Pressure Ulcer

- Localized injury to the skin and/or underlying tissue, usually over a bony prominence, resulting from **sustained pressure** (including pressure associated with **shear**).
Pressure, Friction, and Shear, Oh My

• What are they?
• What might cause them?
Pressure and Tension

Friction

- Surfaces sliding with respect to each other
- Contact force parallel to the skin surface
Static Friction

• Force resisting movement between 2 bodies when they are NOT moving
  – Keeps you from sliding out of bed when head of bed raised

Dynamic Friction

• Force resisting movement between 2 bodies when they are moving
  – Foot rubbing against a shoe
  – Person sliding in bed
Shear

Shear Role

• **Magnitude**
  - Greatest shear load = Greatest injury

Etiology of Pressure Ulcers

- Internal response to external load

Resultant Forces
Tissue Tolerance

- External mechanical load
- Internal local tissue deformation
- Deformation threshold
- Local tissue damage

What Magnitude of Pressure Causes a Pressure Ulcer?

Original Curve

What Magnitude of Pressure Causes a Pressure Ulcer?

Proposed pressure vs. time relationship

- Failure strength of muscle
- Load that can be tolerated


Duration of Pressure

- High pressure short duration
  - Type of load
    - Impact Damage not a pressure ulcer
- Low pressure long duration
- Shear
Etiology of Pressure Ulcer Development

Stage 1/2

vs.

Stage 3/4

Low Pressure Tissue Damage Mechanism

- Low pressure threshold
  - Occlusion of blood vessels
  - Ischemia-induced damage

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Tissue Ischemia

- Muscle most sensitive
- Changes appear in muscle tissue prior to skin
- Vascularity
- Metabolic demand


Tissue Layer Damage

- Skin over bone
  - 100% ulceration

- Skin and muscle overlying bone
  - No skin ulceration
  - Muscle fiber necrosis

Impact of Ischemia

- **Hypoxia**
  - Block removal of waste
  - Lack of nutrients
  - pH changes

- **Reperfusion**
  - Following prolonged ischemia*
  - Oxygen free radicals released

High Pressure Tissue Damage Mechanism

Deformation-induced damage
Resultant Forces

Deformation Mechanism

- Strains >50% lead to tissue damage within minutes
- Strong correlation between strains and damage
Impact of Tissue Deformation

- Cellular deformations
- Alter normal cellular homeostasis

Impact of Deformation

- Interstitial space
  - Location of transport of nutrients and waste
  - Deformation may alter the space

- Cell death mechanism
  - Rupture of cytoskeleton
  - Stretching of cytoskeleton
  - Internal pathways

- Cell Culture
- Computer Models
Low vs. High Threshold Damage Mechanism

- Ischemic loading
  - Changes were reversible

- Compressive loading
  - Changes irreversible

Hypoxia vs. Compression

- Hypoxia
  - Cell death not significant

- Compression
  - Immediate cell death
  - Cell death increased with time


Microclimate

Temperature, humidity, and airflow at patient/support interface

Role of Microclimate

• Dry skin – brittle breaks
• Moist skin
  – Skin weakens
  – Less stiff
Impact of Moisture

- Skin tensile strength decreases
- Load distribution

- Moisture increases friction and shear
  - Increased tissue deformation
  - Maceration

Role of Microclimate - Temperature

- Temperature increases
  - Increase metabolic demand
  - Ischemia risk
  - Increase moisture
Role of Temperature in Reactive Hyperemia

• Pressure and temperature predictors of extent of reactive hyperemia
  – Upper 1-3mm of tissue in healthy volunteers
  – Index of ischemia, laser Doppler flowmetry

Lachenbruch C. OWM, February 2015.

Role of Temperature in Reactive Hyperemia

• At higher temperatures (32-36C) reactive hyperemia increased significantly
  – Greater increase with higher pressure and shear

Lachenbruch C. OWM, February 2015.
Role of Microclimate in Etiology

- Significant
- Details emerging
- Relationship to loading

Pressure Ulcer Development

- Load
  - Magnitude,
  - Type of load
    - Pressure, shear
  - Duration
Pressure Ulcer Development

• Location
  – Tissues present
    • Muscle
  – Anatomical blood supply

• Morphology of individual

• Individual physiology

Pressure Ulcer Development

• Tissue response

• Transport properties
  – Perfusion and Oxygenation

• Thermal properties
  – SCI

• Microclimate
Factors

• Properties of tissue
  – Aging
Factors

- Properties of tissue
  - Aging
- Lifestyle
  - Muscle mass
  - Mobility
- Comorbidities
Factors

- Properties of tissue
  - Aging
- Lifestyle
  - Muscle mass
  - Mobility
- Comorbidities
- Microclimate

Thank You
QUESTIONS?