surgery is polyurethane foams.

**AIM:** The study aimed to describe the risk of pre-operative pressure injury, the use of intraoperative polyurethane foams, and the incidence of post-operative pressure injury in a private hospital in western Indonesia.

**METHODS:** A cross-sectional quantitative descriptive study was conducted among 81 patients undergoing surgery using purposive sampling. The pre-operative risk assessment was conducted with the Munro scale for the pre-operative phase. The use of polyurethane foams during surgery and pressure injury incidence was observed.

**RESULTS:** The results showed that 62 (76.5%) respondents were at moderate risk for pressure injury. 42 (51.9%) respondents used polyurethane foams in the intraoperative phase. Based on observation 72 h postoperatively, there was no pressure injury incidence.

**CONCLUSION:** Pressure injuries can be prevented by identifying risk factors before the surgery. Nurses and surgeons need to be aware of the risk of pressure ulcers in the pre-, inter-, and post-operative phases. The use of polyurethane foams during surgery can be considered an intervention to prevent pressure injury.

## Introduction

A pressure injury is localized damage to the skin or underlying tissue because of pressure on a prominent bone (bony prominence) and external pressure over a long period [1] or may also be related to medical devices or other objects [2]. Direct stress disrupts blood flow resulting in tissue ischemia and eventually cell death. The risk factors for pressure injuries are classified into two groups. The first is the mechanical boundary conditions, including the magnitude and duration of the applied mechanical load and the mode of action, such as pressure or friction. The second factor is individual tolerance (internal anatomy including fine bone structure, tissue morphology, tissue mechanical properties, capacity, and active tissue transport called convection through metabolic processes in the bloodstream) [3].

Patients who will undergo surgery are one group of patients at risk of developing pressure sores. The incidence of pressure injuries in the operating room ranges from 4% to 45% [2]. Intraoperative pressure injuries occur when the load on the tissue is greater than the tissue tolerance or load during surgery up to 72 h after surgery [4]. During the operation, the patient is immobilized, is positioned on a hard surface, cannot feel pain or discomfort due to pressure or friction, and cannot change position to relieve stress.

A systematic review reported that pressure sores in patients undergoing surgery increased from 0.3% to 57%. A study in Brazil involving patients undergoing elective surgery found the incidence of pressure sores reaching 25% [5]. Studies suggest that 5–53.4% of hospital-acquired pressure ulcers are associated with prolonged or multiple surgical procedures [6]. The incidence of pressure sores in patients in the operating room of a private hospital in western Indonesia has increased from one case in 2018 to four cases in 2020.

Pressure injuries are associated with increased morbidity, hospitalization, and health care costs. In 2009, hospital-acquired stress injuries accounted for $11 billion/year in direct and indirect expenses [7]. A 2016 study found that these injuries increased hospital costs by 44% per hospital stay. Reported incidence rates vary with higher rates recorded in intensive care units and operating rooms. Patients who undergo surgery with a long duration have a higher risk for pressure sores in the hospital because of prolonged and unrelieved

pressure on the skin. The length of the procedure or the type of surgery is a significant risk factor contributing to the incidence of pressure sores [7].

Prevention of pressure sores is essential in perioperative patients. Perioperative nurses must know risk factors and preventive measures to prevent pressure sores [8]. Prolonged surgery and anesthesia, specific positions for different operations, excessive blood loss, and physical maneuvers are substantial risk factors for the occurrence of intraoperative pressure sores in these patients. Based on this, appropriate intervention is needed to reduce the incidence of pressure sores during surgery [9]. Munro stated that using the Braden scale before surgery was ineffective because it only assessed moisture, immobilization, nutrition, and no intervention was carried out after the assessment [10]. The Munro Pressure Ulcer Risk Assessment Scale for Perioperative Patients is used to assess risk factors for developing pressure ulcers in patients. Assessment and risk scores are cumulative which include three stages, namely pre-, intra-, and post-operative [11].

One of the interventions to prevent intraoperative pressure sores is using polyurethane foam, which protects areas at risk of pressure sores during surgery. So far, in Indonesia, this intervention is still a collaborative intervention, and there is no operational standard for using the foam for patients with a moderate and high risk of pressure sores. Polyurethane foam is a polymer consisting of stiff and rigid organic units. Polyurethane foam is a flexible foam; after being given a load, it will return to its original shape. The foam molecules will push the air out of the foam cavity when under pressure so that the foam molecules will touch each other. When the pressure is released, the foam molecules will return to their original shape [12]. This study aimed to describe the risk of pre-operative pressure sores, the use of intraoperative polyurethane foam, and the incidence of post-operative pressure injuries in a private hospital in Indonesia.

## Methods

This study used a cross-sectional descriptive quantitative design. The population was patients undergoing surgery at a private hospital in western Indonesia. The purposive sampling was used with inclusion criteria including patients with neurosurgery, cardiovascular, orthopedic, and laparotomy surgeries. The exclusion criteria were patients who had pressure sores before surgery. The number of samples obtained in this study from February to March 2021 was 81 respondents.

Data collection was carried out using four forms. First, the demographic form includes the medical record number, patient's initial, age, type of surgery, duration of the procedure, and patient position during the procedure. Second, the Munro scale assessment form. This study only used a Munro scale assessment form for the pre-operative phase to classify the risk level of pressure injury in the pre-operative phase (Table 1) and did not use the Munro scale assessment form for the intra- and post-operative phases.

The third form is the observation form for the use of intraoperative polyurethane foams. In this study, the polyurethanes foam size was adjusted according to the patient's position during surgery, and it was used during surgery. In the hospital where this study was conducted, the foam density was 24 kg/m$^3$ and a thickness of 5 cm. The fourth form is an observation form to assess the presence or absence of pressure injuries 72 h postoperatively. The Cohen's Kappa test measured inter-rater reliability between observers before taking research data. The pre- and post-operative observers were one researcher with five assistant observers. The intraoperative observer was one researcher with three operating room nurses as assistant observers. Cohen's Kappa test shows a Kappa value of 1.0 with a significance value of 0.000, indicating that the coefficient value suggests a correlation and that rater A and rater B are mutually consistent.

This research has passed the ethical review of the Mochtar Riady Institute for Nanotechnology ethical committee with Protocol No. 2101004-04 and received permission from the hospital leader. The consent has been given to all respondents, including authorization to use the respondent's data for publication. Univariate analysis was used to analyze the data.

## Results

Most of the respondents in this study were in the age group 60 years, as many as 39 people (48.1%). Mainly the types of surgery performed were neurosurgery as many as 42 people (51.9%) with a supine position as 51 people (63%). The duration of the procedure ranged from 2 to 4 h, namely 54 operations (66.7%). The distribution of respondents' characteristics can be seen in Table 2.

Most respondents have a moderate risk of pressure sores, as many as 62 respondents (76.5%) (Table 3). The score was obtained from the accumulation of risk factors, including mobility, age, and comorbid factors (Table 4). The age factor was found as 19 (30.6%) respondents are 40–59 years and 39 (62.9%) respondents were in ≥ 60 years of age. Respondents who required transfer assistance were 21 respondents (33.9%), and five (8.1%) respondents needed full assistance. Respondents with one type of comorbid as many as 29 (52.5%) respondents,

**Table 1: Munro Pressure Ulcer Risk Assessment for Pre-operative Patients**

| Pre-operative Risk Factors Score | | | | |
|---|---|---|---|---|
| Pre-operative Assessment | 1 | 2 | 3 | Total |
| Mobility | Not limited, or slightly limited, moves independently | Very limited, requires transfer assistance | Completely immobile, requires full assistance | |
| Nutritional State (Length of NPO status) | 12 h or < | > 12 h but<24 h | > 24 h | |
| *Body Mass Index* (BMI) | <035 kg/m$^2$ | 30–35 kg/m$^2$ | >35 kg/m$^2$ | |
| Weight Loss (Weight loss in 30–180 days) | Up to 7.4% weight loss, no change or unknown | Between 7.5% to 9.9% weight loss | ≥o0% weight loss | |
| Age (Years) | 39 or less | 40–59 | 60 or greater | |
| Co-morbidity | Each co-morbidity/grouping equals a score of 1. A minimum score of 0 and a maximum score of 6 is possible.<br>Smoking (current)<br>Prehypertension or high BP levels (BP>120/80 mmHg)<br>Vascular/Renal/Cardio-vascular/Peripheral-vascular Disease<br>Asthma/Pulmonary/Respiratory Disease<br>Prior History of Pressure Ulcer/Existing Pressure Ulcer<br>Diabetes/IDDM | | | |

5–6: Low Risk; 7–14: Moderate Risk; 15 or greater: High Risk

**Table 2: Distribution of Respondents' Characteristics Based on Age, Type of Surgery, Position during Surgery, and Length of Procedures (n = 81)**

| Variable | Frequency (n) | Percentage (%) |
|---|---|---|
| Age | | |
| ≤ 39 years | 15 | 18,5 |
| 40–59 years | 27 | 33,3 |
| ≥ 60 years | 39 | 48,1 |
| Total | 81 | 100 |
| Type of Surgery | | |
| Cardio | 9 | 11.1 |
| Laparotomy | 12 | 14.8 |
| Neuro | 42 | 51.9 |
| Orthopedic | 18 | 22.2 |
| Total | 81 | 100 |
| Position during Surgery | | |
| Lateral | 11 | 13.6 |
| Prone | 19 | 23.5 |
| Supine | 51 | 63 |
| Total | 81 | 100 |
| Length of Surgery | | |
| ≤ 2 h | 2 | 2.5 |
| 2–4 h | 54 | 66.7 |
| ≥ 4 h | 25 | 30.9 |
| Total | 81 | 100 |

11 (18%) with two types of comorbid, and four (1.65%) with three types of comorbid.

The data showed that 42 of 81 respondents used polyurethane foam, and 39 respondents did not use polyurethane foam during the intraoperative phase (Table 5). Most respondents with intraoperative polyurethane foam were aged 60 years. Intraoperative polyurethane foam was used mainly in neurosurgery type of surgery, 27 (64.3%) respondents. There were 19 (45.2%) respondents in the prone position, with most of the respondents or 23 (54.8%) having a length of surgery in 2–4 h. Meanwhile, 28 (71.8%) respondents who did not use polyurethane foam intraoperatively were at a moderate risk level for pressure ulcers.

**Table 3: Distribution of Pressure Injury Risk in Pre-operative Patients Based on the Munro Scale Assessment (n = 81)**

| Category of Risk | Frequency (n) | Percentage (%) |
|---|---|---|
| Low | 19 | 23.5 |
| Moderate | 62 | 76.5 |
| High | 0 | 0 |
| Total | 81 | 100 |

The result showed that 42 respondents who used polyurethane foam during the intraoperative phase had no pressure injuries after 72 h post-operative, either in patients with low risk or moderate risk levels (Table 6). Similarly, 39 respondents who did not use polyurethane foam during the intraoperative phase showed no pressure injuries after 72 h postoperatively (Table 7).

**Table 4: Distribution of Risk Factors of the Moderate Risk Category in the Pre-operative Phase (n = 62)**

| Risk Factors | Score | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Mobility | | | |
| Not limited, or slightly limited, moves independently | 1 | 36 | 58 |
| Very limited, requires transfer assistance | 2 | 21 | 33.9 |
| Completely immobile, requires full assistance | 3 | 5 | 8.1 |
| Total | | 62 | 100 |
| Nutritional state/Length of NPO status | | | |
| ≤ 12 h | 1 | 62 | 100 |
| 12–24 h | 2 | 0 | 0 |
| ≥ 24 h | 3 | 0 | 0 |
| Total | | 62 | 100 |
| BMI (Body Mass Index) | | | |
| ≤ 30 kg/m$^2$ | 1 | 62 | 100 |
| 30–35 kg/m$^2$ | 2 | 0 | 0 |
| ≥ 35 kg/m$^2$ | 3 | 0 | 0 |
| Total | | 62 | 100 |
| Weight loss in 30–180 days | | | |
| Up to 7.4% weight loss, no change or unknown | 1 | 62 | 100 |
| Between 7.5% to 9.9% weight loss | 2 | 0 | 0 |
| ≥ 10% weight loss | 3 | 0 | 0 |
| Total | | 62 | 100 |
| Age (years) | | | |
| 39 or less | 1 | 4 | 6.5 |
| 40–59 | 2 | 19 | 30.6 |
| ≥ 60 | 3 | 39 | 62.9 |
| Total | | 62 | 100 |
| Co-morbidity | | | |
| None | 0 | 18 | 27.9 |
| 1 type of comorbid | 1 | 29 | 52.5 |
| 2 types of comorbid | 2 | 11 | 18 |
| 3 types of comorbid | 3 | 4 | 1.6 |
| Total | | 62 | 100 |

## Discussion

As a person gets older, the risk of pressure sores increases because aging results in a decrease in lean body mass, muscle mass, and a reduced amount of water in the body, resulting in decreased skin elasticity. This condition results in a lack of tolerance of the skin surface to pressure. Based on the assessment from 81 respondents, it was found that most of the respondents, or 62.5% were 60 years old. A study conducted in Sweden found that 97% of patients aged 65 years had pressure sores, and 63% were over 80 years old [13]. The results showed that most of the types of surgery

**Table 5: Distribution of Intraoperative Polyurethane Foam Use based on Munro Scale Assessment in Pre-operative Phase (n = 81)**

| Risk factors | Intraoperative Polyurethane Foam Use | | | |
|---|---|---|---|---|
| | Yes (n = 42) | | No (n = 39) | |
| | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) |
| Age (years) | | | | |
| ≤ 39 | 6 | 14.3 | 9 | 23 |
| 40–59 | 14 | 33.3 | 13 | 33.3 |
| ≥ 60 | 22 | 52.4 | 17 | 43.6 |
| Subtotal | 42 | 100 | 39 | 100 |
| Type of surgery | | | | |
| Cardio | 8 | 19 | 1 | 2.6 |
| Laparotomy | 1 | 2.4 | 11 | 28.2 |
| Neuro | 27 | 64.3 | 15 | 38.5 |
| Orthopedic | 6 | 14.3 | 12 | 30.8 |
| Subtotal | 42 | 100 | 39 | 100 |
| Position during surgery | | | | |
| Lateral | 9 | 21.4 | 2 | 5.1 |
| Prone | 19 | 45.2 | 0 | 0 |
| Supine | 14 | 33.3 | 37 | 94.9 |
| Subtotal | 42 | 100 | 39 | 100 |
| Length of surgery | | | | |
| ≤ 2 h | 2 | 4.8 | 0 | 0 |
| 2–4 h | 23 | 54.8 | 31 | 79.5 |
| ≥ 4 h | 17 | 40.5 | 8 | 20.5 |
| Subtotal | 42 | 100 | 39 | 100 |

performed were neurosurgery as many as 42 (51.9%) respondents with a supine position as 51 (63%). In the supine position, the areas at risk for pressure sores are the heels, sacrum, scapula, and back of the head [2]. Research conducted by Guo *et al.* revealed that the control group with the supine position during intraoperative had a significantly higher prevalence of pressure injuries [14]. The duration of the operation also affects the occurrence of pressure sores. In this study, most of the length of surgery was 2–4 h, as many as 23 (54.8%). It was found that the percentage of patients who had pressure sores increased with the increasing length of surgery; the prevalence occurring at a rate of 8.5% or higher among all patients undergoing surgical procedures that varied, but procedures that lasted more than 2.5–3 h were significantly more likely to cause skin and underlying tissue damage [15].

**Table 6: Distribution of Pressure Injury at 72 h postoperatively in patients with intraoperative polyurethane foams (n = 42)**

| Pressure Injury Risk Category | With Intraoperative polyurethane foams | | Pressure Injury Incidence | | | |
|---|---|---|---|---|---|---|
| | | | Yes | | No | |
| | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) |
| Low | 8 | 19% | 0 | 0% | 8 | 19 |
| Moderate | 34 | 81% | 0 | 0% | 34 | 81 |
| High | 0 | 0% | 0 | 0% | 0 | 0 |
| Total | 42 | 100% | 0 | 0% | 42 | 100 |

Most respondents of this study, or 62 (76.5%), were at moderate risk for pressure injuries. The moderate risk level was obtained from risk factors including age 60 years, mobility factors, and comorbidities. Aging results in a decrease in lean body mass, muscle mass, and a reduced amount of water in the body. Skin elasticity decreases and results in a lack of tolerance of the skin's surface to pressure. A study conducted in a private hospital in Brazil found that advanced age was positively associated with perioperative pressure sores, with a higher incidence in patients aged 65 years at 40.0% [5].

Similarly, Powers and Ames found reduced movement or immobility is the most significant risk factor for pressure sores [8]. Other factors such as nutritional deficiencies and advanced age 60 years have increased the risk of pressure sores. Lenche *et al.* also found that from 2099 patients who were hospitalized; there were 1289 (61.4%) patients with an average age of 76.32 years having a total pressure ulcer prevalence of 12.19%, which was significantly affected by the presence of disease (p = 0.021) and neurological disorders (p = 0.051) [13]. Chiari *et al.* also stated that the patients most at risk for pressure ulcers were adults older than 80 years [16].

**Table 7: Distribution of Pressure Injury at 72 h postoperatively in patients without intraoperative polyurethane foams (n = 39)**

| Pressure Injury Risk Category | Without Intraoperative polyurethane foams | | Pressure Injury Incidence | | | |
|---|---|---|---|---|---|---|
| | | | Yes | | No | |
| | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) | Frequency (n) | Percentage (%) |
| Low | 11 | 28% | 0 | 0% | 11 | 28 |
| Moderate | 28 | 72% | 0 | 0% | 28 | 72 |
| High | 0 | 0% | 0 | 0% | 0 | 0 |
| Total | 39 | 100% | 0 | 0% | 39 | 100 |

Impaired mobility decreases a person's ability to change position, and prolonged pressure can result in tissue intolerance to ischemia [17]. A study showed a significant relationship between mobility ability and the degree of pressure sores in hospitalized patients [18]. Likewise, a study conducted by Powers and Ames found that the most significant risk factor for pressure sores is reduced movement or immobility [8]. Other factors such as nutritional deficiencies and advanced age 60 years have increased the risk of pressure sores. The study results are in line with a study conducted by Jaul *et al.* that old age, impaired mobility, and comorbidities can increase susceptibility to pressure sores because aging decreases dermal thickness and sensory perception, which can cause tissue injury more quickly [19]. Based on the results, 22 of 42 respondents with intraoperative polyurethane foam were elderly 60 years. Patients aged 60 years are at risk for pressure ulcers; therefore, using polyurethane foam can reduce the incidence of pressure sores [20]. There have been no specific studies related to the use of intraoperative foam in old age. Still, a study states that prophylactic dressings are bandages applied to the skin surface above the pressure point to reduce the forces of pressure, friction, and shear through a multiple layer construction, protecting the skin brittle from friction thereby preventing pressure injuries [2].

During the study, polyurethane foam was primarily used in neurosurgery with 27 (64.3%) respondents and was in prone positions as many as 19 (45.2%) respondents. Areas at risk for pressure sores in the prone position are the forehead, chin, cheeks, shoulder (anterior), elbow, chest (breast), genitalia, anterior pelvic bones, knee (patella), dorsal feet, and toes and nose [2]. Using polyurethane foam in the prone position intraoperatively will reduce the risk of pressure sores [21]. Most of the respondents who used polyurethane foam during this study were respondents with 2 to 4 h of surgery duration, which were 23 (54.8%) respondents. An investigation revealed

that the prevalence of pressure sores varies from 8.5% or higher among all patients undergoing surgical procedures. Still, procedures lasting more than 2.5 to 3 h are significantly more likely to cause skin and tissue damage underlying it [15]. According to Shen *et al.*, the risk of pressure sores increases gradually with the lengthening of the operation [22]. It is impossible to reduce the length of the operation; therefore, a strategy that can prevent pressure sores in the intraoperative period is using polyurethane foams [23].

The results showed no pressure injury incidence after 72 h post-operative on respondents with and without intraoperative polyurethane foam. There was the probability of confounding factors in this study, such as pre-operative hemoglobin levels, albumin levels, lactate levels, intraoperative blood loss, post-operative immobilization, physical restraints, and post-operative care in the different units, for example, in the intensive care unit and general ward. The other factors include anesthesia, applied moisture, and bed type. Research by Poitras and Frey on the effectiveness of polyurethane foam dressings to prevent pressure sores showed a significantly lower incidence [20]. This study is in line with Huang *et al.*, who analyzed dressings to prevent pressure ulcers and found that the incidence of pressure sores was less among those using foam compared to standard routine care [24]. Primiano stated that when a surgical patient develops a pressure ulcer within 72 h of the procedure, it likely indicates that the wound results from surgery [15]. The rate of intraoperative pressure ulcers ranges from 12% to 66% in surgical patients; it is caused by strong or prolonged pressure that does not subside for a long time, resulting in damage to the skin and underlying tissue. European Pressure Ulcer Advisory Panel suggested that film dressings can help protect the skin from the adverse effects of friction [2]. In addition, they indicated that foam pads could protect body parts from the risk of shear injury. The material that seems to be most effective overall is polyurethane foam, especially in multi-layers. The results showed that 39 respondents who did not use intraoperative polyurethane foam, both with low and moderate risk levels, did not have pressure injuries until 72 h of post-operative observation. This result needs further analysis related to other factors such as confounding factors during the intraoperative phase and post-operative care.

There are several study limitations, including the setting was only in one hospital, with a descriptive approach that did not give a cause and effect relationship. Respondent in the study was voluntary, and the sample selection was intentional and not random. Despite these limitations, this study has provided valuable data regarding the use of Munro scale assessment to help nurses identify the risk level of pressure injury and positive insight for applying polyurethane foam as a strategy to prevent pressure ulcers. Further research is needed on the effectiveness of using polyurethane foam during the intraoperative phase in a more significant number of respondents with different research methodologies.

## Conclusion

The results of this study emphasize information that the Munro scale assessment can help predict the level of risk of pressure injuries in patients undergoing surgery. It is expected that hospitals will consistently apply standard pre-operative procedures to improve the quality of care for patients undergoing surgery. The role of nurses is enormous in the prevention of pressure sores. Nurses are expected to be consistent and responsible in identifying patients at risk for pressure injuries and strengthen collaboration with surgeons in implementing pressure ulcer prevention strategies during the intraoperative phase.

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