

Support Surface Technology

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University of Pittsburgh, Pittsburgh, PA
October 2000

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A Virtual Slide Lecture
from the website of Wheelchair University
(<http://www.wheelchairnet.org/>)

A project of the Rehabilitation Engineering Research Center
(RERC) on Wheeled Mobility
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Objectives

- Define the characteristics of support surfaces that affect tissue integrity
- Classify support surface technologies
- Relate characteristics of support surfaces to their effect on tissue integrity and pressure ulcer prevention

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Prolonged external pressure over bony prominences has long been identified as the primary etiological factor in pressure ulcer development. Other related causative factors include the magnitude of shear and friction forces and the additive effects of temperature and moisture. Each of these factors can be affected by and are related to the characteristics of the support surface. However, it is clear that while extrinsic factors such as temperature, moisture and mechanical characteristics are critical to the development of pressure ulcers, factors intrinsic to the patient's skin and its supporting structures, vasculature or lymphatics also play a significant role in a patient's susceptibility to these factors. In this presentation I concentrate on relationships between support surface characteristics and their effects on pressure ulcer prevention. The characteristics discussed are pressure distribution, shear, temperature control, and moisture control. These characteristics are related to classifications of support surfaces: elastic, viscoelastic, fluid-filled, low air loss, air-fluidized, and alternating pressure.

Support surface characteristics

- Pressure distribution
- Shear (and friction)
- Temperature control
- Moisture dissipation

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Classifications of Support Surfaces

- Elastic foam
- Viscoelastic foam
- Fluid-filled
- Air fluidized
- Low air-loss
- Alternating pressure

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Pressure distribution

- Pressure is force per unit area (stress)
- Forces acting along the skin surface cause shear

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In the context of support surfaces, pressure is considered to be the force per unit area exerted on the body by a mattress, seat cushion, or other body support. In engineering terms, this quantity would be referred to as normal stress. The component of the force exerted on the skin acting along the skin surface can produce what is commonly referred to as shear and will be discussed subsequently. The distribution of pressure on a seat cushion or mattress depends on the relative fit between the body and the support surface, the mechanical characteristics of the body tissues and the cushion or mattress, and the distribution of weight in the body.

The ideal pressure distribution would be one where the soft tissue was not deformed relative to its unloaded condition (Chow, 1978; Levine, 1990; Brienza, 1993). Such a condition would minimize many of the effects believed to lead to the development of pressure ulcers. These effects are capillary blood flow occlusion (Kosiak, 1961; Reswick, 1976; Daniel, 1981), impairment of lymph flow, and excessive interstitial fluid flow (Reddy, 1981a; Mak, 1994). The precise underlying mechanism for cell damage has not been determined. However, since pressure distributions with low peak pressures and low pressure gradients likely minimize each of the presumptive harmful mechanisms leading to pressure ulcers, it is reasonable to strive for loading conditions with these characteristics.

What influences pressure distribution?

- Mechanical and physical characteristics of the support surface
- Mechanical characteristics of the body tissues
- Weight distribution

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The ideal support condition described could only be achieved in zero gravity situations or when the body is suspended in a liquid. In these loading situations, the pressure distribution is uniform across the entire body surface. Such situations are unrealistic with support surfaces for obvious reasons. The best possible pressure distribution on a support surface would be one in which peak pressure and magnitude of pressure gradient are both minimized. The location of the high pressure and high pressure gradients would also seem to be of some importance given the high incidence of pressure ulcers near bony prominences. It is logical to strive to avoid high pressure in these areas.

Pressure distribution - support surface characteristics

- Potential for immersion
- Envelopment characteristics
- Effect on pressure gradient

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Pressure distribution - Potential for immersion

- Immersion allows redistribution of pressure near bony prominences
- Force-deformation characteristics and physical dimensions affect potential for immersion



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The most fundamental strategy for reducing pressure near a bony prominence is to allow the prominence to be immersed into the support surface. Immersion allows the pressure concentrated beneath the bony prominence to be spread out over the surrounding area. Immersion also increases the potential for body weight to be shifted to areas around other bony prominences. For example, when a person is sitting on a relatively hard cushion, a disproportionately large portion of the body weight is born by the tissue beneath the ischial tuberosities. On a softer surface, the protrusions of the ischial tuberosities become immersed in the cushion and weight is distributed to the area beneath the greater trochanters. With this greater immersion, the body weight is divided between these additional bony prominences and pressure is decreased. This definition of immersion does not distinguish between immersion resulting from compression of the support surface and immersion resulting from the displacement of a support surface's fluid components.

The potential for immersion depends on both the force-deformation characteristics of the cushion and its physical dimensions. For fluid-filled support surfaces, immersion would depend on the thickness of the surface and the flexibility of the cover. For elastic and viscoelastic support surfaces, the potential for immersion depends on their stiffness and thickness. Consider how the thickness of a seat cushion might limit the potential for immersion. If the thickness of a seat cushion is 1 1/2 in. and the vertical distance between the ischial tuberosities (ITs) and greater trochanters is 2 inches, the potential for immersion is not large enough to unload the ITs.

Pressure Distribution - Envelopment

- Envelopment describes the support surface's ability to deform around irregularities without causing a substantial increase in pressure
- Typical irregularities:
 - Clothing
 - Bedding or covering materials
 - Bony prominences

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A support surface's ability to envelop describes its ability to deform around irregularities on the surface without causing a substantial increase in pressure. Examples of irregularities are creases in clothing, bedding or seat covers, and protrusions of bony prominences. A fluid support medium would envelop perfectly. However, surface tension plays an important role in envelopment. A fluid-filled support surface such as a waterbed would not envelop as well as water alone. The membrane containing the water has surface tension. The surface tension has a hammocking effect on irregularities of the interface. Poorly enveloping support surfaces may cause locally high peak pressures that could increase the risk of tissue break down.

Pressure distribution - Pressure gradient

- Pressure gradients are pressure differentials
- Pressure differentials necessarily cause flow of the tissues fluid components from areas of higher pressure to areas of lower pressure
- Flow of interstitial fluid might increase the likelihood of intercellular contact and result in cellular ruptures
- Some investigators theorize that pressure gradient is the factor in the development of pressure ulcers (Krouskop, 1983; Reddy, 1981)

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Pressure gradient describes the amount of change in pressure over a distance. If the pressure across a surface were plotted, the pressure gradient would be the slope of the curve. Since the skin and other soft tissues at risk of breakdown consist of a mixture of fibrous collagen network, interstitial fluids, blood vessels, lymphatic vessels, and other elements, a pressure differential between adjacent regions will result in a flow of the tissue's fluid elements from one region to the other. Several investigators have hypothesized that the flow of interstitial fluid caused by pressure gradients is the primary factor in the development of pressure ulcers (Krouskop, 1983; Reddy, 1981). The flow of interstitial fluids from an area of high pressure is believed to increase the likelihood of intercellular contact resulting in cellular ruptures (Mak, 1994; Crenshaw and Vistnes, 1989; Krouskop, 1983; Reddy, 1981). This theory is consistent with the classic experimental results of Kosiak (1959), Daniel, Reswick and Rogers showing a relationship between duration of pressure application and the magnitude of pressure that results in the formation of a pressure ulcer.

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Pressure gradient is intimately linked to pressure and is affected by immersion and envelopment in a similar manner. Although, under certain circumstances, it is possible to have high pressure gradients without high pressure, and vice-versa. For example, at the boundary of the contact area on a support surface there is necessarily a significant pressure gradient where the pressure magnitude transitions from zero outside the area of support to a non-zero value in the supported region. Despite these relatively high gradients, these boundary areas are typically areas of lower risk for pressure ulcer development. This suggests that pressure gradient only becomes an important factor when combined with high pressure. Research is necessary to test and investigate this hypothesis.

Shear (and friction)

- Shear (strain) is the deformation of tissue in the horizontal direction
- Example - when the head of the bed is raised or lowered
- Friction is the force that opposes shear force
- Maximum friction is determined by the coefficient of friction of the support surface and the pressure

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The term *shear* is commonly used to refer to the effect of a loading condition in which the skin surface remains stuck to a support surface while the underlying bony structure moves in a direction tangential to the surface. For example, when the head of a bed is raised or lowered, if the skin over the sacrum does not slide along the surface of the bed or the bed does not absorb the resulting shear force by deforming in the horizontal direction, the effect will be a shearing of the soft tissue between the sacrum and the support surface (Reichel, 1958). In engineering terms, the resulting shearing or deformation of the soft tissue would be referred to as shear strain. The characteristics of the support surface affecting this potentially harmful situation are the coefficient of friction of the surface and its ability to deform horizontally. Certain support surface technologies protect the skin from shear better than others do.

Friction is a tangential force acting at the interface that opposes shear force. In a static condition where the skin is not sliding along the support surface, the friction is equivalent to the shear force. The maximum friction is determined by the coefficient of friction of the support surface and the pressure. This is why surfaces with high coefficients of friction have the potential for high shear.

We need friction!

- Prevents sliding
- Friction and shear are local phenomena - Pressure ulcer prevention is enhanced if friction is minimized near bony prominences

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Some friction is necessary to prevent a person from simply sliding off the support surface in situations such as sitting in bed or in a wheelchair. However, friction and shear are local phenomena. For optimal prevention of pressure ulcers, the friction necessary to prevent sliding should be applied in low risk regions of the support surface and minimized near high risk areas surrounding bony prominences.

Temperature control

- The effect of temperature has not been definitively investigated
- Higher ambient temperatures cause increased metabolism and oxygen consumption (Brown, 1965)
- Repetitive loading alone causes elevated skin temperature (Vistnes, 1980)
- Peak skin temperatures are proportional to magnitude and duration of applied pressure

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The conclusions of research vary depending upon the amount and duration of pressure that is simultaneously applied with varying temperatures (Patel, 1999; Kokate, 1995). However, higher ambient temperatures have been shown to cause an increase in tissue metabolism and oxygen consumption on the order of 10% for every one degree Celsius (Brown, 1965). Thus, the oxygen requirements of high risk patients who already possess compromised tissue may be increased. Any increase in temperature in combination with pressure is believed to increase the susceptibility of the tissue to injury either from ischemia or reperfusion when pressure is relieved . The application of repetitive surface loading alone also induces an elevated skin temperature of 5° C or greater (Vistnes, 1980). In addition, peak skin temperatures have been found to be proportional to the magnitude and duration of the applied pressure .

Temperature control continued

- Effect of temperature on perfusion
 - increase in perfusion with increased temp at pressure below 50 mmHg (Patel, 1999)
- Increase temperature caused increase in stiffness, thus decreased in deformation
- Kokate's (1995) results showed increased temperature caused tissue injury

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In rat or man, increased temperature causes an exponential increase in blood perfusion. Increased perfusion in humans has been associated with an increase in core body temperature as well as in local skin temperature. Patel et al. studied the effect of temperature and pressure on perfusion in fuzzy rats and found that there was a significant increase in perfusion with increased temperature at surface pressures below 50 mmHg. This result was attributed to a local autoregulatory mechanism. In addition, increased temperature caused skin to become stiffer in response to increased surface pressure with resultant decreases in deformation and creep. Thus, by warming the fluid (air or other viscous material) in support surfaces by several degrees (1-5° C), the induced increase in skin stiffness may be beneficial in preventing tissue breakdown. However, these beneficial temperature effects must be balanced against the increasing metabolic requirements of the tissue.

Effects of Moisture

- Excessive moisture may lead to maceration (Yarkony, 1994)
- Reuler & Cooney theorized that skin damage risk increases 5-fold with moisture (1981)
- Increased risk may be due to increased friction (Sulzberger, 1966)
- Skin tensile strength decreases (Wildnauer, 1971)

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Moisture, along with temperature and the mechanical factors previously mentioned, appears to be another key extrinsic factor in pressure ulcer development. The sources of skin moisture that may predispose the skin to breakdown include perspiration, urine, feces and fistula or wound drainage. Excessive moisture may lead to maceration . Reuler & Cooney theorized that one's risk of skin damage increases fivefold in the presence of moisture . Increases may be due to the slight increase in friction that occurs with light sweating or to the increase in bacterial load resulting when alkaline sources of moisture neutralize the protection provided by the normal acid mantle of the skin.

The detrimental effect of an increase in moisture adjacent to the skin has been demonstrated by tensile tests on excised skin strips in a controlled humidity environment. In Wildnauer's study, the tensile strength of the strips decreased 75% with an increase in relative humidity from 10% to 98% . Skin with such reduced strength may be more prone to mechanical damage from shear stress or abrasion.

Support surface characteristics

- Pressure distribution
- Shear (and friction)
- Temperature control
- Moisture dissipation

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Support Surface Technologies

Classified according to materials
and construction or therapeutic
function

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Numerous options exist for classifying support surface technologies. Here, technologies are classified according to their mechanical characteristics or unique therapeutic function. In practice, most products consist of a combination of materials and incorporate multiple therapeutic strategies. Available seating products generally fall into the categories of compressive support mediums (elastic foam and viscoelastic foam), fluid-filled, and alternating pressure. Available bed support surfaces also fall into the same categories with the addition of air-fluidized and low air loss. In this section, we describe the characteristics of products falling into the various categories and discuss their performance relative to their pressure distribution, shear, temperature and moisture control. Examples of representative products falling into these are given in Table 1. This list is included to illustrate the types of products included in the categories and is not intended to be comprehensive.

Classifications of Support Surfaces

- Elastic foam
- Viscoelastic foam
- Fluid-filled
- Air fluidized
- Low air-loss
- Alternating pressure

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Elastic foam

- An elastic material deforms in proportion to the pressure
- Elastic foam has “memory” due to its tendency to return to its unloaded shape
- Resilient foam is frequently combined with other materials to enhance its performance

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An elastic material deforms in proportion to the applied load: greater loads result in predictably greater deformations and vice versa. If time is a factor in the load versus deformation characteristic, then the response is considered to be viscoelastic, which will be discussed separately. The response of support surfaces made from resilient foam is predominately elastic. Foam support surface products are made from two basic types of foam—open cell or closed cell. Foam is said to have “memory” because of its tendency to return to its nominal shape or thickness. Bryant suggests that the minimum density or weight per cubic foot of the bed support surface material should be 1.3 to 1.6 pounds and convoluted foam should have a minimum of 4 inches from the bottom of the foam to the lowest point of the convolution to achieve the optimal pressure reducing effects of the material.

Foam products frequently consist of foam layers of varying densities or combinations of gel and foam. Other products have a series of air-filled chambers covered with a foam structure or are available as multi-density closed cell products, 4-10 inches deep with deflectable tips. For these types of products, “memory” is not total because only the foam components will return to their unloaded shape. Several seat cushion products have this construction. The advantage of support surfaces with a combination of fluid-filled bladders and resilient foam would be to provide a degree of postural stability with a resilient shell and improved envelopment with a fluid or viscous fluid-filled layer at the interface.

Elastic foam



Geo-Mattress® Series
Therapeutic Foam Mattress

SEAN AMERICAN MEDICAL SYSTEMS, INC. | [Medical Products](#)

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Advantages and disadvantages of elastic foam

- Bottoming resistance is predictable
- Stiffness decreases over time, depending on use
- Envelopment characteristics and potential for immersion need to be balanced

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An ideal combination of characteristics for an elastic support surface would be resistance that also adjusts to the magnitude of compressive forces . The support surface should have a high enough compression resistance to fully support the load (prevent bottoming-out) without providing too high a reactive force (memory) to keep interface pressure low. Over time and with extended use, foam degrades and loses its stiffness. This decreased ability results in higher interface pressures. Krouskop estimates that in approximately three years, the mattress wears out and the compressive forces are transferred to the underlying supporting structure used to support the foam . In other words, the mattress “bottoms out”.

Foam is limited in its capability to immerse and envelop by its stiffness and thickness. Soft foams will envelop better than stiffer foams, but will necessarily be thicker to avoid bottoming out. Foam seat cushions are frequently contoured to improve their performance. Pre-contouring the seat cushion to provide a better match between the buttocks and the cushion increases the contact area thus reducing average pressure; pre-contouring also increases immersion and envelopment properties thus decreasing pressure peaks (Sprigle, 1990; Brienza, 1996; Brienza, 1998).

Heat transfer characteristics of foam

- Foam tends to increase skin temperature
- Cover has a significant effect on heat transfer characteristics
- Nicholson (1999) found that transfer rates for covered foam mattresses were less than half compared to mattresses w/o covers

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Foam tends to increase skin temperature because foam materials and the air they entrap tend to be poor conductors of heat. Nicholson *et al.* determined that the heat transfer characteristic of foam mattresses were less than the normal physiological resting heat losses—up to 244 W/m² heat loss (Nicholson, 1999). Nicholson also compared the heat transfer rates for mattresses with and without their covers and found rates for mattresses with covers were less by nearly half compared to heat transfer rates for mattresses without covers.

Moisture control characteristics of elastic foam

- Cover characteristics influence water vapor transfer rates (Nicholson, 1999)

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On foam products with porous covers, moisture doesn't increase as much as on most foam since the open cell structure of the covers provides a pathway through which moisture can diffuse. Nicholson showed that water vapor transfer rates were reduced by more than half when foam mattresses were covered with non-stretch and two-way stretch covers (Nicholson, 1999). Patient movement can increase transfer rates. Mean temperature increases of 3.4 degrees C and a 10.4% increase in moisture at the skin surface have been recorded by Stewart on foam products after one hour of contact .

Viscoelastic foam

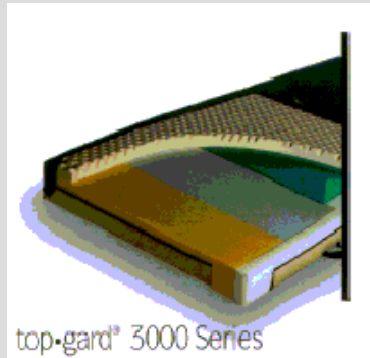
- Viscoelastic foams are 100% open cell foam that is temperature sensitive.
- Viscoelastic foam becomes softer at operating temperatures near body temperature.
- The effect of the softening is improved envelopment compared to resilient foam.
- A disadvantage is that the desirable softening effect may not be realized when conditions prevent the foam from warming.
 - Eg., when clothing insulates the body or when ambient temperature is too low.

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Viscoelastic foam products consist of viscoelastic, 100% open cell foam that is temperature sensitive. The foam becomes softer at operating temperatures near body temperature. The effect of this softening is that the layer of foam nearest to the body provides improved pressure distribution through envelopment when compared to high resilient foam. The viscoelastic foam acts like a self-contouring surface because the elastic response diminishes over time, even after the foam is compressed. The disadvantage of the temperature and time sensitive response is that the desirable effects may not be realized when the ambient temperature is too low. The properties of viscoelastic foams vary widely and must be chosen according the specific needs of the patient for both seat and mattress applications.

Viscoelastic foam



GAYMAR®

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Gel products

- Gel products are also viscoelastic in nature
- Gel products, however, tend to maintain skin contact temperature or cause it to decrease
 - Stewart (1980) showed that gel products have a higher specific heat capacity than foam, but that heat transfer decreased after 2 hours
- Since gel is non porous, water vapor transmission is limited
 - In Stewart's study moisture increased 22.8% over 2 hours

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Solid gel products respond similarly to viscoelastic foam products and are included in the category.

Mean temperature increases of 2.8 degrees C have been reported for viscoelastic foam . Gel products tend to maintain a constant skin contact temperature or may decrease the contact temperature. Gel pads have higher heat flux than foam due to the high specific heat of the gel material. However, in Stewart's study the heat transfer decreased after 2 hours indicating that the heat reservoir was filling. This suggests that the temperature may increase during longer periods of unrelieved sitting (>2 hours). Stewart also found that moisture increased 22.8% over a one-hour period. The relative humidity of the skin surface increases considerably because of the nonporous nature of the gel pads.

Fluid-filled support surfaces

- Fluid filled surfaces consist of small or large chambers filled with air, water, or viscous fluid
- Fluid flow from chamber to chamber or within a single chamber in response to pressure differentials (pressure gradients)
 - “air flotation” support surfaces such as those manufactured by Roho, Inc. are included in the fluid-filled category

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Fluid-filled products may consist of small or large chambers filled with air, water or other viscous fluid materials such as silicon elastomer or silicon or polyvinyl. The fluid flow from chamber to chamber or within a single chamber is passive in response to movement and requires no supplemental power. The term “air-flotation” is sometime used to describe interconnected multi-chamber surfaces such as those manufactured by ROHO, Inc. For air cushions, care must be taken to maintain the correct levels of inflation in order to achieve optimal pressure reduction. Under-inflation causes bottoming-out and over-inflation increases the interface pressure. For viscous fluid-filled seating surfaces like the Jay2 seat cushion (Sunrise Medical, Inc.) it is important to monitor the distribution of viscous material and manually move it back to the areas under bony prominences if it has moved away from these areas.

Fluid-filled support surfaces



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Pressure distribution in fluid-filled surfaces

- Most fluid-filled surfaces permit a high degree of immersion
- Immersion reduces pressure peaks by increasing surface area
 - Wells (1998) found that the RIK mattress had pressure relief characteristics similar to air fluidized and low air-loss technologies
- Fluid filled products generally have very good envelopment characteristics

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Most fluid-filled products permit a high degree of immersion allowing the body to sink into the surface with the surface conforming to bony prominences. This effectively increases the surface pressure distribution area and lowers the interface pressure by transferring the pressure to adjacent areas. These products are capable of achieving small to modest deformations without large restoring shear forces. In a direct comparison of interface pressures with air-fluidized (Clinitron™, Hill-Rom, Inc.) and low air loss (Therapulse®, Kinetic Concepts International) beds, the RIK® mattress was shown to relieve pressure as effectively as the aforementioned technology .

Temperature characteristics of fluid-filled surfaces

- Temperature is affected by the specific heat of the fluid material contained in the support device
- Air has a low specific heat
- Water has a high specific heat
- Viscous fluid material in RIK mattresses has a high specific heat and has been shown to reduce skin temperature (Wells, 1998)

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Skin temperature is affected by the specific heat of the fluid material contained in the support device. Air has a low specific heat (limited ability to conduct heat) and water has a high specific heat (greater capacity to increase heat flux). The viscous material used in the RIK® mattress also has a high specific heat and skin temperature decreases have been demonstrated with this product .

Moisture control of fluid-filled products

- Difficult to generalize due the large variety of covers
- Stewart showed increases in relative humidity due to the insulating characteristics of rubber and plastic in some fluid -filled products (Stewart, 1980)

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Given the large variety of materials used as covers in products falling into the fluid-filled category it is difficult to generalize on the moisture control characteristics. However, the insulating effects of rubber and plastic used in some fluid-filled products have been shown to increase the relative humidity due to perspiration .

Air-fluidized support surfaces

- Consist of silicon (glass) beads encased in a polyester or Gore-Tex® sheet
- Beads exhibit fluid characteristics when warm, pressurized air is forced up through them
- Fluidization is variable on some models to adjust for individual needs

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Air-fluidized beds have been available since the late 1960's and were originally developed for use with burn patients. These products consist of ~2,000 lbs. of silicon (glass) beads (75-150 μm) encased in a polyester or Gore-Tex® sheet. The beads take on the characteristics of a fluid when warm pressurized air is forced up through them. In some models (FluidAir™, KCI) the fluidization feature is variable which permits individualization based on needs and aids in the reduction of evaporative water loss. Feces and other body fluids flow freely through the sheet. In order to prevent bacteriologic contamination, the bed must be pressurized at all times and the sheet must be properly disinfected after use by each patient and at least once per week with long-term use by a single patient .

Air-fluidized support surfaces



CLINITRON® RITE-HITE® Air
Fluidized Therapy Unit

Hill-Rom.
A HILLENBRAND COMPANY

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Immersion in air-fluidized surfaces

- Permit the highest degree of immersion - up to two thirds of the body may be immersed (Holzapfel, 1993)
- Shear forces are minimized by having a loose fitting but tightly woven covering material

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Air-fluidized beds use fluid technology to decrease pressure through the principle of immersion while simultaneously reducing shear. Air-fluidized products permit the highest degree of immersion currently available. The surface conforms to bony prominences by permitting deep immersion into the surface. Almost two-thirds of the body may be immersed into the surface. This effectively lowers the interface pressure by increasing the surface pressure distribution area. The greater deformations possible with this technology enable the transfer of pressure to adjacent body areas and other bony prominences. Envelopment and shear force are minimized by the loose (reduced surface tension) but tightly woven polyester or Gore-Tex cover sheet.

Temperature and moisture characteristics of air-fluidized technology

- Temperature can be controlled by controlling the temperature of the pressurized air
- Water vapor permeable covers permit moisture to be transported away from the patient

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The pressurized air in these products is generally warmed to a temperature level of 28 to 35° C. This warming feature may prove to be beneficial or harmful depending on specific patient characteristics. For example, the heat may be harmful to patients with multiple sclerosis or beneficial for patients in pain. In any case, the beneficial effects must be balanced against the increasing metabolic demands of the tissue.

The high degree of moisture vapor permeability of the system is very effective in managing body fluids. In cases of severe burns, air-fluidized beds have been known to cause dehydration. The variable level of fluidization provided by the FluidAir™ would be advantageous in such cases.

Low air-loss support surfaces

- Low air loss systems consist of a series connected air-filled compartments
- Air pump circulates a continuous flow of air through the device
- Inflation pressures are adjusted based on individual needs - Some systems allow sections to be adjust individually
- Alternating or pulsating low air loss systems are also available that incorporate features of *alternating pressure* surfaces

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Low air loss systems use a series of connected, air-filled cushions or compartments. These cushions are inflated to specific pressures to provide loading resistance based on the patient's height, weight and distribution of body weight. An air pump circulates a continuous flow of air through the device, replacing any air that is lost through the surface's pores. The inflation pressures of the cushions vary with patient weight distribution and some systems have individually adjustable sections for the head, trunk, pelvic or foot areas . One manufacturer offers the ability to individualize each of the compartments rather than just the sections . In addition to static low air loss systems, these products are now available with alternating and pulsating pressure features.

Low air loss systems continued

- The patient lies on a loose-fitting, waterproof cover that is placed over the air cushions
- The waterproof cover allows air and water vapor penetration
- The covers are smooth with a low coefficient of friction to reduce shear

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In low air loss systems, the patient lies on a loose-fitting, waterproof cover that is placed over the cushions. The waterproof covers are designed to have air pass through the pores of the fabric and are usually made of a special nylon or polytetrafluorethylene fabric with high moisture vapor permeability. Manufacturers have addressed the problem of dehydration of the skin by altering the number, size and configuration of the pores in the covers. The material is very smooth with a low coefficient of friction, bacteria impermeable, and easy to clean.

Low air loss mattress



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Low air loss - pressure distribution

- Pressure distribution is managed through immersion
- Adjustable air pressure and/or volume controls immersion until it is limited by the overall thickness

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Low air loss beds use fluid (air) technology to distribute pressure through the principle of immersion. The deeper the immersion, the greater the surface area for pressure distribution. These devices permit adjustment of the air inflation level to increase the immersion and pressure distribution. These devices are capable of achieving moderate to large deformations without large restoring or shear forces.

The volume of air may be adjusted to provide more or less immersion for the body as a whole or for specific sections or even individual chambers or cells. The loose-fitting covers envelop and decrease friction. In fact, care must be taken to avoid sliding patients off the mattress during bed transfers.

Low air loss - temperature/moisture

- Heat transfer is very high, greater than 350 W/m² (Nicholson, 1999)
- The moisture vapor permeability, the air flow and porosity of the cover and cushioning material, and the thermal insulation of the cover together determine the tissue's local environment
- These factors can be managed through proper design and adjustments

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As with other fluid-filled surfaces, the temperature of the skin is affected by the specific heat of the fluid material and air does not have a high specific heat. In addition, the circulating air is warmed. However, the constant air circulation and evaporation tend to keep the skin from overheating. Nicholson showed that heat transfer on a low air loss mattress was greater than 350 W/m² (Nicholson, 1999).

In low air loss systems, the patient's skin is in contact with the cover. The local tissue environment is a function of the moisture vapor permeability of the cover and cushion materials, the air flow and porosity of the cover and cushion materials, and the thermal insulation of the cover. The ideal combination of these factors would be a material with a high thermal insulation to prevent excessive loss of body heat, a high moisture vapor permeability to prevent accumulation of excess moisture on the skin, and a moderate airflow to keep the skin from overheating. In a study by Flam, low air loss cover materials were rated based on a normalized comparison of these parameters. The combination of a cover made from nylon/high air loss Gore-Tex® laminate material and a cushion made from nylon/high air loss Gore-Tex® laminate material had the highest scores and were most likely to promote a favorable local climate at the skin-cover interface. Low air loss devices have been shown to prevent build-up of moisture and subsequent skin maceration.

Alternating pressure support surfaces

- Alternating pressure systems contain air-filled chambers arranged lengthwise, interdigitated, or in various other patterns
- Air is pumped into the chambers periodically to inflate and deflate the chambers
- Pulsating pressure refers to shorter duration inflation and higher frequency cycling

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Alternating pressure systems contain air-filled chambers or cylinders arranged lengthwise, interdigitated, or in various other patterns. Air is pumped into the chambers at periodic intervals to inflate and deflate the chambers in opposite phases thereby changing the location of the contact pressure. Pulsating pressure differs from alternating therapy in that the duration of peak inflation is shorter and the cycling time is more frequent. The latter appears to have a dramatic effect on increasing lymphatic flow .

The concept of alternating pressure for prevention of tissue ischemia is not new. Kosiak concluded in 1961 that "since it is impossible to completely eliminate all pressure for a long period of time, it becomes imperative that the pressure be completely eliminated at frequent intervals in order to allow circulation to the ischemic tissue". Houle's conclusion that a dynamic device that alternately shifts the pressure from one area to another would be "the choice to provide adequate protection against the development of ischemic ulcers" has been supported over the years by many others (Kosiak, 1976; Souther, Carr & Vistnes, 1974; Seymour, 1985; . Rather than increasing the surface area for distribution through immersion and envelopment, alternating pressure devices distribute the pressure by shifting the body weight to a different surface contact area. This may increase the interface pressure of that area during the inflation phase.

Alternating Pressure



SENTRY... Alternating
Pressure Relief
Mattress Systems

•Brienza & Geyer

SenTech
Medical Systems, Inc.



Alternating pressure - pressure distribution

- Alternating pressure systems periodically redistribute pressure to manage pressure rather than providing increased immersion and envelopment
- Research questions remaining concern the geometry of the cells and space between cells, and the nature of the alternating cycle in terms of magnitude, frequency, and pattern of relief.

•Brienza & Geyer, 10/2000



The lack of sufficient study of the tissue responses to alternating pressure leaves many questions regarding this type of support surface. Namely, what are the ideal characteristics of the support surface: geometry of the surface (size/shape of cells and space between cells), material, depth, composition and shape of the supporting structure? Also, what are the ideal characteristics of the alternating cycle (rise time, hold time, duration of total cycle, pattern of relief)?

Classifications of Support Surfaces

- Elastic foam
- Viscoelastic foam
- Fluid-filled
- Air fluidized
- Low air-loss
- Alternating pressure

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