The Effect of Offloading Heels on Sacral Pressure

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ABSTRACT

Offloading a patient's heels during supine surgical procedures is a common practice to prevent heel pressure injuries. This practice may increase sacral pressure and jeopardize sacral skin integrity, but prophylactic dressings may help protect sacral skin. The purpose of this study was to examine the effects of offloading the heels and of multilayered silicone foam dressings on sacral pressure. We measured the sacral pressure of 50 healthy volunteers using a pressure-mapping system under four conditions: heels not offloaded and sacral dressing applied, heels offloaded and dressing applied, heels not offloaded and no dressing, and heels offloaded and no dressing. We used linear mixed-effects modeling to compare the effects of these conditions on sacral pressure. Offloading the heels significantly increased sacral pressure ($P < .001$), whereas the dressing had no effect on sacral pressure ($P = .49$). Offloading a patient's heels may increase the risk of sacral pressure injuries. *AORN J 106 (September 2017) 194-200. © AORN, Inc, 2017. http://dx.doi.org/10.1016/j.aorn.2017.07.002*

Key words: *intraoperative pressure injuries, pressure mapping, interface pressure, sacral pressure, offloading heels.*

Hospital-acquired pressure injuries (HAPIs) are nurse-sensitive indicators; a stage 3, a stage 4, or an unstageable pressure injury acquired after admission or presentation to a health care facility is considered a never event.[1] Nevertheless, HAPIs remain a challenging, frequently occurring problem in hospitalized patients. The National Pressure Ulcer Advisory Panel (NPUAP) reported the incidence of pressure injuries directly attributable to the OR to range from 4% to 45%.[2] Long surgical procedures are associated with increased risk of pressure injuries.[2,3] The prevalence of pressure injuries is 8.5% or higher among patients whose surgeries last three hours or longer.[4] Pressure injuries are associated with poor patient outcomes and increased hospital costs. A pressure injury in a surgical patient adds approximately 44% to the cost of the surgical stay.[5]

Many surgical procedures require placing the patient in the supine position. This position puts the patient at risk of developing a pressure injury, especially on the heels or sacrum. The heel has a unique anatomy and microcirculatory system, so complete relief of heel pressure (ie, offloading) during surgery requiring the supine position is recommended to prevent heel pressure injuries.[6] Offloading the heels may result in increased pressure on the sacrum from weight and pressure redistribution, jeopardizing sacral skin integrity. Primiano et al[4] reported that 23% of the 21 patients in their study who developed sacral pressure injuries had their heels elevated off the OR bed during surgery. The direct effect of offloading the heels on sacral pressure has not been documented, however.

Another recommendation for decreasing the risk of pressure injuries is to apply a prophylactic dressing, such as a multilayered silicone foam dressing, to susceptible areas.[7,8] This type of dressing protects the skin from breakdown by decreasing friction and shear forces and improving the microclimate of the skin.[9,10] Whether such a dressing can provide pressure relief has not been adequately studied, however. Determining the relationship between offloading

http://dx.doi.org/10.1016/j.aorn.2017.07.002

the heels and the amount of pressure exerted on the sacrum is imperative to inform the practice of positioning patients on OR bed surfaces. Of equal importance is determining the effect of a multilayered silicone foam dressing on the amount of pressure exerted on the sacrum during heel offloading.

STATEMENT OF PURPOSE

The purpose of this study was to examine the effect on sacral pressure of offloading the heels of healthy adult volunteers in the supine position. We further examined the effect on sacral pressure of a multilayered silicone foam dressing applied to the sacrum with and without the heels offloaded.

RESEARCH QUESTIONS AND SIGNIFICANCE TO NURSING

The standards of care to reduce pressure injuries for patients in the supine position include completely offloading the heels and applying a prophylactic dressing to the sacrum.[7,8] The sacrum is the most vulnerable area when patients are in the supine position, however. Therefore, the possibility of increasing sacral pressure by offloading the heels is of particular concern.[6,11] We conducted this study to answer the following questions:

- Does offloading the heels of healthy volunteers in the supine position increase pressure on the sacrum?
- Does a multilayered silicone foam dressing applied to the sacrum decrease sacral pressure?

LITERATURE REVIEW

Hospital-acquired pressure injuries continue to occur across health care settings despite focused attention on patient safety, the implementation of prevention strategies, and lack of reimbursement for their treatment.[6,12] The development of HAPIs contributes to poor patient outcomes, including increased lengths of stay, pain, infections, decreased patient satisfaction, and even mortality.[4] Perioperative patients are at risk for developing HAPIs. When a patient develops a pressure injury within 72 hours after a surgical procedure, it is most likely that the injury began in the OR.[4] Several studies have explored the causes of HAPIs in surgical patients and reported multiple environmental and individual risk factors, including immobility, sensory impairment, hemodynamic fluctuations, vasoactive medications, positioning, and positioning devices (eg, pillows, wedges).[13-16] Although some of these variables may be difficult to modify while the patient is anesthetized, prophylactic measures such as offloading the heels from the OR bed and applying multilayered silicone foam dressings to the sacrum are common practices to prevent pressure injuries in OR patients.

The literature supports elevating or offloading the heels as an effective way to prevent heel pressure injuries. Accordingly, NPUAP and AORN recommend that a patient's heels be completely elevated off the OR bed if elevation can be performed in a manner that does not place pressure on the Achilles tendon and that redistributes the weight of the leg along the calf.[7,8] Offloading the heels can help prevent heel pressure injuries; however, a literature search failed to locate any studies that tested the effect on sacral pressure of offloading the heels, suggesting that this study may be one of the first on this topic.

Clinical and scientific data support the prophylactic application of multilayer silicone foam dressings to bony prominences to prevent pressure injuries in susceptible patients.[9,10,12,17,18] This body of literature informed the development of a clinical practice guideline by NPUAP, the European Pressure Ulcer Advisory Panel, and the Pan Pacific Pressure Injury Alliance that recommends applying prophylactic dressings to bony prominences subjected to friction and shear.[2] Multilayered silicone foam dressings have been associated with a decrease in the incidence and severity of pressure injuries in hospitalized patients.[17] Although the role of this dressing in decreasing shear and friction forces has been documented, its effect on the amount of pressure exerted and pressure distribution has not been adequately studied. Additionally, no reported studies tested the effects of offloading the heels on the amount of pressure exerted on the sacrum. We performed this study to address these gaps in the literature.

CONCEPTUAL FRAMEWORK

We used the Donabedian model for assessing quality of care to guide this study.[19] This model includes three phases for assessing quality: structure, process, and outcome. Structure refers to the physical and organizational environment of the health care setting as well as patient characteristics. Process refers to resources and polices relating to patient care activities. Outcome focuses on results as a function of the interaction between structure and process. In this study, structure refers to the perioperative environment, which might affect the risk of developing pressure injuries. This includes the practice of placing patients in the supine position for surgery and patient characteristics (eg, age, weight) that could affect the risk of developing a pressure injury. Process refers to strategies used to reduce the risk of developing a pressure injury (eg, offloading the heels during surgery). Outcome describes the effect of the interaction between structure and process on a potential increase of sacral pressure, which may contribute to the development of a sacral pressure injury.

OPERATIONAL DEFINITIONS

For the purposes of this study, we define pressure mapping as a method of measuring interface pressure using a specialized pad with calibrated pressure-sensitive sensors placed under the participant's sacrum. Interface pressure is the pressure load between the skin and support surface. Pressure redistribution refers to transferring pressure from one area of the body to another. Finally, offloading is the action of removing pressure (eg, complete lifting and elevation of the heels off the OR bed with no part of the foot, including the heels, touching the bed).

METHODS

We used a repeated-measures design for this cross-sectional descriptive study to test the effect of offloading the heels and using a sacral multilayered silicone foam dressing on sacral pressure in healthy volunteers. A convenience sample of 50 healthy hospital employees volunteered to participate in the study. Data collection took place in a designated private room at a community hospital in southern California. The room was equipped with a standard OR bed with a foam mattress and XSENSOR pressure-mapping equipment. The institutional review board of the hospital system approved this study.

We measured pressure exerted on the sacrum (interface pressure) using the XSENSOR X3 version 6, which consisted of a thin, pliable, 18-inch by 18-inch pad equipped with independent pressure sensors. Pressure exerted on the pad by the body generates a voltage difference that increases linearly with the amount of pressure. The pad was connected to a laptop computer equipped with XSENSOR software that translated the voltage difference into real-time pressure (mm Hg). The voltage was displayed on the monitor screen as graded color-coded images. The device was calibrated to measure a range of pressures between 0 and 200 mm Hg. This technology has been used to map pressure areas of patients in a variety of health care settings with reportedly good reproducibility.[20-23]

After receiving an explanation of study procedures and aims, volunteers who elected to participate signed the consent form. We provided privacy and asked each participant to remove all clothing from the waist down, except underpants, and then to put on scrub pants. We measured and recorded the participant's height and weight. We then placed the participant in the supine position on a standard OR bed covered with one hospital grade flat sheet. We placed the 18-inch by 18-inch pressure-mapping pad directly under the sacral area, which included the lower back and buttocks. We offloaded the participant's heels by placing two standard pillows stacked under the calves and knees, with the knees slightly flexed. The participant's arms were positioned at their sides. We did not use any additional positioning devices.

The participant settled on the OR bed for two minutes before pressure mapping began. We chose a settling time of two minutes because other researchers found no difference in interface pressure recorded at 2, 3, 15, and 30 minutes.[20,23,24] Each pressure-mapping measurement lasted for 10 seconds and collected 10 or 11 images (approximately one image per second). The pressure-mapping procedure recorded interface pressure as a color image on a monitor screen. Colors indicated different thresholds of pressure measured. We recorded four 10-second pressure mappings on each participant, including one pressure mapping under each of the following conditions: heels not offloaded and sacral dressing applied, heels offloaded and sacral dressing applied, heels not offloaded and no sacral dressing, and heels offloaded and no sacral dressing. The entire procedure lasted approximately seven minutes for each participant.

Data Analysis

We implemented linear mixed-effects models to compare the average amounts of pressure exerted on the sacrum in response to the four conditions tested. The mixed-effects modeling approach allows for assessment of the joint covariate effects of several main variables (heel offloading, multilayered silicone foam dressing, and a combination of both) on correlated observations made on the same subjects, while adjusting for the effects of other significant confounders. This allowed us to derive the best predictive model (achieved by exhaustive model-building via stepwise variable selection) to achieve unbiased estimates of the effect sizes. Allowing for inclusion of important covariates gives the linear mixed-effects approach a clear advantage over the classical repeated-measures techniques for comparing treatment effects such as repeated measurements analysis of variance and Hotelling's *T*-squared tests. We completed all calculations and model-building steps using the R statistical package version 3.3.3.[25]

RESULTS

Fifty healthy volunteers participated in the study. Most participants were females between 24 and 71 years old. Of the sample participants, 24 (48%) had a normal body mass index, 14 (28%) were overweight, 10 (20%) were obese, and 2 (4%) were extremely obese. A descriptive analysis of the sample is presented in Table 1.

The average, unadjusted amounts of sacral pressure for each of the four study conditions are displayed in Table 2. After

Table 1. Demographic Characteristics of the Sample (N = 50)

Characteristic	n (%)
Sex	
Male	14 (28)
Female	36 (72)
Body Mass Index	
17-24.9	24 (48)
25-29.9	14 (28)
30-39.9	10 (20)
>40	2 (4)
	Mean (SD)
Height, inches	66.2 (3.8)
Weight, pounds	170.2 (43.6)
Age, y	46.4 (11.2)

SD = standard deviation.

building the linear mixed-effects model, we identified the following best predictive model:

$$P_{ij} = a_i + \beta_0 + \beta_1 A_i + \beta_j + e_{ij},$$

where P_{ij} is the pressure measurement on the ith person subjected to the jth treatment; a_i is the random effect for the ith person that accounts for the correlations between repeated measurement taken on the ith subject; β_0 is the intercept and equals the average pressure for the reference treatment group (ie, heels not offloaded and no sacral dressing); β_1 is the effect of age; A_i is the age of the ith person; β_j is the contrast for the jth treatment versus the baseline treatment; and e_{ij} is the regression error term.

We found that after adjusting for age, heel offloading was the only variable that significantly increased sacral pressure ($P < .001$) by approximately 10 mm Hg regardless of the presence or absence of a multilayered silicone foam dressing. The application of the multilayered silicone foam dressing had no significant effect on sacral pressure when heels were elevated or not elevated ($P = .49$ and $P = .60$, respectively). Detailed results from the best predictive mixed-effects model are displayed in Table 3. Figure 1 shows the average age-adjusted pressure values for the four conditions and their pairwise comparisons. Sex, weight, height, and body mass index were not significantly associated with the amount of sacral pressure ($P = .34$, .35, .52, and .41, respectively). The only other significant predictor apart from heel offloading was the continuous covariate age ($P = .03$), which had an effect size of 0.35, suggesting that for any of the four conditions, each additional year of age was associated with an increased pressure of 0.35 units.

Table 2. Average, Unadjusted Sacral Pressure for Each Treatment Condition

Variable	Mean (SD)
Heels not offloaded and sacral dressing applied	62.8 (14.5)
Heels offloaded and sacral dressing applied	72.7 (15.2)
Heels not offloaded and no sacral dressing	62.2 (13.2)
Heels offloaded and no sacral dressing	73.8 (17.8)

SD = standard deviation.

Table 3. Summary Results From the Best Predictive Mixed-Effects Model

Variable	β	SE	t	P
Intercept (ie, heels not offloaded and no sacral dressing)	56.34	7.46	6.40	<.001
Heels not offloaded and sacral dressing applied	−1.37	1.99	−0.69	.50
Heels offloaded and sacral dressing applied	8.56	1.99	4.30	<.001
Heels offloaded and no sacral dressing	9.62	1.99	4.80	<.001
Age	0.35	0.15	2.29	.03

SE = standard error.

DISCUSSION

The literature documents the high incidence of heel and sacral HAPIs in perioperative patients.[16,26] Perioperative nurses play a critical role in identifying risk factors for HAPIs and implementing best perioperative positioning techniques to prevent their occurrence. Current recommendations include offloading the heels and applying prophylactic dressings (eg, multilayered silicone foam dressings) to susceptible areas.[7,8] Findings from our study showed that heel offloading significantly increased sacral pressure, regardless of the presence or absence of a sacral multilayered silicone foam dressing. This finding suggests that offloading the heels might increase the risk of sacral pressure injury if additional measures are not taken. Our findings also suggest that sacral multilayered silicone foam dressings do not reduce sacral pressure during heel offloading. The documented benefits of this dressing in terms of deflecting shear forces away from the point of impact, however, suggest that intraoperative nurses should continue applying sacral dressings while using strategies that minimize sacral pressure.[9,10,12,17,18]

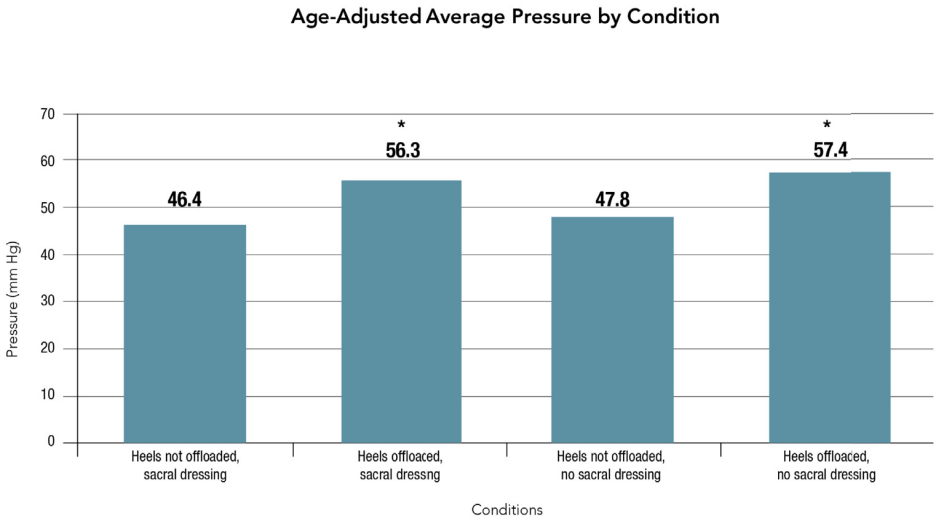

Figure 1. Age-adjusted average pressure by condition. Asterisks indicate a significant result at $P < .001$.

According to AORN's Prevention of Perioperative Pressure Injury Tool Kit,[27] three principles guide pressure reduction: reduce, relieve, and redistribute. Perioperative nurses should be diligent in implementing risk reduction strategies throughout the perioperative period. Measures to relieve pressure during surgery for patients in the supine position may include intermittent repositioning of the legs to relieve sacral pressure and using and alternating pressure redistribution OR surfaces, such as thermoactive foam pads or gel pad overlays.[27] A recent study reported that gel surfaces provided significantly greater protection against sacral pressure injuries compared with multilayered silicone foam dressings in critically ill patients.[28] To prevent heel pressure injuries without increasing the sacral pressure associated with heel offloading, perioperative nurses may consider applying multilayered silicone foam dressings to the heels. Miller et al[29] reported that applying multilayered silicone foam dressings to the heels resulted in significantly lower heel interface pressure and suggested the use of heel dressings to reduce the risk of heel pressure injuries.

In our study, age was a statistically significant predictor of pressure regardless of presence or absence of heel offloading and sacral dressing. Bhattacharya and Mishra[30] reported that pressure injuries are common among older individuals and listed age-related loss of soft-tissue padding as a possible contributor. Aging is associated with thinning of the skin and loss of the protective fat layer that serves as a natural pressure-reducing cushion.

Limitations of the Study

We used a sample of healthy volunteers who were fully conscious; average and peak sacral pressure in response to heel offloading may be different in anesthetized patients. Other researchers, however, found no difference in peak interface pressure between anesthetized patients and healthy volunteers.[24]

RECOMMENDATIONS FOR PRACTICE

Our data show that offloading patients' heels from the OR bed increases the pressure exerted on the sacrum. Although our results suggest that applying a multilayered silicone foam dressing to the sacrum does not decrease sacral pressure, this dressing has been shown to reduce the incidence of pressure injuries by protecting the skin from shear forces and improving the skin's microenvironment.[9,10] Accordingly, its use as a prophylactic measure is recommended.[7,8,17,18]

RECOMMENDATIONS FOR EDUCATION

Patients may be transferred between multiple care areas throughout their hospitalization; thus, it becomes more difficult for all nurses to take personal ownership of HAPI prevention. Intraoperative nurses need to shift their thinking, assessment, and actions based on a continuum approach. They also should be aware of how risk factors directly related to the OR (eg, length of surgery, type of surgery, blood loss, hypothermia, anesthetic agents) combine with other risk factors (eg, malnutrition, diabetes) to increase HAPI risk. Nurses also should be aware of the effect that redistributing pressure and offloading pressure areas may exert on other areas of the patient's body.

RECOMMENDATIONS FOR FUTURE RESEARCH

This study has demonstrated a significant increase in sacral pressure in healthy volunteers with various body

sizes in response to offloading heels. Future research should explore strategies to relieve heel pressure without increasing sacral pressure. Moreover, additional retrospective research should be conducted to determine the effect of heel offloading on actual sacral pressure injury formation for surgical patients in the supine position to determine whether increased sacral pressure resulting from heel offloading translates to increased incidence of sacral pressure injuries.

CONCLUSION

Given the risk of heel pressure injuries, AORN and NPUAP recommend offloading the heels from the OR surface in patients undergoing supine surgical procedures.[7,8] We performed this study to determine the effect of such offloading on sacral interface pressure. Our results suggest that offloading the heels can increase sacral pressure. Strategies to minimize sacral pressure in the perioperative patient population are warranted.

Editor's note: *XSENSOR is a registered trademark of the XSENSOR Technology Corporation, Calgary, Alberta, Canada.*

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