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A study to assess the effectiveness of silicon foam patch as prophylactic measure in pre-operative pediatric cardiac patients to prevent pressure injuries post operative cardiac surgery

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Abstract
Critically ill infants and children are at high risk for hospital-acquired pressure injuries (HAPIs) in the pediatric cardiac intensive care unit (PICCU). Most of the children undergo complex cardiac procedures that require extended periods of immobility, inotropic support, sedation medications, and chemical paralytics to aid in the healing process. These therapies, in conjunction with the physiologic consequences of the child's cardiac lesion, can lead to decreased oxygenation and perfusion, increasing the patient's risk for injury to the skin. Hence preoperative risk assessment and interventions are required to prevent pressure injuries in pediatric cardiac patients who are at high risk due to multiple factors.

Keywords: Skin injury, silicon barrier patch, cardiac surgery, prophylaxis, Braden scale

1. Introduction
Pressure injuries (PIs), previously referred to as pressure ulcers, are localized damage to the skin and underlying tissue caused by prolonged pressure or pressure combined with shear. In cardiac surgical patients, prolonged operative times, immobility, and use of multiple medical devices significantly increase PI risk. Literature reports an incidence of 5-10% in pediatric cardiac surgery patients, with most injuries being occipital region [2].
Prophylactic dressings, such as silicone-based patches, have gained attention for their ability to redistribute pressure, minimize friction, and protect vulnerable skin areas. Evidence in adult critical care shows reduced Pressure injury incidence with silicone patches, but limited research exists on their use in pediatric cardiac populations. This study focuses on the innovative application of silicone patches in the pre-operative phase, hypothesizing that prophylactic use at pressure points areas may prevent Pressure injury development during the postoperative recovery period [3].

2. Materials and Methods
2.1. Aim
To assess the effectiveness of silicon foam patch as prophylactic measure in pre-operative cardiac patients to prevent pressure injuries post open cardiac surgery.

2.2. Objective
a) To evaluate the incidence of pressure injuries in patients receiving silicon foam patch compared to those without the patch after open cardiac surgery.
b) To assess the severity and grading of pressure injuries in both study groups post-operatively.
c) To examine the relationship between silicon foam patch application and Braden Scale scores in the pre- and post-operative periods in both groups [5].

2.3. Variables
A quasi-experimental study conducted among children undergoing open cardiac surgery. The

variables used:

1. **Dependent:** Paediatric patients undergoing open cardiac surgery
2. **Independent:** In this study Silicon barrier patch is the independent variable

2.4. Setting

The study was conducted in the Pediatric Cardiothoracic Intensive Care Unit in Apollo hospitals, Navi Mumbai.

2.5. Population and Sample

a. Target Population: Paediatric patients undergoing open cardiac surgery at Apollo hospital, Navi Mumbai.
b. Sample size: 60.
c. Sampling Method: In this study Purposive sampling
d. Inclusion criteria

1. Age group of neonates to 16years of age.
2. Patients with Congenital Heart failure undergoing Open heart surgery

Exclusion criteria

1. Age group of more than 16years of age.
2. Patients with non-surgical intervention.
3. Patient who had pressure injuries before the admission.

2.6. Instruments / Tools

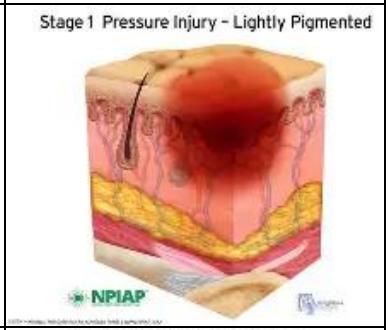
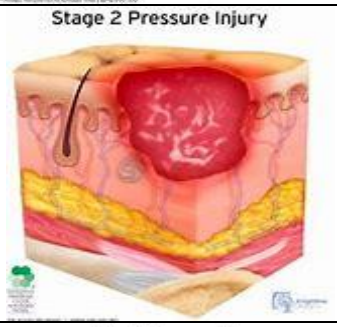
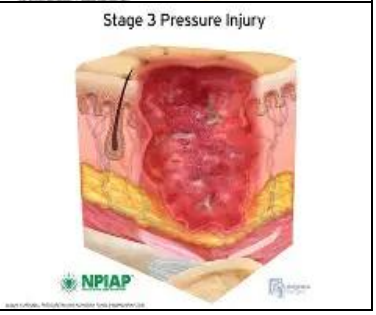
a. Demographic proforma: Age, gender, diagnosis, surgery type, operative time.
b. Braden scale: For Pressure injury risk assessment.
c. NPUAP/EPUAP Pressure Injury Staging system: For assessment and grading

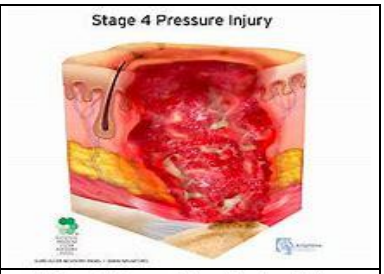
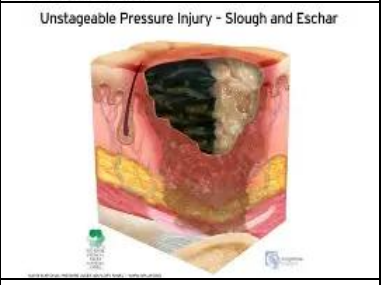
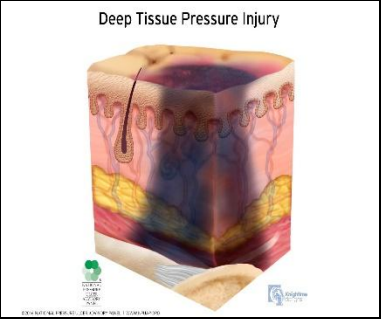
3. Subheadings

A pressure injury or ulcer is defined by the National Pressure Ulcer Advisory Panel (NPUAP) as localized damage to the skin and underlying soft tissue usually over a bony prominence or injury related to medical or other devices. The injury occurs as a result of intense and/or prolonged pressure or pressure in combination with shear stress.

In 2016, the NPUAP and European Pressure Ulcer Advisory Panel expanded the definition of pressure ulcers to 6 different stages [6]:

Classification/Grading of Pressure Injuries (or Pressure Ulcers)

Grades	Description	Observation
Grade I	Non blanchable erythema (redness) of intact skin, discoloration of skin, warmth, oedema, induration of hardness may also be used as indication particularly on darker skin.	
Grade II	Partial thickness skin loss involving epidermis, dermis or both, the injury is superficial and presented clinically as an abrasion or blister.	
Grade III	Full thickness skin loss involving damage to or necrosis of subcutaneous tissue that may extend down to, but not through underlying fascia.	

Grade IV	Extensive Destruction, tissue necrosis or damage to muscle, bone or supporting structures or without full thickness skin loss.	
Unstageable	Full thickness tissue loss where the extent of tissue damage cannot be determined due to the presence of slough or eschar. Until enough slough or eschar is removed to expose the base of the wound, the true depth and stage cannot be determined.	
Suspected Deep tissue pressure injury	Ulcers that form from suspected deep tissue injury can be difficult to diagnose. On the surface, it may resemble a stage 1 or 2 sore. Underneath the discolored surface, this ulcer could be as deep as a stage 3 or stage 4 wound.	

3.1. Incidences and risk factors of pressure injury in pediatric cardiac intensive care unit

It has been reported that the incidence of hospital acquired pressure injuries in pediatric patients with congenital heart disease range from 9.7% to 15.6%. The occurrence of pressure injuries not only causes physical and psychological pain to pediatric patients but also increases the risk of complications, significantly hindering their post op recovery.

There are multiple risk factors associated with pressure injuries in pediatric cardiac surgeries such as prolonged immobilization, hypothermia, perfusion during intra operative period, use of corticosteroids, Hemoglobin& Albumin level etc [7].

3.2 Pressure Injury Risk Assessment

The risk assessment of Pressure ulcer in pediatric cardiac cases was done preoperatively. The Braden scale was used to assess the risk of pressure injury. A patient with a score of 16 or less is considered to be at risk of developing pressure ulcer, more than 16 are considered to be low risk, 13-14 are considered to be Moderate risk, 12 or < is considered to be high risk. Risk assessment was done in every shift and intervened according to scores.

Cardiac patients have unique risk factors associated with the pathophysiology of abnormal heart function. Since they are at increased risk for developing pressure injury during hospitalization, health care providers must adopt preventive practices according to their unique physiology. Adult and general pediatric skin care bundles warrant evaluation and refinement to enhance their specificity for pediatric cardiac patients. During the postoperative period, significant risk factors associated with acquiring a pressure ulcer included mobility, invasive lines & drains, medical devices and body temperature. (8)

3.3Mechanism of Silicon foam patch use

a) **Pressure redistribution:** The presence of a dressing with adequate thickness distributes forces over a larger area, thus accomplishing pressure redistribution by reducing the percentage of magnitude of forces applied to the skin.

b) **Shear redistribution:** The dressing translates shear force to the skin outside the area of concern. Within the dressing itself, the interface of multiple layers aids in the absorption of shear. The elastic nature of the silicone adhesive also absorbs shear.

c) **Friction reduction:** The texture and material of construction of the dressing's outer layer is 'slippery'. Friction is the result of 2 surfaces moving relative to each other and decreasing friction reduces shear forces.

d) **Microclimate management:** The dressing maintains an optimal level of humidity at the skin surface, which maximizes resilience by avoiding either excessive dryness or maceration predisposing to skin breakdown [9].

3.4. Review of literature

3.4.1. Risk assessment

1. The National Pressure Ulcer Advisory Panel (2014) recommend using a structured approach to risk factor assessment, they do not specify the pressure injury risk assessment tool that should be used. The recommendations from National Pressure Ulcer Advisory panel for preventive skin care include: incontinence management, keeping the skin clean and dry, avoid positioning on an area of erythema, protect skin from excessive moisture, and using a skin moisturizer to hydrate skin when necessary. Interventions can be implemented to prevent pressure ulcers including: adequate nutrition, individualized care

plan, repositioning and early mobilization, and appropriate support surfaces [10].

2. Ms. Ashlee shields (2020) found that intraoperative temperature, lower perfusion or hypotension operative use of steroids and anticoagulation's significantly increase risk factors to develop Pressure injuries among CHD patients [11].
3. Mr. He lin Haiyen chen (2024) revealed that Low Braden scores, use of steroids, skin abnormalities and low saturation intraoperative leads to pressure injury and these factors exhibited good predictive performance and clinical applicability. Thus, it will be convenient tool to assist nurses in early identification of high-risk patients for pressure injury. Hence operating room nurses should consider applying gel pads of foam dressings intraoperatively for such risk patients to reduce the incidence of pressure injury in post op [12].
4. Mr. Kulik (2019) found that OR time greater than 4 hours, having oxygen saturation levels less than 85%, Low Braden scores are associated with HAPI development and it can be prevented by Comprehensive approach including skin assessment, keeping skin clean and dry under devices, alternating interfaces, device rotation or repositioning [13].

3.4.2. Use of silicon foam dressings

1. Mr. Chelsea P Kriesberg (2018) found that products included adhesive options such as foam dressings applied when anticipating prolonged time of immobility to bony prominences to offload pressure and wick away moisture [14].
2. Mr. Charles M Geller (2020) (Journal of Thoracic and cardiovascular surgery) found that use of silicone foam dressings when used prophylactically has been found to be superior standard HAPI prevention protocols [15].

3.4.3. Use of bundle cares in pressure injury prevention

1. Ms. Janet M Simsic (2019) found pressure ulcer bundle which includes 1. barrier cream use for diapered patients.2. Saturation probe rotation every 8 hours.3 Use of pressure reduction surfaces.4. Patients turning schedule every 2 hours. 5.Heel pressure relief. 6.Elevation of head end of the bed. 7.Wound nurse Consult for all pressure ulcer >Stage 2 [16].
2. Mr. Kulik LA (2018) found that Standard Clinical Assessment and Management Plans (SCAMPs) which includes Head to toe assessment every shift paying attention to bony prominences, back and under and medical devices. Repositioning every 2hourly, use of pressure redistribution surfaces/supports, place heels off bed, Manage moisture, Gel pillow under heads [17].
3. Mr. Zeynep (2024) Found that use of REPRISE bundle to prevent pressure injuries which includes R-Risk assessment, E-Evaluation of the skin, R-Repositioning, S-Support surfaces, E-Evaluation of Nutrition, P-Prevention of pressure ulcers caused by medical devices, I-Incontinence management [18].

Pressure injuries remain a common complication among high-risk and cardiac surgery patients. Early risk assessment using validated tools like the Braden Scale and preventive skin care are essential. Studies show that silicone foam dressings, when used prophylactically, effectively reduce pressure, shear, and moisture—thereby lowering the incidence of hospital-acquired pressure injuries. In addition, bundle care approaches combining repositioning, use of pressure-relieving surfaces, adequate nutrition, and skin monitoring further enhance prevention. Overall, integrating silicone foam patches within a comprehensive pressure injury prevention strategy provides significant protective benefits for pre-operative cardiac patients

4. Footnotes

1. **NPUAP/EPUAP Guidelines (2019):** The international standard for Pressure injury staging and prevention.
2. **Braden Scale:** A validated Pressure injury risk assessment tool.
3. Silicone dressings have been shown to redistribute pressure and reduce shear, making them good prophylactic devices.

5. Results & Discussion

The study included 60 patients, evenly divided into those with and without a silicon patch applied before surgery. More than 50% of age group were infant aged more than 28 days to 1year, highlighting a significant representation of younger age groups in the patient population. Children aged 2-5 years account for 21.67% of the patients, whereas those older than 5 years constitute only 10%. Neonates (less than 1 month old) represent the smallest subgroup, making up 8.33% of the total patients. Across all time points, mean BRADEN scores showed slight differences between the two groups, with scores generally lower in the silicon patch group before surgery (16 ± 2 vs. 17 ± 3). Postoperative scores at POD-0, POD-01, POD-02, and POD-03 were similar between groups, thus, even in the absence of significant postoperative differences, the application of silicon patches before surgery appears to provide an additional layer of protection and may serve as a valuable strategy in preventing pressure injuries in the high-risk population.

6.Tables and Figures

Table 1: Participant's characteristics

Description	Silicon Patch Applied Before Surgery			
	No		Yes	
Total Patients	30		30	
Age Group	**Frequency**	**Percentage**	**Frequency**	**Percentage**
0-28days	0	0	1	3.33
29 days -1year	1	3.33	4	13.22
1-2 Years	16	53.33	20	66.66
2-5 Years	9	30.00	4	13.33
>5years	4	13.33	2	0.66
BRADEN Score (Mean ± Stand. Deviation)				
Before surgery	17 ± 3		16 ± 2	
POD-0	11 ± 2		11 ± 2	
POD-01	12 ± 2		11 ± 2	
POD-02	13 ± 1		12 ± 2	
POD-03	14 ± 1		14 ± 2	

(This is a table with error bars showing the mean BRADEN scores for "No silicon Patch" and "with silicon patch" conditions across the time points. The error bars represent the standard deviations, providing a clear comparison of variability and trends.)

Fig 1: Comparison of BRADEN Scores (No Silicon Patch Vs with Silicon Patch) Across Time Points

A one-way ANOVA test was conducted to compare the BRADEN scores between the groups with and without silicon patch application across different time points. Before surgery, a statistically significant difference was observed ($F=4.12$, $p=0.045$), indicating that patients without a silicon patch had a higher risk of pressure injury. With the application of a silicon patch, patients maintained steady BRADEN scores across all postoperative time points (POD0 to POD3), suggesting a stabilizing and protective effect during recovery. These findings indicate that while there was a preoperative disparity in BRADEN scores, the application of a silicon patch supported favorable recovery trends during the postoperative period, highlighting its beneficial role in promoting stable healing. (Table 2)

Table 2: ANOVA Results for BRADEN Scores Across Time Points Based on Silicon Patch Application

Braden Score	F	Sig.
Before surgery	4.2	0.045
POD-0	1.258	0.267
POD-01	3.502	0.066
POD-02	1.929	0.17
POD-03	1.134	0.291

The BRADEN scores were analyzed across five time points to compare the effects of silicon patch application within different age groups. Before surgery, patients without a silicon patch exhibited higher BRADEN scores in older age groups, with the highest scores seen in patients aged >5 years (20 ± 3). In contrast, patients <1 month old without a silicon patch had the lowest scores (12 ± 0). Among those with a silicon patch, scores were more uniform across age groups, with slightly lower scores in older patients (>5 years: 18 ± 3), indicating potential preoperative vulnerability in this group.

At POD-0 and POD-1, BRADEN scores showed minimal differences between the silicon patch and non-patch groups for most age categories, except in patients aged >5 years, where scores were notably higher in the silicon patch group (POD-0: 14 ± 0 vs. 12 ± 0; POD-1: 14 ± 0 vs. 13 ± 0). These findings suggest a possible early benefit of silicon patch application for older patients immediately after surgery.

By POD-02 and POD-03, scores showed a trend of recovery across all age groups in both treatment arms, with the silicon patch group consistently demonstrating slightly higher scores across the board. Notably, the youngest age group (<1 month) exhibited faster improvement in the silicon patch group, with BRADEN scores increasing from 12 ± 1 (pre-surgery) to 11 ± 1 (POD-03). Conversely, the non-patch group in this age category started with lower scores and showed slower improvement over the same period.

Overall, the data indicates that while both groups followed a similar trajectory of recovery, silicon patch application may provide a slight advantage in maintaining skin integrity, particularly in the youngest and oldest age groups. The uniformity in scores across the silicon patch group suggests a stabilizing effect, potentially reducing age-related disparities observed in the non-patch group. (Table 3)

Table 3: Comparison of BRADEN Scores Across Age Groups and Time Points Based on Silicon Patch Application

Time Point	Braden Score	<1 Month	<=1 Year	2-5 Years	>5 Years
Before surgery	Without Silicon Patch	12 ± 0	16 ± 2	18 ± 2	20 ± 3
	With Silicon Patch	15 ± 1	15 ± 1	18 ± 2	18 ± 3
POD-0	Without Silicon Patch	8 ± 0	11 ± 0	12 ± 0	12 ± 0
	With Silicon Patch	9 ± 0	11 ± 0	11 ± 0	14 ± 0
POD-1	Without Silicon Patch	8 ± 0	12 ± 0	13 ± 0	13 ± 0
	With Silicon Patch	9 ± 0	11 ± 0	12 ± 0	14 ± 0
POD-02	Without Silicon Patch	9 ± 0	13 ± 1	13 ± 1	13 ± 1
	With Silicon Patch	10 ± 1	13 ± 2	13 ± 1	15 ± 1
POD-03	Without Silicon Patch	10 ± 0	14 ± 1	14 ± 1	15 ± 1
	With Silicon Patch	11 ± 1	14 ± 2	14 ± 1	15 ± 1

7. Conclusion

The findings of this study demonstrate that prophylactic application of silicone patches in pediatric patients undergoing open-heart surgery may contribute to improved skin integrity and reduced risk of pressure injuries. Clinical observations revealed that patients treated with silicone patches showed more consistent Braden scores across various age groups, with notable improvements in the most at-risk populations infants under one month old and children over five years. The use of silicone patches appeared to minimize age-related disparities in skin vulnerability and offered an early postoperative advantage, especially within the first 48 hours after surgery when patients are most at risk. These results highlight the potential of silicone patches as a simple, nurse-driven, and cost-effective intervention in perioperative care.

Integrating silicone patch application into routine preoperative and postoperative protocols may strengthen nursing strategies aimed at enhancing patient outcomes, reducing complications, and improving the overall quality of care in pediatric cardiac surgery units.

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10. Conflict of Interest

Not available.

11. Financial Support

Not available.

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