Clinical Aspects of Shear

Ann N. Tescher, PhD, APRN CNS, CCRN, CWCN, FCCM
Certified Clinical Nurse Specialist-Surgical/Trauma/CV Surgery ICU
Mayo Clinic – Rochester MN
Disclosure

- No Conflicts of Interest to Disclose
A Clinician’s View of Shear

“I shall not today attempt further to define the kinds of material I understand to be embraced within that shorthand description; and perhaps I could never succeed in intelligibly doing so. But I know it when I see it…”

Justice Potter Stewart (1964)
Definitions (S3I NPUAP)

- **Friction**
  - The resistance to motion in a parallel direction relative to the common boundary of two surfaces (S3I Terms and Definitions)

- **Shear**
  - The force per unit area exerted parallel to the plane of interest

- **Shear strain**
  - Distortion or deformation of tissue as a result of shear stress
An Unforgettable Patient
Challenges for Clinicians in Understanding Shear

• How does one measure shear in the clinical environment?
  • *What the heck is a Newton or a kPa?*

• Current measurement devices are designed for a research environment

• Friction vs. shear

• Blisters due to shear often assumed to be due to pressure (PI Stage 2)
Mechanoreceptors

- Excessive mechanical force (shear) can result in **blister formation**
  - Occur in deeper part of epidermis or between epidermis and dermis
- Results in epidermal cell necrosis, causing an **intra-epidermal slit** which fills with fluid
- Necrosis due to repeated cellular distortion, which denatures the cellular protein
Mechanically Induced Blisters

- Occur most commonly at the dermo-epidermal junction
- Anchoring filaments between the basal cells to basal lamina are disrupted

Mechanisms:
- **Spongiosis**
  - Cells become separated by accumulation of edema fluid
- **Epidermal Cell Necrosis**
  - Cells become swollen and vacuolated to produce “balloon degeneration
- **Damage to intercellular ‘cement’**
  - Cells that form intercellular cement lose cohesion
What Does Shear Do to Tissue?

- Often combined with pressure
- Shear deformation of tissue magnifies damage due to ischemia and subsequent reperfusion injury
- Shear deformation of tissue extends the size of the original injury
Common Clinical Factors Associated With Shear

- Horizontal lateral transfers
- HOB elevation and rotational therapy
- Incontinence/moisture
- Adhesives (MARSI)
- CPAP masks
- Transport vehicles
Horizontal Lateral Transfers

Bed to Transport Cart  Repositioning in Bed
Head of Bed (HOB) Elevation

- Competing clinical priorities
  - Decreasing aspiration risk/Ventilator Associated Pneumonia (VAP)
  - PI prevention
- Bulk modulus
- Friction coefficient of linens/surfaces vs. repositioning up in bed

Courtesy of Evan Call
Continuous Lateral Rotational Therapy

- Shear forces are multidirectional and continuous
- Incorrect assumption that since patient is being constantly turned they are at decreased PI risk
- Adequate “packing” is important but not a guarantee
- Microclimate needs to be considered since there is no air-loss in the surface
Lateral Rotational Therapy

Magnetic Resonance Imaging (MRI)

The inset slide shows the tissue over the buttocks when completely off-loaded.

When the body is resting on a solid surface, the extent of distortion (spread) in the muscle can be visualised.

Cross section through the body at the level of the trochanter

http://www.npuap.org/resources/educational-and-clinical-resources/shear-force-slide-set/
Lateral Rotational Therapy

Movement influences shear forces

Pressure (8mmHg)

No lateral movement

Pressure (8mmHg)

Only 5mm lateral movement!

Direction of movement

Increased strain in deep tissues

Makoto Takahashi, Yuta Tamura (Sapporo, Japan) provided in 2007

http://www.npuap.org/resources/educational-and-clinical-resources/shear-force-slide-set/
Incontinence/Moisture

Moisture

Breakdown

Friction

Maceration

Gefen, A., From incontinence associated dermatitis to pressure ulcers, J Wound Care, 23(7): 345
Medical Adhesive Related Skin Injury (MARSI)

- Often seen with high adhesive tapes
  - Stretched on skin
  - Exacerbated by fluid overload and third-spacing
- Painful!
- Although superficial, could affect occlusiveness and efficacy of dressings, especially Negative Pressure Wound Therapy (NPWT)

CPAP Masks – Not a Laughing Matter

Bridge of Nose Pain From CPAP Mask
Totally Occlusive Seals
May be Harmful!
Simple Interventions to Reduce Shear

- **Horizontal Lateral Transfers**
  - Use of Ergonomic Devices
    - Slider Boards, Slider Sheets, Ceiling Lifts, AirPal

- **HOB Elevation**
  - Assess for optimal HOB elevation
  - Prophylactic silicone multi-layer dressings
  - Anti-shear mattress overlays
  - “Releasing tissue” with position changes
Simple Interventions to Reduce Shear

- **Continuous Lateral Rotational Therapy**
  - Optimal “packing” with frequent reassessment
  - Use surface only as long as clinically indicated
  - Not an exclusive substitute for turning

- **Incontinence/Moisture**
  - Minimize use of excessive linen
  - Underpads/products that wick moisture away from skin
  - Barrier products on skin of incontinent patients to avoid maceration
  - Consider microclimate of surface
Simple Interventions to Reduce Shear

- **Medical Adhesive Related Skin Injury**
  - Avoid over-stretching tape when applying
  - Consider adhesive removers or non-adhesive securement devices

- **CPAP Masks**
  - Avoid Overtightening
  - Consider alternative masks
  - Prophylactic blister bandages
Transport Vehicles

- Transport involves acceleration/deceleration and turns
- Necessary features of ambulance stretchers
- Long vs. short distances
- Present-On-Admission (POA) Pressure Injury
Use of an Anti-Shear Mattress Overlay (ASMO) in Pre-Hospital Transport

• Prospective, randomized trial with cross-over design
  • Standard stretcher vs. Standard stretcher +ASMO
• 30 subjects (3 BMI categories)
  • Subjects served as their own controls
• 3 HOB elevations
  • 5 ambulance runs at each elevation
• 3 anatomic sites measuring shear and pressure w/PREDIA
  • Sacrum
  • Ischial Tuberosity
  • Heel
• Subjects also self-reported pain scores w/HOB positions
• Accelerometer used to distinguish run “events”
Fasten Your Seat Belts!
Fasten Your Seat Belts!
Average Shear at Sacrum

-5.00
-3.00
-1.00
1.00
3.00
5.00
7.00
9.00

Start Acceleration Turn Bumps Deceleration Stop

Shear (N)

Surface A - HOB 0
Surface B - HOB 0
Surface A - HOB 15
Surface B - HOB 15
Surface A - HOB 30
Surface B - HOB 30
Average Shear at IT

- Start Acceleration Turn Bumps Deceleration Stop

Shear (N)

Surface A - HOB 0  Surface B - HOB 0  Surface A - HOB 15  Surface B - HOB 15  Surface A - HOB 30  Surface B - HOB 30
Average Shear at Heel

-5.00 -3.00 -1.00 1.00 3.00 5.00 7.00 9.00

Start Acceleration Turn Bumps Deceleration Stop

Shear (N)

- Shear values for different stages of the process:
  - Surface A: HOB 0, HOB 15, HOB 30
  - Surface B: HOB 0, HOB 15, HOB 30
Average Shear at HOB 0

Shear (N)

<table>
<thead>
<tr>
<th>Start</th>
<th>Acceleration</th>
<th>Turn</th>
<th>Bumps</th>
<th>Deceleration</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface A - Sacrum</td>
<td>Surface B - Sacrum</td>
<td>Surface A - IT</td>
<td>Surface B - IT</td>
<td>Surface A - Heel</td>
<td>Surface B - Heel</td>
</tr>
<tr>
<td>1.00</td>
<td>3.00</td>
<td>5.00</td>
<td>7.00</td>
<td>9.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Average Shear at HOB 15
Average Shear at HOB 30

- Surface A - Sacrum
- Surface B - Sacrum
- Surface A - IT
- Surface B - IT
- Surface A - Heel
- Surface B - Heel

Shear (N)

- Start
- Acceleration
- Turn
- Bumps
- Deceleration
- Stop
Acknowledgements
Research Team
Thank You!