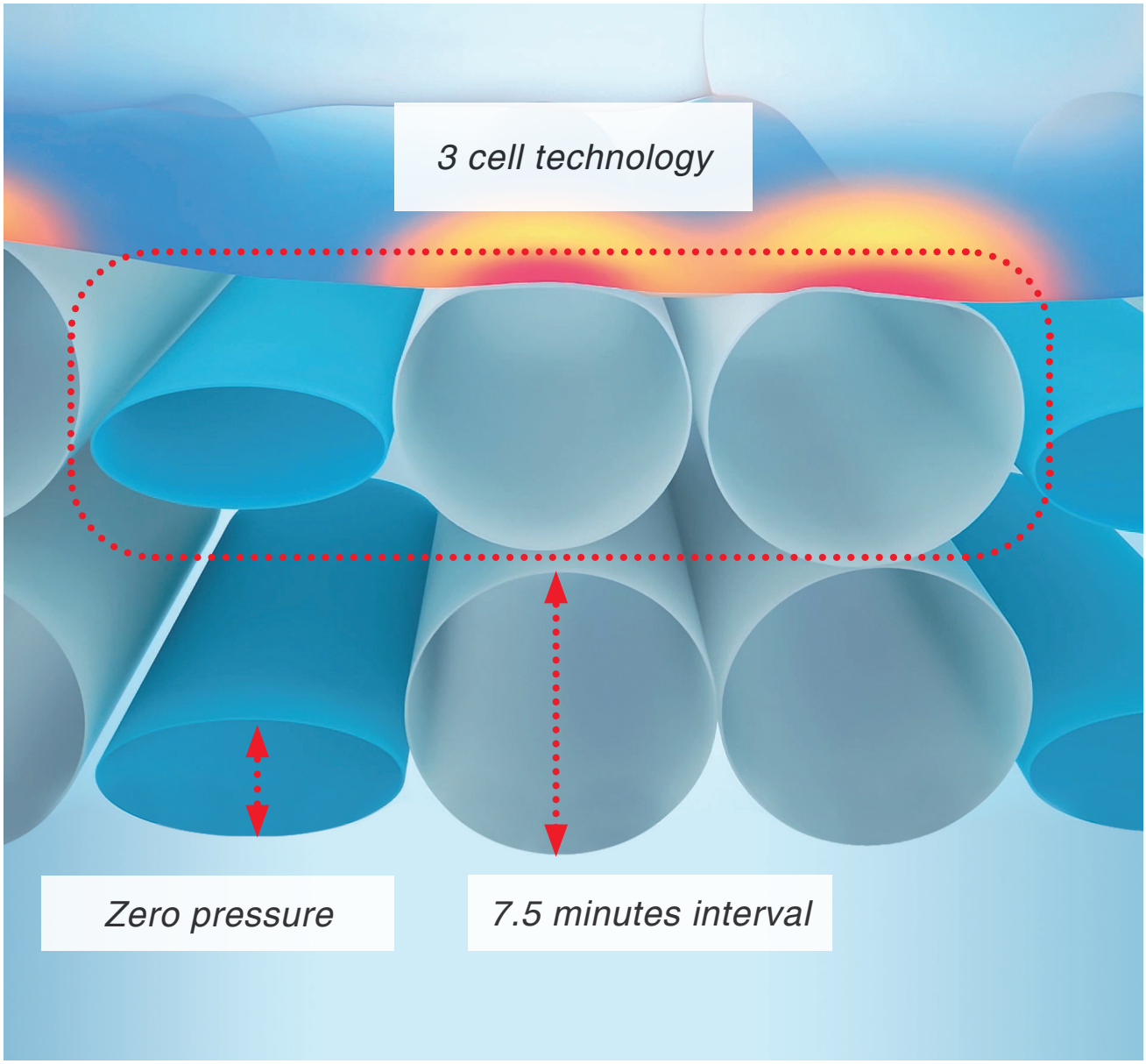
Clinical Guide

LINET

Why Alternate?



Understanding the Design and Use of Alternating Pressure Surfaces

Why Alternate?

Challenge

Global pressure injury
incidence in acute hospitals is estimated to be around 6.3 %.[1]

Up to 95 % of pressure
injuries are believed to be avoidable.[2]

Nationally, the U.S.
spends about $26.8 billion a year treating pressure injuries.[3]

Introduction

Specialty air mattresses have been used to prevent and support the treatment of pressure injuries for many years. International guidelines recommend an “assessment of the relative merits of using an alternating pressure air mattress or overlay for individuals at risk of pressure injuries”.[4]

There are several types of support surfaces designed to help reduce shear and pressure. These include passive foam mattresses, closed and open system hybrids and active systems such as low air loss, constant low pressure, and alternating pressure. The scope of this document is to explore the various Alternating Pressure Systems.

This clinical guide outlines how alternating pressure mattresses work and the different design options available.

Pressure Injury Development

In order to understand how alternating pressure can prevent pressure injuries, it first helps to understand how pressure injuries can develop.

What is a Pressure Injury?

A pressure injury is defined as “localized damage to the skin and/or underlying tissue, as a result of pressure or pressure in combination with shear. Pressure injuries often occur over a bony prominence but may also be related to a medical device or object”.[4]

[Image 1]: Pressure Injury

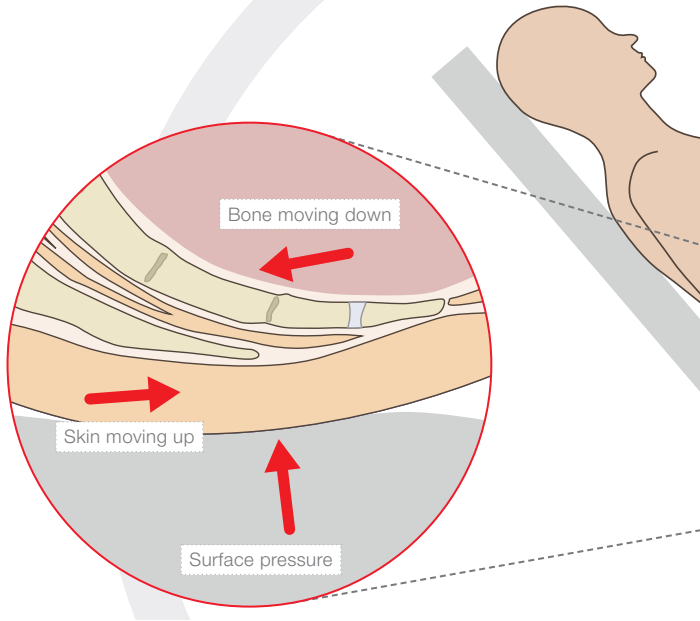
How Does a Pressure Injury Develop?

Mechanical forces can cause damage through several mechanisms:

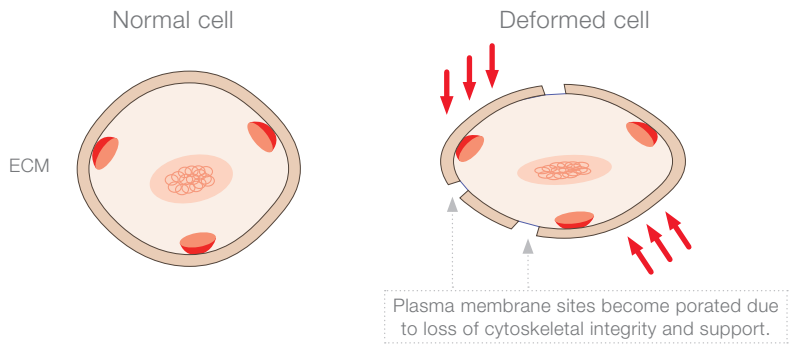
Cell Deformation: Direct damage to individual cells as a result of being squashed or distorted. This can cause inflammation and cell death.

Inflammation and Edema: Damage from inflammation of the cells which can cause further cell deformation and result in cell death.

Reperfusion Injury: Tissue damage can be caused by oxygen free radicals released following prolonged ischemia (inadequate blood supply).[5]

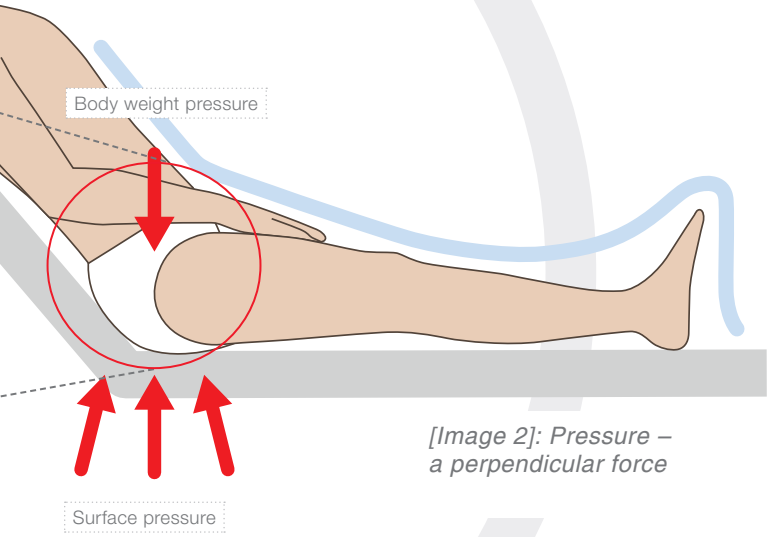


[Image 3]: Shear – a parallel force



[Image 4]: Illustrating cell deformation through pressure and shear

Capillary Occlusion/Distortion: Closure or distortion of the capillaries from pressure, shear, or cell/tissue inflammation reducing the supply of nutrients to the tissue. This mechanism also reduces lymphatic drainage which is the body's way of removing toxic waste products from the tissue. This can cause ischemia (tissue death).



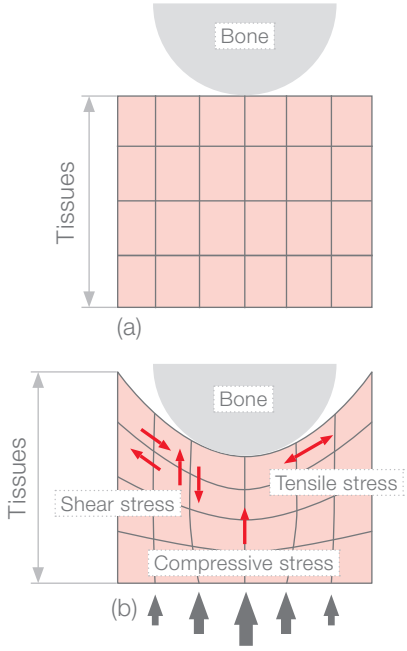
[Image 2]: Pressure – a perpendicular force

Where Do Pressure and Shear Come From?

Forces generated by a patient's body weight or exerted externally by a medical device or other object can lead to a pressure injury if sustained for a prolonged period of time. Pressure is defined as the amount of perpendicular force applied.

Forces can also be applied parallel to the skin's surface, for example when a patient slides down the bed. These types of forces are referred to as shear.

It should be noted that there is a continuous interaction between ischemia and inflammation. Inflammation affects the function of epithelial cells and capillary walls while ischemia contributes to the build-up of edema.[4]

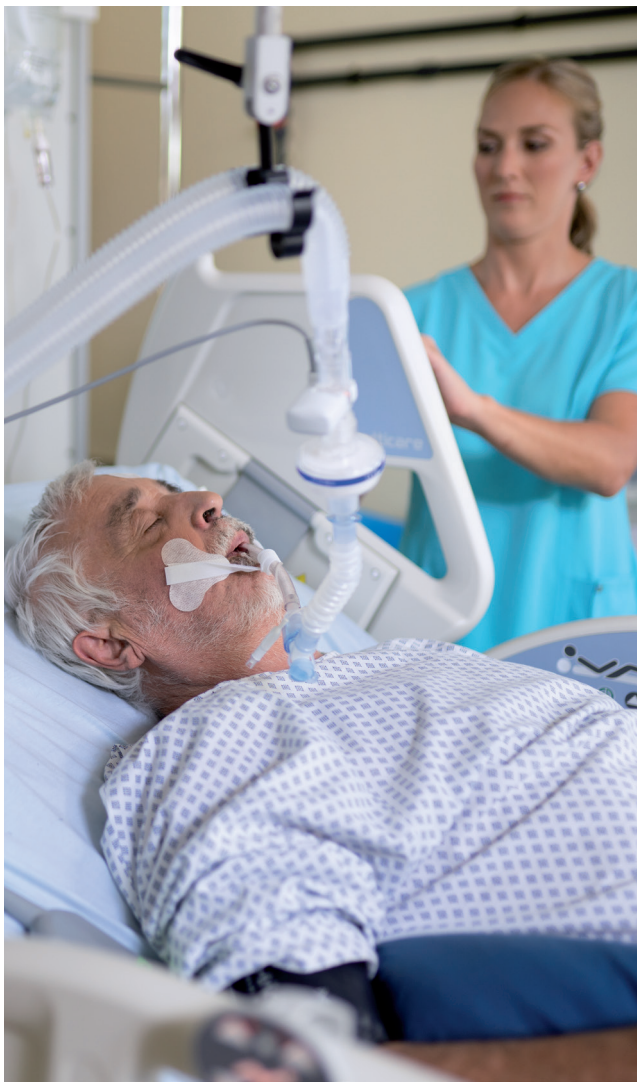


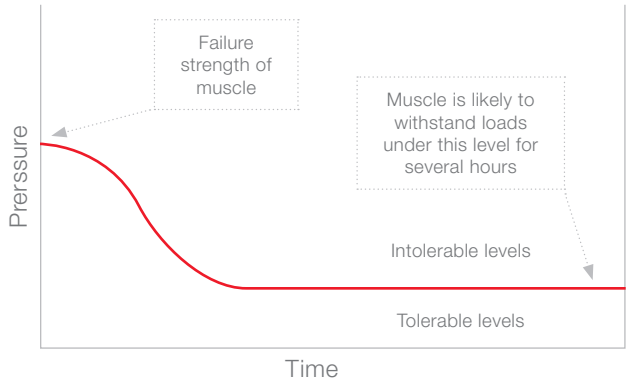
[Image 5]: Tissue distortion due to pressure

The figure above illustrates the stresses caused on the tissue by externally applied pressure over a bony prominence (b). Some lines are closer together while others are elongated, this demonstrates that even when perpendicular pressure is directly applied both tensile and shear stresses also occur.[6]

Load Duration

The EPUAP guidelines state that “deformations of skin and/or deeper tissues due to bodyweight loads or exerted from the environment (e.g. a medical device) must be sustained for the tissue damage that characterizes a pressure injury to occur”.[4] This means that the relationship between time and pressure is very important.





Key
Left vertical axis = direct pressure on muscle tissue (Linder-Ganz at of 2006)

[Graph 1]: Tolerance behavior of soft tissues subjected to sustained mechanical loads. Gefen curve of pressure and tissue tolerance over time. [4]

When pressure on an area of tissue is completely removed regularly, cells and capillaries can recover their shape. This enables blood flow to be restored (reperfusion) to capillaries previously occluded. In turn, this increase in blood flow facilitates reactive hyperemia. Reactive hyperemia is the body’s natural response mechanism, temporarily increasing blood flow to the area to compensate for the previous deficits in oxygen and nutrients.[7] Studies show that reactive hyperemia can bring three times the normal offloaded blood flow to the tissue.[8,9]

Alternating Pressure Mattress Systems

Unlike pressure redistribution mattresses, which aim to reduce peak pressures through pressure redistribution, alternating pressure mattress systems work through periodic pressure relief. Alternating Pressure Systems are designed to prevent any part of the body from being subjected to sustained pressure. They do this by alternating the parts of the body that are loaded at any one time. Some studies also suggest alternating pressure could promote wound healing.[10,11]

For alternating systems to be effective however, the support surface must sufficiently reduce pressure low enough and long enough to allow reperfusion.

Alternating pressure mattress systems vary in several ways, meaning not all alternating pressure systems are the same. The main technical differences are cell size, cell configuration, and cycle time.

Cell Size

Cell sizes can vary from mattress to mattress. If the cells are too small, there is a risk that the cells adjacent to a deflated cell will fill the resulting gap and prevent pressure relief. “Work by Cullum et al (1995), suggests that cells less than 10 cm in diameter cannot lift the patient sufficiently.”[12]

Cycle Time

7.5 minute cycle times mimic natural spontaneous movements to relieve pressure. This is highlighted in physiological studies that showed that patients who moved every 7.5 minutes did not go on to develop pressure injuries.[13]

Longer cycles are also designed to provide regular reperfusion and may be more comfortable for some patients.

Cell Configuration

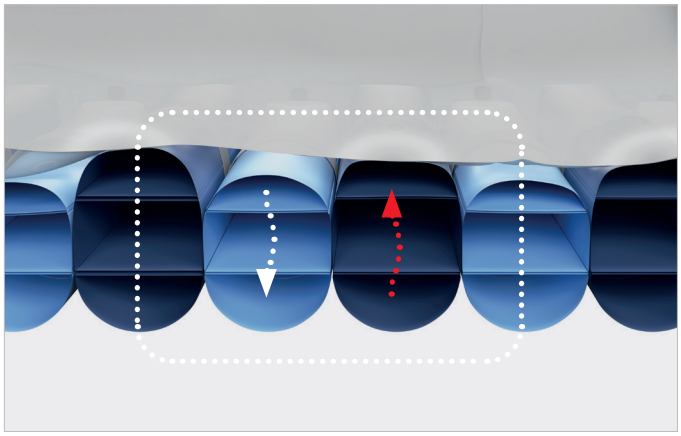
Most alternating pressure mattress systems use a configuration of 2 cell or 3 cell alternation. Both of these systems are designed to minimize the time the body is loaded to avoid biochemical and physiological effects that can lead to tissue death. This is done by simulating normal body movement. This intermittently takes the pressure below individual thresholds and allows a natural reactive hyperemic response. For individuals with a normal response to offloading, reperfusion can be rapid,[11] although some patients may take longer to reach previous unloaded levels.[14] For this reason, the LINET®’s Virtuoso® mattress, for the most vulnerable patients, is designed to optimize pressure by following 5 principles, see Virtuoso® Design Principles, P9.

Cell Configurations

2-Cell Systems

In a 2-cell system, every alternate cell inflates while the intermediate cells deflate. As cell deflation covers 50 % of the body's surface area at any one time, 2 cell systems tend not to eliminate interface pressures. This allows for regular reduction of any peak pressures present. E.g.

LINET®'s Air2Care range is a 2-cell system, which provides cost-effective alternating pressure.

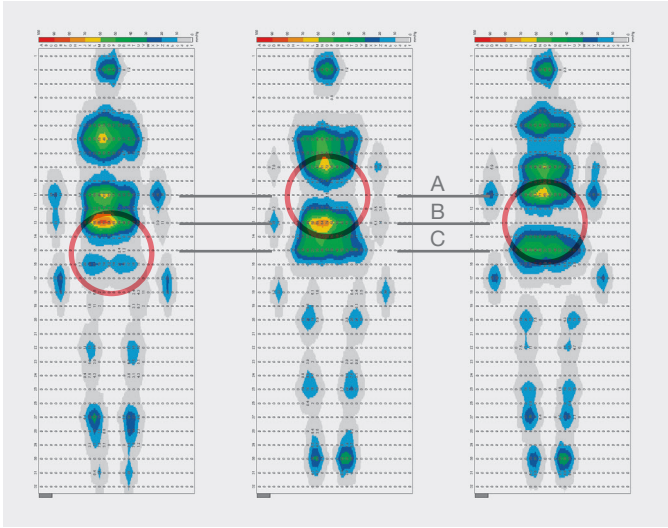


[Image 6]: 2-Cell System[15]
Air2Care mattress provides 2-cell alternating pressure reduction, designed to minimise sustained peaks pressures to the patient's body

3-Cell Systems

In a 3-cell system, only one in three cells deflates at any given time. This allows for 66 % of the body's surface to always be supported and 33 % to be completely off-loaded. When sitting up, 80 % of the patient's body weight can be loaded into the small seat area of the mattress. In this case, the additional support provided by a 3-cell system can also beneficial.

LINET®'s Virtusoso is a 3-cell system which provides advanced alternating pressure.



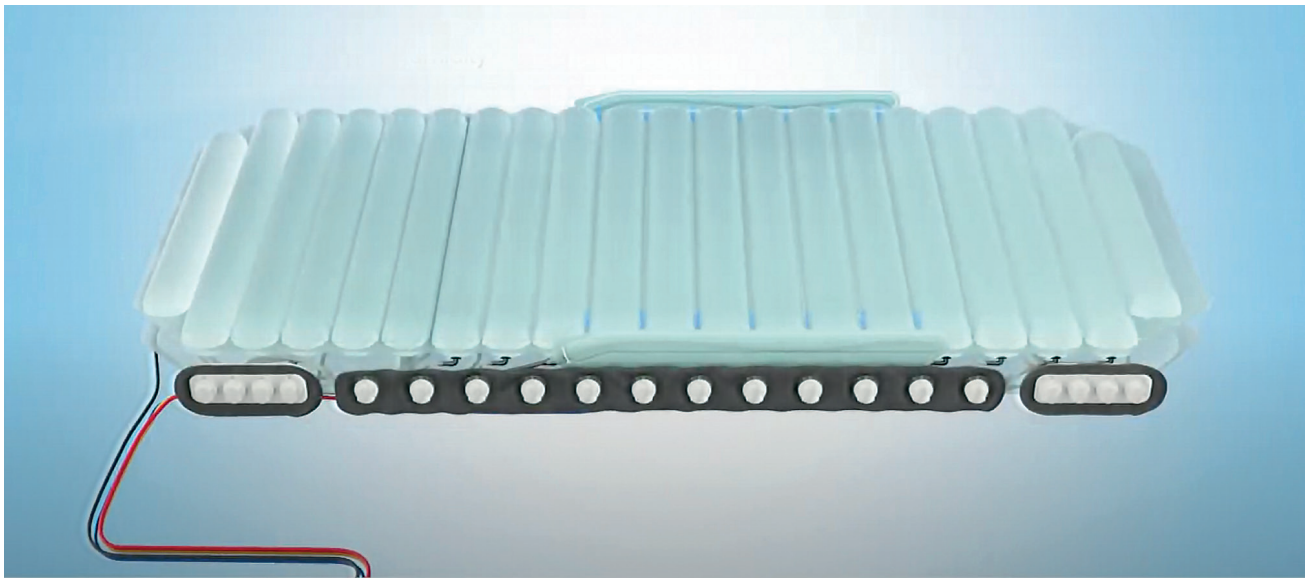
[Image 7]: 3-cell system
Zero Pressure 3 cell (A, B, C) cycle

Integrated Microclimate Management

Moisture and temperature at the patient interface can also contribute towards tissue breakdown. This is because an increase in temperature and humidity causes the skin to become weaker and more vulnerable to breakdown.[3,16,17] Therefore, the microclimate is also a key factor of support surface design and function.

Alternating pressure mattresses allow some temperature and moisture control through frequent relief of contact pressure and permitting increase in air flow around the skin and interface with the mattress.

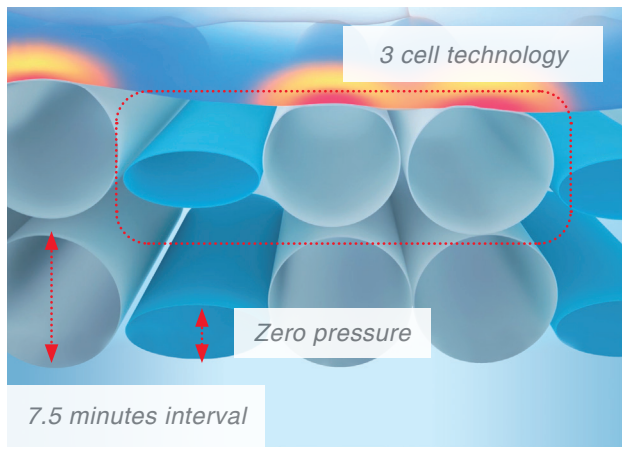
The frequent change of air within the cells also contributes to the prevention of heat buildup. In addition, some systems such as Virtuoso®, have active microclimate controls that aid moisture vapor transfer through the cover material.



[Image 8]: Illustration showing the airflow of active microclimate management in the Virtuoso®]

Virtuoso® Design Principles

1. Cycle time is sympathetic to natural movement, i.e. every 7–12 minutes.[13]
2. Rapid application and removal of pressure to simulate the effect of natural movement
3. Reduces pressures below arbitrary capillary closing pressures of 10, 20, 30 mmHg.[18]
4. Internal pressure in inflated cells should be sufficient enough to support the patient clear of deflated cells. This is sometimes referred to as ‘zero pressure’.
5. Holding pressures low enough for as long as possible to allow reperfusion.[14,19]



Alternating Pressure Air Mattresses: Factors to Consider

— Cell Size

— Cell Construction

— Cell Configuration (2-cell, 3-cell etc.)

— Cycle Time

— Ability to Provide Sufficient Pressure Relief or “Zero Pressure”

— Time Below Pressure Thresholds

— Microclimate Features

Reference

(1) Al Mutariri, K.B., Hendrie, D. Global Incidence of Pressure Ulcers in Public Hospitals. A Systematic Review. Wound Medicine, 2018, 22, p23-31.

(2) Hibbs, P. (1988). The economic benefits of a prevention plan for pressure sores. Conference presentation. The Fourth National Pressure Sore Symposium. The Guildhall, Bath

(3) Morse, S. (2019). More on Acute Care: Pressure ulcers cost the health system $26.8 billion a year. Healthcare Finance. Oct 10, 2019.

(4) European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance. (2019). Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline. The International Guidelines. Emily Haesler (Ed.). EPUAP. NPIAP/PPPIA

(5) Peirce SM, Skalek TC, Rodeheaver GT. (2000). Ischemia-reperfusion Injury in Chronic Pressure Ulcer Formation: a skin model in the rat. Wound Repair and Regeneration, 2000. 8(1): 68-76.

(6) Adapted from: Takahashi M. Pressure reduction and relief from a view point of biomedical engineering. Stoma 1999; 9(1): 1- 4. cited in: International review. Pressure ulcer prevention: pressure, shear, friction and microclimate in context. A consensus document. London: Wounds International, 2010.

(7) Thompson, D. (2005). A critical review of the literature on pressure ulcer aetiology. Journal of Wound Care. Vol 14, No 2, February 2005.

(8) Herrman et al (1999). Skin perfusion responses to surface pressure-induced ischemia: Implication for the developing pressure ulcer. Journal of Rehab Research and Development. Vol. 36, No. 2, April 1999

(9) Mayrovitz, H., Sims, N., and Taylor, M.C. (2002). Sacral skin blood perfusion: A factor in pressure ulcers? Ostomy Wound Manage. 48(6):34-42.

(10) West, J. et al. (1995). The effect of a unique alternating pressure mattress on tissue perfusion and temperature. Presented at the European Tissue Repair Society Conference 1995

(11) Gunter, R.A., and Clark M. The effect of a dynamic pressure redistribution bed support surface upon systemic lymph flow and composition. Trend of Tissue Usability. 10(3):10–15.

(12) Cullum N, Deeks J, Fletcher A, Long A, Mouneimne H, Sheldon T et al. 1995). The prevention and treatment of pressure sores: How effective are pressure-relieving interventions and risk assessment for the prevention and treatment of pressure sores? Effective Health Care 1995; 2(1):1-16.

(13) Exton-Smith, A.N., Cantab, M.A. (1961). The Prevention of Pressure Sores Significance of Spontaneous Bodily Movements. The Lancet. Vol 278. Issue 7212. P1124-1126.Nov 18, 1961.

(14) Coggrave, M.J., and Rose, L.S. (2003) A specialist seating assessment clinic: changing pressure relief practice. Spinal Cord (2003) 41, 692–695

(15) MacGregor, L. (Ed.). (2010). International review. Pressure ulcer prevention: Pressure, shear, friction and microclimate in context. A consensus document. London: Wounds International.

(16) Yusuf, S. et al. Microclimate and development of pressure ulcers and superficial skin changes. International Wound Journal. 2015, 12(1), 40-46.

(17) Gefen A. How do microclimate factors affect the risk for superficial pressure ulcers: a mathematical modeling study. J Tissue Viability 2011; 20:81–8.

(18) Twiste, M., and Rithalia, S. Measurement system for the evaluation of alternating pressure redistribution mattresses using pressure relief index and tissue perfusion – a preliminary study. Wound Practice and Research. Vol 16, No 4, November 2008. P192-198.

(19) Bader, D. (1990), The recovery characteristics of soft tissue following repeated loading. JRRD. Vol 27. No 2. PP141-150.

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