The Use of Pressure Mapping: An Educational Report

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ABSTRACT

A pressure ulcer/injury (PU/I) is caused by multiple factors with sustained pressure being the major contributor to its development. This pressure may be measured by a health care provider using a pressure mapping device in order to assess pressure distribution properties of surfaces used. This educational article describes a general overview, the value, how to perform, and how to incorporate pressure mapping into clinical practice. Also included is an exemplar of a nurse and a physical therapist using pressure mapping to identify the best surface and position for a wheelchair-bound patient in order to minimize PU/I risk.

KEY WORDS

pressure ulcer, pressure injury, pressure mapping, pressure redistribution

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A pressure ulcer/injury (PU/I), once termed decubitus ulcer, pressure sore, and bedsore, is a local area of skin and underlying tissue damage that usually occurs over a bony prominence.[1] Despite the term *pressure* to describe skin damage, the etiology of a PU/I[2] is multifactorial and is not solely dependent on interface pressure. However, prolonged pressure or pressure in combination with shearing forces while the patient is lying in bed or sitting in a wheelchair contribute to the development of a PU/I.[1,3]

Current practice guidelines for PU/I prevention include redistributing or offloading of the surface pressure, preventing shear and moisture, and providing adequate nutritional support.[1] Despite current interest in PU/Is and advances in science and medical care, PU/Is remain a major cause of morbidity and mortality.[1,4] Therefore, prevention of PU/Is is paramount to maintaining maximum function for patients with temporary or permanent mobility issues.

Skin assessment can provide a superficial assessment of external tissue load and determine the amount of friction and trauma to the external tissues. While friction, moisture, and trauma originate in the skin, deep tissue injuries (DTIs) that may evolve into stage 3, 4, or unstageable PU/I originate in the deeper tissues.[5] Currently, no tool exists to measure the deep tissue pressure or perfusion.

Research[6] shows capillary blood flow with normal blood pressure measures about 32 mm Hg. At the point the surface pressure exceeds the capillary pressure, perfusion is potentially compromised. In addition, when blood pressure drops, one could conclude that the capillary blood flow also would drop, thus decreasing perfusion to areas with sustained surface interface pressure exceeding 32 mm Hg.[5,6] This is supported by research[5] conducted by the present authors in which they found a strong quantitative relation between low blood pressure (diastolic < 49 mm Hg) and the development of DTIs that evolved into stage 3, 4, and unstageable PU/Is within an acute care hospital in the intensive care unit setting. Although no conclusive clinical threshold for interface pressure and its contribution to the development of a PU/I has been found, pressure mapping is available to measure the surface interface pressure and how pressure is redistributed in order to keep the surface pressure at the lowest possible measurement and the largest surface contact area.

PRESSURE MAPPING OVERVIEW

Pressure mapping is a noninvasive, objective, and reliable way to measure the surface interface pressure and pressure redistribution.[3-7] The surface interface pressure is measured as both peak and average pressures between the body and the surface. The peak surface interface pressure is the highest pressure over a small contact area (usually over bony prominences). The average surface interface pressure is calculated by the computer and depicts the full-body surface average interface pressure. The pressure redistribution is the peak pressures over a small area being dispersed or redistributed over a larger area in order to relieve higher pressure areas.[8,9] To better understand the concept of surface interface pressure and redistribution, consider the site comparison of a stiletto shoe with a running shoe. While a person in a stiletto will weigh the same amount when wearing a running shoe, the surface interface pressure in the stiletto will mainly be concentrated

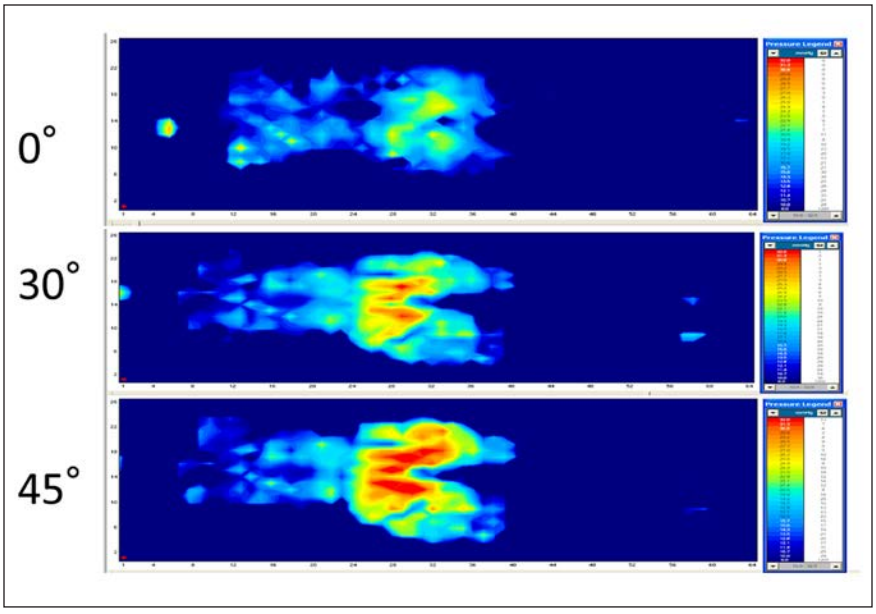

Figure 1. Pressure mapping of a patient on a standard hospital mattress with the head on the left and the head of bed (HOB) flat at 0°, 30°, and 45°. The color gradient scale shows the highest peak pressures in red and lowest peak pressures in dark blue. With the HOB flat, the pressures over the sacrum and buttocks is lower than the 32 mm Hg per the setting. As the HOB was raised to 30° and then to 45°, the peak pressure rose and one can imagine shearing with the red linear appearance.

in the forefoot area; in the running shoe, the weight will be distributed more evenly across the entire sole of the foot.

Pressure mapping involves the measurement of interface pressure and pressure redistribution using a high-tech, semiconductor sensor technology to quantify and visualize the pressure between 2 contacting objects (the individual and the surface). The pressure mapping mat is placed between the person to be measured and the surface to be tested. To allow acclimation, the person needs to be centered on the mat for 5 minutes before recording measurements. The goal is to find the lowest possible peak pressures (< 32 mm Hg) and the largest body surface contact area between the person and the surface being tested. Some pressure mapping systems provide both color and measurement in millimeters of mercury (mm Hg) for peak and average pressures and for body surface contact area in centimeters squared (cm^2), whereas some provide a color image alone. The measured pressure from sensors is transmitted as a reading in millimeters of mercury and accompanied by a color image on a computer screen. Areas depicting red are considered to be *hot spots* or high-interface pressure and the blue areas are the areas of the least amount of pressure. Simultaneously, the sensors transmit body surface contact area in centimeters squared. The outline of the individual (pressure redistribution) is seen clearly on the screen images.[10,11]

The positioning can be changed to determine if a change in position or weight load will remove the dangerous or hot spots of high pressure. The highest pressures are found primarily over bony prominences, such as the ischial tuberosity, the coccyx, the sacrum, the scapula, occiput, and heels. This is especially useful for assessing the pressure changes during functional activities, such as self-propelling a wheelchair, rolling in bed, and elevating the head of the bed to eat. For example, **Figure 1** depicts pressure mapping of an individual on the same surface but flat, head of bed (HOB) at 30°, and HOB at 45°. This image shows how increasing the HOB can increase the pressure and shearing forces on the buttocks and sacrum.

VALUE OF PRESSURE MAPPING

Pressure mapping technology is used primarily in research but has become an integral part of clinical assessment for providers in order to provide individualized care and education for patients. Results from pressure mapping provide reliable and quantifiable evidence in order to make informed decisions for both bed and seating surface selection.[3,12,13] In order to provide PU/I prevention or to minimize the risk, it is important to choose the best pressure redistribution surface specific to each patient.[1]

In cases of an existing PU/I, pressure mapping is an important part of the treatment plan. While most wounds heal rapidly (4 weeks–12 weeks depending on wound size, location, and patient's general health), PU/I do not heal in a timely manner due to ongoing pressure.[1,7] Therefore, treatment options for PU/Is must always involve pressure redistribution or complete relief.

The pressure mapping results also provide specific information to communicate quantitative results and display, record, and share those results with patients and families for positioning (to redistribute pressure). Sharing the results and developing a plan of care with patients and families can positively influence patient engagement,[14,15] PU/I prevention, and wound healing (as shown in the **Case Example** section).

GOALS OF PRESSURE MAPPING

The overall goal of pressure mapping is to choose the surface with the best pressure redistribution properties specific to each patient's body mechanics and morphology. In order to achieve the overall goal, the following tasks should be implemented:

1. Evaluate and assess an individual patient's functional abilities, personal preferences, and lifestyle issues regarding mobility and wheelchair issues.
2. Perform a physical assessment to determine flexibility, range of motion, and optimal postural alignment.
3. Pressure map each individual on different surfaces to assess pressure redistribution properties and positioning and provide color photos

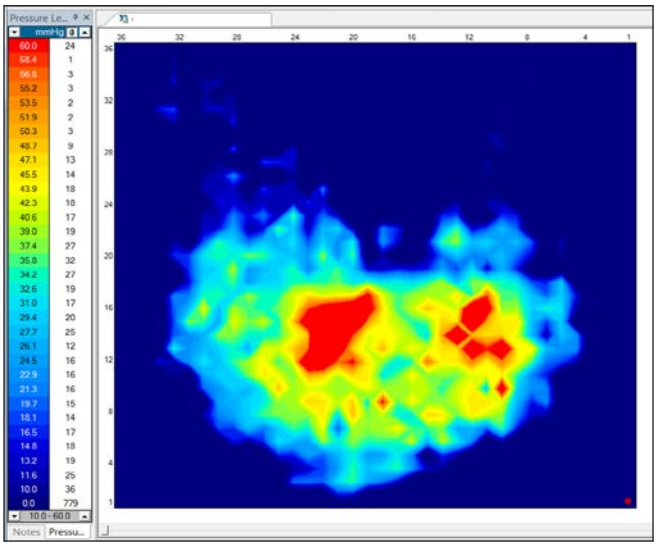

Figure 2. A patient seated on a static air cushion in her usual position in a wheelchair (her legs at the 12 o'clock position). Note the greater peak pressures (depicted in red) over the left ischium more than the right ischium.

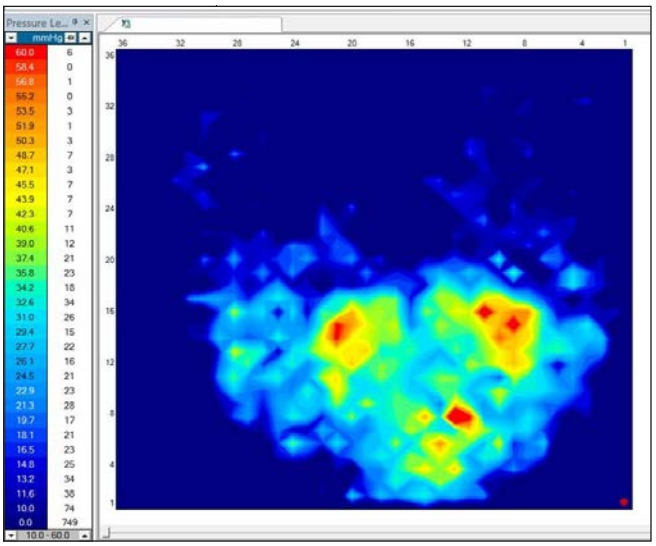

Figure 3. A patient seated on a static air cushion in a reclining wheelchair position. Note how the high-pressure areas decreased when she was readjusted into a slightly reclined position.

of pressure mapping outcomes for follow-up appointments and caregiver education.

4. Work closely with vendors, clinicians, and family members/caregivers to recommend the best seating surface and mattress that meets the patient's specific needs for redistribution.

SURFACE SELECTION

Beds

Patients with prolonged time lying on beds, gurneys, operating room tables, or for prolonged interventional procedures are at an increased risk of developing a PU/I.[8] As such, all surfaces in hospitals should be pressure mapped for comparison of surfaces to meet the patient's specific needs and surface selection that provides the best redistribution properties.

Chair or wheelchair seating

Due to immobility, shear, friction, and moisture, patients who use wheelchairs are at risk for developing complex PU/Is.[16] Complete avoidance of the seated position is not an option, as the seated position facilitates communication, mobility, toileting, and nutritional intake. In addition, being seated allows relief from immobility in the bed (with its risks) and improves overall psychological health.[17]

The selection of the optimal seated position to maximize the functional benefits noted previously will need to be balanced with the risks associated with the patient's medical condition. The wheelchair seat cushion must properly redistribute pressure to prevent skin breakdown, while allowing for the greatest amount of independence in function and mobility.[3,18]

HOW TO INCORPORATE PRESSURE MAPPING INTO PRACTICE

Use of a multidisciplinary wound team (MDT) has long been recognized as beneficial to efficiency of care, patient care satisfaction, and outcomes.[1] The team may include a plastic surgeon, physiatrist, physical medicine and rehabilitation physicians, advanced practice nurses, certified wound care nurses, physical and occupational therapists (PT/OTs), and orthotists to assess, manage, and educate patients and families/caregivers on wheelchairs, specialized seating surfaces, and transfers.

A wound team with PT/OTs can identify patients who would benefit from pressure mapping and then identify the surfaces that provide the lowest surface interface pressure and best pressure redistribution properties. Therapists on the MDT evaluate the functional information that relates to the patient's life and what activities and functions the patient and caregiver will perform once leaving the hospital. Therapists then can make equipment recommendations for patients, and by using the mapping images, they can justify ordering pressure-relieving cushions, mattresses, and wheelchair parts (eg, elevating arm rests or a tilt in space seating system) that relieve pressure. The PT/OT also may use the pressure mapping with a patient as a biofeedback device. This biofeedback can show patients images of positioning for pressure redistribution and aid with training the patient and caregiver on how to use the pressure-relieving equipment and implement pressure relief in real time.

All positions and surfaces should be recorded for documentation in the electronic medical record for analysis and comparison. All imaging and mapping results should be shared with the patient and caregiver to enhance the education on positioning and pressure relief/redistribution.

CASE EXAMPLE

A 34-year-old woman was admitted from a long-term care (LTC) facility with urosepsis. She had a history of C7 spinal

cord injury from a motor vehicle accident 10 years prior. The patient presented to a Northern California academic medical center with bilateral ischial stage 4 PU/Is that had occurred 3 years prior. The patient had spent the last 10 months in a local LTC. Her PU/Is were managed by nurses with wet-to-dry dressings. She was assessed for activities of daily living and found to be dependent on a manual wheelchair with an air-filled seat cushion. She presented with contractures leaning to the left. The PT/OT and wound care nurse evaluated the patient for mobility, transfer techniques, and seating position. She was pressure mapped on 2 different seat cushions for pressure redistribution. The seat cushion with the lowest interface pressure and largest surface area was selected. Further pressure mapping was conducted and analyzed. The results indicated she had the greatest peak pressure over left ischial as compared to the right (**Figure 2**). The high-pressure areas were decreased when the patient was readjusted into a slightly recline position (**Figure 3**). After this assessment, the PT/OT recommended a specific seating surface with a reclining seating protocol. Nursing staff and the patient were educated on the pressure mapping results and the recommended care. The patient returned to her LTC with documented pressure mapping results, photos, and seating recommendations.

CONCLUSIONS

Although no conclusive clinical threshold for interface pressure and its contribution to the development of PU/Is has been found, pressure mapping is available to measure the surface interface pressure and determine how pressure is redistributed. However, nurses and PTs/OTs can use pressure mapping in order to find the surface that provides the best pressure redistribution for patients in bed or in wheelchairs for PU/I prevention.

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