Despite the publication of clinical practice guidelines addressing pressure ulcer prevention and treatment by the Agency for Health Care Policy and Research (AHCPR) within the past decade, the length of stay and cost associated with pressure ulcers continues to rise.


WHY?
MAYBE….

Keep it Simply Scientific

Physiology is the bridge between basic science and clinical medicine.

- Basic Science
  - Anatomy
    - Macro
    - Micro
  - Cellular Biology
  - Chemistry
    - Inorganic
    - Organic
  - Mechanics
    - Static
    - Dynamic
  - Physics

- Clinical Medicine
  - Healthy State
    - Homeostasis
  - Unhealthy State
    - Disease

Pressure Ulcer Development

Contributing Factors

- Nutrition
- General Medical Condition
- Moisture
- Temperature
- Pressure
- Friction
- Shear
- Mobility

\{ \text{PresShear Components} \}
**HOMEOSTASIS**

“Wisdom of the Body”
Walter Cannon, early 1900’s

**Homeostasis**

The body’s ability to maintain relatively stable internal conditions even though the outside world changes continuously.
How does the body maintain Homeostasis?

- **Negative feedback**
  - Common events maintaining narrow parameters
    - Body temperature
    - Blood glucose levels
    - Heart rate
    - Blood pressure
    - Rate and depth of breathing
    - Carbon dioxide levels
    - Oxygen levels
    - Hemostasis
    - Hemodynamics
    - Inflammatory response
    - Oxidative reactions

- **Positive feedback**
  - Infrequent events that don’t require continuous adjustment
    - Blood clotting
      - Laceration
      - Damage to lining of blood vessel
    - Enhancements of labor contractions

Homeostatic Imbalance

- **Disease**
  - CAD
  - PVD
  - Shock
  - Stroke
  - SIRS (Systemic Inflammatory Response Syndrome)
  - ARDS (Adult Respiratory Distress Syndrome)
  - DIC (Disseminated Intravascular Coagulation)
  - MODS (Multiple Organ Distress Syndrome)
  - Gingivitis

- **Pressure Ulcers**
  - (ischemic necrosis)
  - Malnutrition
  - Aging
  - Mechanical stress
    - Gradient Pressure
    - Shear/Friction
  - Soft Tissue distortion
  - Turbulent blood flow
  - Endothelial damage
  - Hyperinflammation
    - MODS
    - SIRS
  - Hypercoagulation
  - Abnormal tissue environment
    - Acidosis
    - Oxygen Free Radicals
    - Interstitial Edema

Key Point:

Pressure ulcers are not the result of an ischemic event, not a crush injury.
Gross Anatomy
The body is 3-Dimensional

Clemente CD. Anatomy: A regional atlas of the human body.
Baltimore (MD): Williams & Wilkins; 1997.

The Culprit? Gravity

Body Weight (Skeletal Press)

Tissue at Risk (Viscoelastic soft tissue)

Support Surface (Media, Container design)

Weight = Gravity x Mass
Soft Tissue at Risk

• *Epithelial* - covering
  – skin-epidermis
  – endothelium-lining of the vessels
• *Connective* - support
• *Muscle* - movement
• *Nervous* - control

Circulatory System

Lymphatic System

Blood Velocity

Local control of blood flow by tissues


Definition of Reactive Hyperemia
Reactive hyperemia occurs after the blood supply to a tissue is blocked for a short time with subsequent decrease in oxygen saturation and increase in metabolic waste.

Definition of Active Hyperemia
Active hyperemia occurs when the tissue metabolic rate increases.
Blood pressure varies throughout the systemic circulation

Vasomotion

What affects perfusion?

- Decreased perfusion pressure
  - Cardiovascular disease
  - Shock
  - Soft tissue shape deformation (distortion)
  - Intraluminal obstruction (emboli-clots)
- Increased capillary closing pressure

External
- Mechanical stress
  (gradient pressure or shear)

Internal
- Edema
- Clotting
- Venous hypertension
- Soft tissue shape deformation (distortion)
Even *minimal* distortion can be disruptive to homeostatic balance.

- Hemodynamics
  - Cardiovascular status
  - Size of vessels
  - Health of vessels
  - Direction of vessels

**Definition of Ischemia**

Local decrease in blood supply


**Definition of Necrosis**

Death or disintegration of a cell or tissues caused by disease or injury

**Definition of Inflammation**

A nonspecific defensive response of the body to tissue injury; includes dilation of blood vessels and an increase in vessel permeability; indicated by redness, heat, swelling and pain.


**Definition of Pressure Ulcer**

An area of localized damage to the skin and underlying tissue caused by pressure, shear, friction and or a combination of these.

European Pressure Ulcer Advisory Panel - 1999

**Etiology of Pressure Sores**

Normal Inflammatory Response

- Normal Inflammatory Response
  - Chemotaxis secondary to cell death
  - Margination of neutrophils
- No endothelial damage
  - Diapedesis
  - Migration
  - Phagocytosis

Pressure Ulcer Development - 1987

1987

Pressure & Shear

Cell death

Decrease in capillary flow

Local tissue anoxia

Increased capillary permeability

Inflammation & Extravasation

Ischemia

Support Surface

Decreased Perfusion

Interstitial Edema

Phagocytosis

Increased capillary permeability

Acidosis (H+)

Axenetic metabolism

Cellular Injury

Inflammation & Extravasation

Decrease in capillary flow

Decrease or change in capillary flow

Margination of intravascular cells

Endothelial damage

Leakage of fluid proteins & neutrophils

Soft Tissue Distortion (Swelling)

Stasis & Coagulation
Normal Inflammatory Response

- Pathophysiology
  - Mechanical stress (Gradient pressure or shear)
  - Soft tissue distortion
  - Change in velocity or character of blood flow
  - Margination of intravascular cells
    - Endothelial damage
    - Intravascular coagulation
    - Decreased oxygen
    - Anaerobic metabolism
    - Ischemia
    - Necrosis
    - Inflammatory Response

Homeostasis Imbalance

Normal Laminar Blood Flow

Turbulent Blood Flow

Margination-Endothelial Damage & Capillary Permeability
Endothelial Damage

• Cause
  – Intravascular cell margination
  • Enzymatic and oxygen free radical injury

• Result
  – Loss of smoothness
  – Loss of glycocalyx-thrombomodulin layer

• Effect
  – Activation of Factor XII and platelets with initiation of intrinsic pathway clotting
  – Damage to vascular wall activates extrinsic pathway clotting
  – Increased capillary permeability

Potential Outcomes

• No restoration of blood flow
• Return to normal blood flow with no damage
• Return to blood flow with reperfusion injury
Definition of Reperfusion Injury

Post-ischemic tissue injury caused by highly reactive oxygen free radicals (Oxidative reaction imbalance)

- Predisposing factors
  - Age
  - Malnutrition
    - Protein/calorie
    - Vitamin/mineral
  - Cellular Injury
    - Hyperinflammatory response
How can we prevent and treat pressure ulcers?

Facilitate & Maintain Homeostasis

Know the effect of the support surface on the soft tissue at risk

- Mechanical Stress
  - Pressure
  - Gradient pressure
  - Non-gradient pressure
  - Shear
- Soft tissue strain
  - Distortion
  - Volumetric
Know the effect of the support surface on the soft tissue at risk

• Mechanical Stress
  – Pressure
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    – Shear

• Soft tissue strain
  – Distortion
    – Volumetric

FLOTATION THERAPY

Mechanical Stress

Pressure
Load perpendicular to the plane of interest.

Shear
Load parallel to the plane of interest.

Friction
Tendency of two objects to stick together

Compression Distortion Distortion

Soft tissue responds to mechanical stress in either distortion or volumetric support.

Gradient vs. Non-gradient Pressure

Non-gradient Pressure

Rigid Surface

Modulus of Elasticity

Force Gradieny

Vertical Shear

Pressure Gradient

Rigid Surface
Horizontal Shear

Vertical Shear (gradient pressure)

Basic scientific principles relating to mechanics and physics explain the effects of various support surfaces.

- Basic physics
  - 200 BC
  - Archimedes
  - 17th Century
  - Boyle
  - Pascal
  - Newton
  - Hooke’s
- Physical properties of media
  - Static (non-powered)
    - Gas
      - minimal molecular bonding
    - Liquid
      - moderate molecular bonding
    - Solid
      - strong molecular bonding
  - Dynamic (powered)
    - Fluid
    - Gas

Physical Properties of Media

<table>
<thead>
<tr>
<th>Mechanical Stress</th>
<th>Soft Tissue Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient Pressure and</td>
<td>Distortion</td>
</tr>
<tr>
<td>Shear</td>
<td>Volumetric</td>
</tr>
<tr>
<td>Solid</td>
<td>X</td>
</tr>
<tr>
<td>Static Fluid (non-powered)</td>
<td>X</td>
</tr>
<tr>
<td>Air</td>
<td>X</td>
</tr>
<tr>
<td>Water</td>
<td>X</td>
</tr>
<tr>
<td>Soil</td>
<td>X</td>
</tr>
<tr>
<td>Powered Air</td>
<td>X</td>
</tr>
</tbody>
</table>
All containers are solid, thus the design of the container is very important.

• Pliable
• Flexible
• Durable

Must compliment the physical properties of the media

Pressure & Shear Vector
Since the human body is 3-dimensional

Then
Deliverance of gradient pressure and shear mechanical stresses by the support surface (solids, gels, and powered fluids) will
Cause soft tissue distortion, change in velocity and flow pattern of the circulation, causing endothelial damage resulting in ischemia and possible infarction of the soft tissue at risk (pressure ulcer)
thus
Selection of these types of media must be evaluated by scientific facts and soft tissue strain visualization (CT or MRI scanning) since pressure mapping is 2-dimensional and unreliable in defining causation of soft tissue distortion

Pressure & Shear Vector
If the human body is 3-dimensional

Then
Volumetric support is needed to maintain proper tissue orientation
then
A static fluid media (gas, liquid, sol) is needed to float the body in a flexible container that is properly filled or inflated and
Static air is preferred to liquid or sol because it has less density and no viscosity

FLOTATION THERAPY
“Equalized distribution of the body’s weight”
Definition of a Clinical Flotation Device

Supports a 3-dimensional body in a pliable solid container filled with a static fluid media.

Result of a Well-designed Flotation Therapy Device

Mechanical stress = Non-gradient perpendicular pressure with minimal shear

Soft tissue strain = Volumetric support with minimal distortion

Flotation Therapy Facts

Contouring is not equal to Flotation Therapy

Dynamic fluids do not deliver Flotation Therapy

Overinflation or Overfilling of a static media container will not deliver Flotation Therapy
Flotation Therapy

- Technology Reference
  - Archimedes (200 BC)
  - Boyle, Pascal, Newton, Hooke's (17th Century)
  - Manufacturing (1970-Present)

- Basic Reference
  - CT Scan, MRI

- Clinical Reference
  - Outcome studies

- Physiology Reference
  - Living in atmosphere (air, water)
  - Fetus in uterus

Nature's Flotation
Maintain Autoregulation

- Clinical Protocols
  - Nutrition
  - Mobilization
- Ambulate
- Turn
- Passive Range of Motion
- Support Surface
- Bed, Chair, Cart, Emergency Room, Operating Room
- Incontinence Care
- Wound Care
- Continuum of Care
- Treatment of other general medical conditions

DO NO HARM!

Do No Harm
Hippocratic Oath

- Clinicians are held accountable to proven clinical standards of care
  - Understand the underlying problem
  - Do not impair the body's autoregulatory mechanism
    (Homeostasis)
  - Product selection should be based upon scientific facts not marketing materials
- Clinicians are now held accountable for cost-effective care
  - Increased expenditure does not always guarantee better outcomes

If clinical outcomes are equal, choose the most cost-effective product.
Caution:
Cost-effectiveness does not always mean “the cheapest”

Proper Product Utilization

“Match the product to the patient, not the patient to the product”