ECRONICON OPEN ACCESS

EC ORTHOPAEDICS
Review Article

Preventing Ischemic Induced Ulcers

Robert H Graebe*

Rehabilitation Engineering and Applied Research Laboratory, Georgia Institute of Technology, USA

***Corresponding Author**: Robert H Graebe, Rehabilitation Engineering and Applied Research Laboratory, Georgia Institute of Technology, USA.

Received: August 29, 2021; **Published:** September 28, 2021

Abstract

Pressure doesn't cause a pressure sore. Divers and under water habitat dwellers can stay for long periods of time submerged in a high-pressure hydro static environment to avoid the long process of out gassing their blood, decompression, to avoid the bends when they return to the surface and normal atmospheric pressures.

When a person arrives at a hospital or an emergency center for whatever reason they most likely have good healthy skin. If they are disabled or immobilized protecting their skin requires selection of a proper support surface to prevent development of an ischemic ulcer.

Keywords: *Ischemic Ulcer; Pressure Sore*

Introduction

Pressure doesn't cause a pressure sore. Divers and under water habitat dwellers can stay for long periods of time submerged in a high pressure hydro static environment to avoid the long process of out gassing their blood, decompression, to avoid the bends when they return to the surface and normal atmospheric pressures.

When a person arrives into a hospital or an emergency center for whatever reason they most likely have good healthy skin. If they are disabled or immobilized protecting their skin requires selection of a proper support surface to prevent development of an ischemic ulcer.

It is the purpose of this discussion to present how a support surface that applies hydrostatic loads minimizes the four pathways to soft tissue necrosis [1]. Cellular death is the result of long time exposure to these pathways.

A person floating in water or on an air cell based cushion, a hydrostatic suspension environment is created and the person experiences only small changes to their shape. Shape change creates deformation-causing ischemia. Shape matching reduces shape change reducing ischemia. The reason there is no deformation when floating in a fluid is equal hydrostatic forces. Flotation is a shear and friction free environment. It is also an unstable environment for posture, position and it is wet and heavy. Observation of fingertips while supporting a clear glass plate shown in figure 1 demonstrates how soft tissues assume the flat shape of the glass. Deformation occurs to those tissues, and they have become blanched an indication that blood has moved away from the deformed tissues a condition of ischemia.

Figure 1: *Showing finger tips holding a pane of plate glass where the finger tips are made flat and blanching has occurred.*

Assessing the patient for their resistance to shape change

Skin and muscle tone offer deformation resistance. Blood pressure also contributes to deformation resistance. Palpation is one means of feeling absence of tone, atrophy, emancipated or loose skin with a visual observation can be used to estimate skin thickness and tensile strength. Blood pressure is a measurable parameter and when low maybe a deformation resistance risk. Those persons having low resistance to deforming forces need special shape fitting support surfaces, a medical necessity, to minimize their risk of developing a decubitus ulcer. When seating a medically dependent person trade offs are made between 1. Maintaining weight bearing tissues viable, 2. Positioning the person and 3. Providing a stable base including a suitable back. Achieving an optimum solution, a moving target, to the patient's benefit is a challenging problem while meeting financial limitations.

Selecting a support surface based on its shape fitting capabilities

All support surfaces develop a summation of counterforces that equal the weight of the person being supported and creates a compressive environment. Contact area with the support surface varies with the person and position of the person being supported. Contact area is greatest with immersion, which is a local adjustment for DRY FLOATATION® [3]; all suspension forces act through the soft tissues and against the nearby skeletal components. Universal shape compliance is an important feature permitting one cushion to be fitted for multiple users.

Resistance to shape change is a tolerance each individual has and degrades with time. Support surface forces act to compress the soft tissues. Compression minimizes edema by forcing interstitial fluids away from the external forces bringing capillaries closer to tissue cells. Reduced local interstitial fluids improve the probability that an efficient metabolic exchange will take place that benefits tissue vi-

ability. Compression with small shape change facilitates healing a wound forcing some interstitial fluid to flow through a near by open wound. External counter forces work to move body fluids much as low negative vacuum forces.

Personal observations of an open wound site when exposed to non-deforming counter forces show that the contacted site becomes wet

Fluids, i.e. water, offer very low levels of resistance through their surface. A fluid contacts, wets, all surfaces of an object no matter how complicated its shape. A traditional way of making a waterbed support surface is to contain water in a bag. The bag introduces resistance, surface tension, to being able to penetrate into the water limiting shape compliance to the shape of the supported object. Adding covers to any support surface increases the tension in their surface, which increases penetration force needed envelop a persons shape. Fluids are made up of molecules having six degrees of freedom. This freedom allows a fluid to completely wet complex shapes and have a low surface tension permitting easy penetration into the fluid. Fluids have shear resistance called viscosity, which is a motion dependent parameter.

Estimating an individual's tolerance to deforming forces

Skin tightness, thickness, muscle bulk and tone provide mechanical resistance. Blood pressure and blood density with blood column height provide hydrostatic pressures producing hydraulic resistance to deforming forces. Choosing a device to support a person, who may be immobilized is limited by what financial coverage that person has. The available choices most likely would be price driven and not performance driven. This forces selection based on how bad can its shape compliance performance is while minimizing the risk of causing an ischemic/decubitus ulcer. Choosing a support surface for a wheelchair bound patient means from a reimbursement view point a five-year product life is expected. To estimate the suspension needs of the patient five years into their future brings about making a worst-case scenario for the tissue viability needs of the patient. If the patient has a SCI the tissue deformation resistance can be expected to decline but no method has been developed to estimate the individual's rate of decline.

Mixing a fresh batch of plaster and placing the person on it before it hardens can achieve a near perfect hydrostatic fit to a person's weight bearing shape. A problem develops when they leave and then try to re-enter. Hard shapes are unforgiving with misalignment on reentering an impossible challenge even for able-bodied sensate persons. This approach to having a perfect shape match when using high molecular weight fluids is not a useful clinical solution to good seating. Portability, lightweight and ease of entry and exit, while maintaining a good fit, and reusable by other persons make for a useful commercial support surface. Envelopment compromises ease of entry and exit but improves prevention of a tissue failure by shape fitting especially for a disabled person [2]. Covers modify envelopment but protect the support surface, which is another trade off between maintaining tissues viable and easier maintenance of the support surface especially when an incontinent person is the occupant. A cover employing two way stretch cloth is provided with each ROHO DRY FLOATATION® cushion to minimize surface tension.

A support surface that complies with shapes, especially severe shapes i.e. the hipbone, can be estimated by thrusting a fist into the device. The support surface should envelop the fist and very little pressure should be felt about the fist. DRY FLOATATION® is a synthesis of the floatation properties that a fluid has.

Those properties are low surface tension, six degrees of freedom, constant restoring forces and low friction. A method of construction to make a support surface is with multiple air cells that are soft flexible and mounted on a base, which has air-restricted passages to provide viscosity and air intercommunication between air cells to provide equal air pressure to all air cells. The tops of each air cell have six degrees of freedom and are free to assume the shape of an object being supported. The tops of each air cell rolls at its of point contact not making a sliding motion. Rolling along the interface with a tissue deficient wound is thought to be beneficial in aiding granulation by not knocking off nodules as they form. Internal air is free to move throughout the device and depending on immersion depth selected, by bleeding off internal air, by opening a valve, until the fingers between the air cell bases and a boney prominence are within about one

to two fingers from the bottom of the support device. The occupant now has a safe working internal air pressure, (Immersion depth). An optional slide valve is used to connect four groups of air cells and when closed pneumatic isolation is achieved. The benefit when the valve is closed is an improvement in stability and when the valve is open a good shape fit is achieved after the immersion/posture selection process is complete the valve is closed. In this operational mode the patient is moved, while the valve is open allowing airflow to maintain and track shape, until a desired position is obtained.

Positioning the posture of an occupant is made with the valve open by moving the occupant to a posture considered proper by the person in charge. A good shape fit is maintained during the positioning operation and when the valve is closed the position/posture is maintained. As time passes and the initial posture selected needs be redone the positioning process is repeated. All adjustments are made while the patient is being supported.

Selection of a commercially available seat cushion

Based on the criteria that shape change is detrimental to the viability of weight bearing tissues then a bench test method of evaluating support surfaces on how well they comply in accommodating a known shape can be designed. Proposed bench test method requires a low temperature warmed plastic sheet used to make splints to be placed on top of the surface to be tested. This plastic sheet is heated to the point that it becomes soft and readily deformable. While in this state, a known shape and its volume are forced into the assembly of support surface and plastic sheet. It is held there until it cools enough to retain the shape created by the object. Filling it the resultant shape with water and then pouring the water into a measuring cup can now measure the volume of the resultant shape, which can be compared to the volume of the known shape and create a non-dimensional ratio.

A comparison between each cushion when tested can give the clinical person a means of choosing the best shape-fitting cushion for the person and their reimbursement coverage.

When a disabled person is being seated a series of trade offs are made. Tissue viability, vs. stability, vs. posture is three trade offs that can be selected. What ever parameter(s) is/are the most important to meet that person's current needs will change with time and they will need to be reassessed and/or readjusted. A multi -celled support surface such as with DRY FLOATATION® makes for a porous surface allowing drainage/ventilation. Drainage through the surface introduces a sanitation issue where cleaning needs to be performed frequently. This is a cause for the use of membrane type of covers, to keep the support surface dry but compromises shape compliance.

Thermodynamics properties of a support surface must be considered. The operational environment influences the patient's well-being and a DRY FLOATATION® support surface is not an insulator. When located on a cold surface or a warm surface or a cold or hot climate those temperatures affect the person and will cool or heat the occupant. The cover should have non-ventilated side panels when heat retaining is desired. Shape fitting with reduced deformation promotes blood flow, which will bring warmth to the tissue interface and moisture from perspiration. Moisture reduces the tensile strength of skin reducing deformation resistance.

Reliability Considerations/Conclusion

All devices fail. When support surfaces fail tissue also may fail. Decubitus ulcers are a critical tissue failure and are a wound, which may cause death of a person. An air inflated support surface fails in a very obvious manner by going flat. Air cell based support surfaces can be repaired by replacing defective air cells extending their useful life. The ROHO support surfaces are made with Neoprene rubber and can be cleaned with water based cleaning agents. All support surfaces, i.e. foam, fail but are difficult to detect that they have failed and continued use and may cause a wound.

Bibliography

1. Takashi Nagase., *et al*. "Clinical and Molecular Perspectives of Deep Tissue Injury: Changes in Molecular Markers in a Rat Model".

2. Ayelet Levy., *et al*. "An air-cell-based cushion for pressure ulcer protection remarkably reduces tissue stresses in the seated buttocks". *Journal of Tissue Viability* 23.1 (2014): 13-23.

3. DRY FLOATATION® is a registered trademark of ROHO Inc.

Volume 12 Issue 10 October 2021