Faculty

Susan Kennerly, PhD, RN, CNE, WCC, FAAN  
Professor  
Department of Nursing Science  
School of Nursing  
East Carolina University  
Greenville, North Carolina

Chungmei Shih, MSN, RN, CNS, CWON  
Patient Care Manager, Wound/Ostomy Department  
Stanford Health Care  
Stanford, California

Barbara Mayer, PhD, RN  
Director, Nursing Quality & Practice  
Clinical Instructor, Division of General Medical Disciplines  
Stanford Health Care/Stanford Medicine  
Stanford, California

Tracey L. Yap, PhD, RN, CNE, WCC, FAAN  
Associate Professor  
Duke University School of Nursing  
Senior Fellow  
Duke University Center for Aging and Human Development  
Durham, North Carolina

Disclosures

Dr. Mayer: Co-author of manuscript—Leaf Healthcare

Dr. Kennerly, Ms. Shih, and Dr. Yap have disclosed no relevant financial relationships with any commercial interests.
Learning Objectives

• Describe current practices and state of the evidence regarding patient turning effectiveness in reducing facility-acquired pressure ulcers
• Explore technologies designed to monitor compliance with turning schedules and compare and contrast outcomes of pressure ulcer prevention practices coordinated by real-time monitoring technology versus traditional methods
• Review outcomes of a randomized controlled trial comparing optimal patient turning, achieved with the aid of a proprietary patient monitoring system, to that of traditionally coordinated turning practices in reducing the incidence of hospital-acquired pressure injuries
• Discuss current gaps in evidence and future evidence generation

Repositioning Effectiveness in Reducing Facility-Acquired Pressure Ulcers:

• Current Practices and State of the Science
• Current Gaps in Evidence and Future Evidence Generation

Pressure Ulcer

Definition:
Localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear.* Often immobile, and commonly elderly.

Key Causative Factor: Prolonged Pressure

Key Solution: Repositioning for Pressure Relief

What is Repositioning?

Movement from one body position into a different position to remove or redistribute pressure from a particular part of the body.* Turning is one method of changing body position.

Various features
- Positions used vary by individual, e.g. flat to upright
- Performed by self or assisted
- Methods include: turning, shifting, standing, and tilting
- Surface change may be involved, e.g. bed to chair
- Typically a pre-determined minimum interval, e.g. 2 hrs.


Prevention Effectiveness

Effectiveness degree to which something is successful in producing a desired result.

Our Desired Result Every patient be ulcer free

Current Prevention Effectiveness Measure = ↓ in PRU Incidence

Prevalence rates vary greatly across care settings and remain unacceptable.
- LTC ~ between 8.5 to 32% reported*
- Hospital ~ 11.9%**


Factors Affecting Pressure Tolerance

A complex interplay of factors affects tissue tolerance of pressure

Intrinsic Factors
- Skin condition
- Age
- Nutrition
- Mobility/activity/physical condition
- Temperature
- Incontinence
- Sensory perception

Extrinsic Factors
- Heat
- Friction/shear
- Humidity

No single factor explains PrU risk

Isn't everyone At Risk?

**Risk Assessment**
A process to identify potential hazards and help us anticipate events, like PrUs.

- Risk assessment is considered a prevention cornerstone; however, due to complexity perhaps it is an alert signal.*
- There is limited evidence:
  - Use of risk assessment tools is correlated with PrU incidence.**
  - An established PrU risk pattern is based on any combination of etiology, pathophysiology, or other factors.***
- There is much variation in factors and risk levels across individuals.
- We need to develop baseline evidence about a common pattern of risk factors and establish a baseline of safe, consistent care practices for all persons at risk, including those at low risk.

Any change in health condition affects risk factors.

---

**Multifaceted Approach to Prevention**

<table>
<thead>
<tr>
<th>Prevention Focus</th>
<th>Common Clinical Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>PrU risk assessment</td>
<td>• Develop targeted prevention plan</td>
</tr>
<tr>
<td></td>
<td>• Determine who is at risk</td>
</tr>
<tr>
<td>Preserve skin integrity</td>
<td>• Skin care (moisturize, clean, dry, moisture wicking briefs, avoid positioning on erythema)</td>
</tr>
<tr>
<td>Maintain good nutrition/hydration</td>
<td>• Nutritional support and/or supplementation program</td>
</tr>
<tr>
<td>Reduce or prevent friction and shear</td>
<td>• Caregiver lifting/moving guidelines</td>
</tr>
<tr>
<td>Redistribute pressure</td>
<td>• Appropriate surface</td>
</tr>
<tr>
<td>Minimize duration of pressure</td>
<td>• Reposition (position; tilt angle)</td>
</tr>
<tr>
<td></td>
<td>• Adequate decompression time</td>
</tr>
</tbody>
</table>

---

**Repositioning Standards**

**Standard practice**
Based on achieving adequate decompression:

- Prior position area offloaded
- New position sustained ≥ 15 minutes
- 30 degree tilt desired
- Establish an effective position sequence
- Reposition at regular intervals, typically every 2 hours

**So, why are we not as effective as we want?**
Practicality and standard of every 2 hour repositioning lacks evidence; even National Pressure Ulcer Advisory Panel failed to reach consensus.
Barriers to Repositioning Effectiveness

<table>
<thead>
<tr>
<th>Care Goal</th>
<th>Implementation Challenge</th>
</tr>
</thead>
</table>
| Achieving an adequate turn for ≥ 15 minute decompression | • Patients turn back  
• Insufficient wedges and pillows  
• Lack of repositioning education and training |
| Establishing and documenting an effective repositioning sequence | • Traditional position sequence (in bed) left side, back, right side, back  
• Document by exception without accountability |
| Regular, on-time repositioning (Compliance) | • Other care priorities supersede repositioning  
• Staff on-time compliance low (~ 60%) |

Common challenges to all care goals include:  
• Limited nursing time  
• Culture norms (behaviors and expectations)  
• Teamwork/Communication  
• Complex interactions between risk factors; therefore, using a total risk score to develop individualized prevention plans is illogical

Repositioning as a Regimen

A systematic prescribed course of patient repositioning care aimed at relieving or redistributing the pressure to reduce the risk of PrU development.

<table>
<thead>
<tr>
<th>Regimen (SIP)</th>
<th>Traditional</th>
<th>Emerging Evidence</th>
<th>Contingencies</th>
</tr>
</thead>
</table>
| Surface       | Standard mattress | Redistributing pressure mattresses  
- Mattress integrity  
- Staff knowledge |
| Interval      | Q2h | Potential to extend from Q2 to 3 or 4hr  
- Surface  
- Repositioning compliance |
| Position      | Alternate supine & lateral  
30 degree Tilts | - Sustaining position  
- Self movements |

Surface Evidence

Support surfaces should constitute part of an overall preventive approach.

- Patients lying on ordinary foam mattresses are more likely to get PrUs than those lying on a higher-specification foam.
- Patients lying on sheepskin overlays on mattresses are less likely to develop PrUs.
- The merits of higher-specification constant low-pressure and alternating-pressure support surfaces for preventing PrU development is unclear.

Rigorous research is needed comparing different support surfaces.
Interval Evidence

Only 2 repositioning studies in the last 12 years merit consideration:

1. Tom DeFloor’s (2005) Study (UK)
   Found fewer PrUs on residents using visco-elastic (VE) foam surfaces with a 4 hour repositioning interval than on non-VE surfaces with more frequent repositioning.

   Found no significant differences in PrU incidence (3 weeks) between 2, 3, or 4 hour repositioning for moderate and high risk residents using VE surfaces.

Protocol compliance and staff documentation...


Position Evidence

30° Supine Tilt Position

Although tilting has been shown to be most beneficial, further research is needed to evaluate if this position can be adopted by the patients and how this position can best be combined with other positions.

Semi-Fowler’s Positions

Need to evaluate how the tissue is affected in different Semi-Fowler’s positions because these are commonly used in clinical practice.

There is a need for high-quality, adequately-powered trials to assess the effects of position and optimal frequency


Current Repositioning Evidence

What we know
- Prolonged pressure leads to PrUs
- Repositioning promotes decompression

Areas where evidence is lacking
- How does repositioning really work in practice as a preventive strategy?
- How are tissue responses affected by different pressure loads as the body is placed in different positions?
- Is there an ideal repositioning interval?
- What is the optimal repositioning regimen (intervals, surfaces, and positions)?
Improving Prevention Effectiveness

“The exact frequency and the method of repositioning to adopt remains unclear”

Improving prevention effectiveness begins with establishing a baseline of evidence.

- Measure effectiveness of interventions individually—interval, surface, position.
- Examine nursing adherence to repositioning protocols and feasibility of mechanisms for enhancing compliance.
- Establish a means of automating real-time documentation of repositioning.
- Evaluate system level factors influencing repositioning capacities (staff level resources, resource costs).


Build on Baseline Evidence

Leverage baseline evidence to explore the interaction effects of interventions.

- Examine effective position and repositioning intervals at the same time, while using a protective surface (e.g., high-density foam) to establish a safe repositioning regimen.
- Determine to what extent patients minor movements between nursing staff-induced repositionings support offloading of tissues.
- Examine how staff carry out preventive repositioning interventions.
- Explore the efficacy of preventive measures by PrU risk group (mild, moderate, high, very high).

Repositioning Effectiveness in Reducing Facility-Acquired Pressure Ulcers:

Technology’s Potential to Bridge Gaps in Evidence
Emerging Technology Innovations

Despite existing gaps in evidence, technological innovations offer promise for facilitating PrU prevention.

New sensor technologies offer new opportunities to:

- Facilitate prevention care rather than treatment
- Improve quality of life and create new economic efficiencies.
- Expand our capabilities at two levels:
  - Patient Level
  - System Level

Embracing Technology to Facilitate Repositioning

What if we could increase our capabilities to use repositioning data to inform both practice and research?

<table>
<thead>
<tr>
<th>Patient Level</th>
<th>System Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Track position, degree of tilt, self movement, and decompression time</td>
<td>• Dashboards cue staff and promote on-time repositioning</td>
</tr>
<tr>
<td>• Document repositioning activity</td>
<td>• Enables determination of repositioning compliance</td>
</tr>
<tr>
<td>• Tailor repositioning interval to support patient needs (sleep and quality of life)</td>
<td>• Provides staff feedback to reinforce accountability</td>
</tr>
<tr>
<td></td>
<td>• Facilitates teamwork and communication to enhance staff workflow</td>
</tr>
</tbody>
</table>

Adaptive and Technical Challenges Associated with Use of Nursing Home Resident Monitoring Technology in Pressure Ulcer Prevention: A Pilot Study

Design

- Convergent mixed methods pre/post-test intervention
- Compare nursing home resident and staff outcomes.

Methods

Wireless sensor worn mid-sternum was used to:

- Monitor resident position and movement 24 hours/day
- Cue staff when repositioning was required

Duration: 3-day baseline; 21-day intervention

Data collected: resident position, changes in position, and repositioning frequency
Adaptive and Technical Challenges Associated with Use of Nursing Home Resident Monitoring Technology in Pressure Ulcer Prevention: A Pilot Study

Residents monitored (2 or more days): n=44

- Staff on-time repositioning compliance improved from 10.6% to 66% on all shifts with use of sensor system.
- Staff responded positively to the sensor system visual repositioning cues.
- Staff reported an enhanced sense of teamwork in order to achieve on-time repositioning, believing that usual care was provided faster as a result of repositioning when prompted by the system cues.

Repositioning Effectiveness in Reducing Facility-Acquired Pressure Ulcers:

Future Evidence Generation

- Nursing should not uncritically assume PrU prevention is a measure of the quality of care specific to preventive care delivered.
- Newer technology opens the door for consideration of different repositioning/turning schedules
- Testing interventions to manage risk factors
- Determine the efficacy of specific interventions based on severity of subscale risk.
- Both efficacy and effectiveness studies are needed.
- Systematically examine repositioning care as a regimen.
Evidence for Optimizing Intervals

<table>
<thead>
<tr>
<th>Study</th>
<th>Braden Scale Score</th>
<th>2-hour</th>
<th>3-hour</th>
<th>4-hour</th>
<th>6-hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defloor, et al. 2005</td>
<td>13.0 ± 2 (Moderate to high)</td>
<td>9/63 (14%) Standard Mattress</td>
<td>14/58 (24%) Standard Mattress</td>
<td>2/66 (3%) Visco-elastic Mattress (15cm)</td>
<td>10/63 (15.9%) Visco-elastic Mattress (15cm)</td>
</tr>
<tr>
<td>Belgium (n=761)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bergstrom, et al. 2013</td>
<td>8/321, 2.5%</td>
<td>2/326, 0.6%</td>
<td>8/295, 2.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA (n=942)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

High-density Foam Mattresses

Preventing Pressure Ulcers with Repositioning Frequency and Precipitating Factors

5 year, three-arm, cluster randomized trial with 6-week intervention period at each nursing home (NH).
Each NH has a facility-wide repositioning interval (2, 3, or 4 hr) and integrates sensor monitoring and scheduling of resident repositioning; time to next repositioning resets with assisted and self movement.

Specific Aims:
- Determine differences in incidence of new pressure ulcers for residents repositioned at 2, 3, or 4 hour intervals.
- Determine how medical severity components change in relation to risk level and repositioning schedule.
- Evaluate individual/system-level costs, as well as resident/staff satisfaction.

Thank You

Susan Kennerly, PhD, RN, CNE, WCC, FAAN
kennerlys16@ecu.edu

Tracey L. Yap, PhD, RN, CNE, WCC, FAAN
tracey.yap@duke.edu
Technology vs Tradition

Monitoring Turning Compliance

Historical Perspective

Edwin Smith Papyrus
3000 BC

5000 Years of Pressure Injuries

Historical Perspective

Ambroise Paré
1510–1590
“…we should make him a little pillow of down to keep his buttock in the air, without his being supported on it.”
Leicester, 1982

Charles-Édouard Brown-Séquard
1817–1894
“…no ulceration appeared when I took care to prevent … a continued state of compression…”
Cediac, 2014
Effective Turning

- Effective turning includes
  - Frequency
  - Angle
  - Duration

Monitoring Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Type</th>
<th>Frequency</th>
<th>Effectiveness</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>Direct</td>
<td>✓</td>
<td></td>
<td>Central &amp; Bedside, No</td>
</tr>
<tr>
<td>Pressure Mapping</td>
<td>Direct</td>
<td>✓</td>
<td>✓</td>
<td>Central &amp; Bedside, Yes</td>
</tr>
<tr>
<td>Wearables</td>
<td>Direct</td>
<td>✓</td>
<td>✓</td>
<td>Central &amp; Bedside, Yes</td>
</tr>
</tbody>
</table>

Traditional Monitoring

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turning Clocks</td>
<td>Easy to use, visible</td>
<td>Inconsistent completion, accuracy</td>
</tr>
<tr>
<td>Checklists/Forms</td>
<td>Comprehensive, easy to use, visible</td>
<td>Inconsistent completion, questionable accuracy, easily outdated</td>
</tr>
<tr>
<td>Chart Review</td>
<td>Comprehensive data, sample can be large</td>
<td>Retrospective, time consuming</td>
</tr>
<tr>
<td>Observation</td>
<td>Concurrent, ability to address immediately</td>
<td>Labor and time intensive, small data sets, biased?, inconsistent</td>
</tr>
<tr>
<td>Physical Assessment</td>
<td>Concurrent</td>
<td>Competency, time, inability to track</td>
</tr>
</tbody>
</table>
Continuous Bedside Pressure Mapping

“Smart” Beds

Continuous Bedside Pressure Mapping

- Sensor placed within or under the mattress
- Provide continuous monitoring of
  - Heart rate
  - Respiratory rate
  - Movement
  - Pressure
- Continuously retrieves data from sensors and transfers to a visual display providing
  - Pattern recognition of patient movement
  - Real-time image to more effectively position patient
  - Alerts to staff based on each patient’s predefined protocol


Evidence: CBPM

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Design</th>
<th>Setting</th>
<th>N</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sakai K, et al.</td>
<td>Prospective clinical study</td>
<td>ICU, acute care hospital</td>
<td>30</td>
<td>CBPM reduces intensity and duration of pressure sores in ICU setting</td>
</tr>
<tr>
<td>Zimlichman E, et al.</td>
<td>Retrospective, pilot study</td>
<td>Medical unit, acute care hospital</td>
<td>1659</td>
<td>61% decrease in new PI (P = .04), 99% agreement that alerts 1 turn frequency</td>
</tr>
<tr>
<td>Zimlichman E, et al.</td>
<td>Prospective clinical study</td>
<td>Medical unit, acute care hospital</td>
<td>116</td>
<td>1.5 x increase in # turns (P = .08)</td>
</tr>
<tr>
<td>Zimlichman E, et al.</td>
<td>Prospective clinical study</td>
<td>Medical unit, acute care hospital</td>
<td>9</td>
<td>58% decrease in PI (P = .007)</td>
</tr>
<tr>
<td>Scott RG, et al.</td>
<td>Prospective clinical study</td>
<td>Long-term care hospital</td>
<td>10</td>
<td>24% increase in peak pressure when CBPM visible</td>
</tr>
<tr>
<td>Behrendt R, et al.</td>
<td>Prospective controlled study</td>
<td>MICU, academic medical center</td>
<td>422</td>
<td>29% fewer new PI (P = .001), 99% accuracy of visual cues to effectively position patients</td>
</tr>
</tbody>
</table>

CBPM = Continuous Bedside Pressure Mapping; ICU = Intensive Care Unit; MICU = Medical ICU; PI = Pressure Injury.
Wearable Devices

"Devices that can be worn or mated with human skin to continuously and closely monitor an individual’s activities, without interrupting or limiting the user’s motions."

"Wearable devices are restricted by several factors. The most critical elements are size, battery life, weight, and capability of adding on-board sensors."

<table>
<thead>
<tr>
<th>Product</th>
<th>Sensor Placement</th>
<th>Data Monitored</th>
<th>Sensor</th>
<th>Monitored</th>
<th>Nurse Alert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Monitoring System</td>
<td>High risk areas of the body</td>
<td>Turning frequency, pressure</td>
<td>Reusable, bedside &amp; central</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Wireless Patient Monitoring System</td>
<td>Upper chest</td>
<td>Turning frequency, turning effectiveness, mobility tracker</td>
<td>Disposable, bedside &amp; central</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Smart Bandage</td>
<td>High risk areas of the body</td>
<td>Pressure-induced tissue damage</td>
<td>Disposable, bedside</td>
<td>Unknown, Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
**Evidence: Smart Bandage**

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Design</th>
<th>Affiliation</th>
<th>Participants</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swisher SL, et al.</td>
<td>Proto-type</td>
<td>UC Berkeley, UCSF</td>
<td>Pre-clinical</td>
<td>Impedance is correlated with tissue health and can detect early tissue damage from pressure</td>
</tr>
<tr>
<td>Farooqui MF, et al.</td>
<td>Proto-type</td>
<td>Abdullah University</td>
<td>N = 1</td>
<td>The device was able to detect bleeding, pH levels, and external pressure levels</td>
</tr>
</tbody>
</table>

**Evidence: Pressure Monitoring System**

- Only 1 product trial result available

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Design</th>
<th>Setting</th>
<th>N</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dudziak S, et al.</td>
<td>Pre-post test</td>
<td>120-bed long-term facility</td>
<td>77</td>
<td>- 60% reduction in HAPI&lt;br&gt;• $343,000 in saving</td>
</tr>
</tbody>
</table>

**Evidence: Wireless Patient Monitoring System**

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Design</th>
<th>Setting</th>
<th>N</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parker C, et al.</td>
<td>Pre-post test</td>
<td>Med-Surg units, Community hospital</td>
<td>138</td>
<td>- 103% average turn compliance&lt;br&gt;• 79% reduction in rental bed cost</td>
</tr>
<tr>
<td>Cosdon K, et al.</td>
<td>Pre-post test</td>
<td>Med-Surg unit, Teaching hospital</td>
<td>69</td>
<td>- 90.2% average turn compliance</td>
</tr>
<tr>
<td>Walters B, et al.</td>
<td>Pre-post test</td>
<td>ICU, county teaching hospital</td>
<td>451</td>
<td>- 93% average turn compliance&lt;br&gt;• 25% reduction in HAPI incidence</td>
</tr>
</tbody>
</table>
Evidence: Wireless Patient Monitoring System (cont’d)

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Design</th>
<th>Setting</th>
<th>N</th>
<th>Results</th>
</tr>
</thead>
</table>
- 38% reduction in overall facility HAPI incidence |
| Larson B, et al. Presented at NPUAP; 2017. | Retrospective | 11 units at 4 acute care hospitals | 4209 | - 54% increase in average turn compliance  
- HAPI incidence was over 5× more likely in patients with a turn compliance < 85% |
| Pickham D, et al. 2017; In preparation. | Randomized controlled trial | 2 ICUs, Academic medical center | 1226 | - 13% increase in average turn compliance  
- 73% reduction in HAPI incidence  
- No HAPI in patients with greater than 80% turn compliance |

Summary

- Routine repositioning remains the gold standard for pressure injury prevention
- Technology supporting this clinical practice is an emerging market
- Supportive evidence is in its infancy
- Need for further high-quality studies (Cochrane review)

Thank you!

Barbara Mayer, PhD, RN, CNS
bmayer@stanfordhealthcare.org

Chungmei Shih, MSN, RN, CWON, CNS
cshih@stanfordhealthcare.org