Preventing ICU Complications

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Improving the ICU

- Major component of health care systems
- Cost
  - US health care most expensive
- Quality
  - Ranking 37th in overall performance and 72nd in population health
- Variation in practice – in a bad way
  - Lack of standardization

Institute of Medicine Round Table Report

Serious and widespread quality problems exist throughout American medicine. These...occur in small and large communities alike, in all parts of the country and with approximately equal frequency in managed care and fee for-service systems of care. Millions of Americans are not reached by proven effective interventions that can save lives and prevent disability. Perhaps an equal number suffer needlessly because they are exposed to the harms of unnecessary health services. Large numbers are injured because preventable complications are not averted...Quality of care is the problem.

Goals for Improvement

- Reduce complications
- Reduce cost
- Improve Survival
- Improve meaningful survival
Preventable Complications
- Health Care Associated Infections
- CRBSI
- VAP
- Pressure Ulcer
- Delirium
- Mobilization

Hand Hygiene
- Most effective way to decrease transmission of nosocomial pathogens
- Non-compliance is well documented
- Physicians are worst offenders

Hand Washing Decreases Nosocomial Infections

Use Alcohol-based Hand Rub

Figure 3: Trends in prevalence of nosocomial infections and annual attack rate of MRSA, 1993–98, University of Geneva Hospitals

Hand Hygiene

- May 5th is Hand Hygiene day
- 100K lives campaign
- Costs of Health Care Associated Infections
  - $28.4-33.8 Billion
  - 20% potentially avoidable
- Hand hygiene is a surrogate measure

Catheter Related Blood Stream Infection

- Epidemiology of CRBSI
  - > 5 million central venous catheters inserted each year (15 million CVC days)
  - CRBSI occurs with 3-5% of catheters and affects more than 250,000 patients per year in the US (5.3 per 1000 catheter days)
  - Prolong hospitalization by 7 days
  - Mortality: 5-35%
    - 2500 to 20,000 deaths per year
  - UCSF cost $80,000/CRBSI

- CRBSI Prevention Bundle
  - Hand hygiene
  - Maximal barrier precautions (mask, gown, gloves and full barrier drapes)
  - Chlorhexidine skin antisepsis
  - Optimal catheter site selection, with subclavian vein as the preferred site for non-tunneled catheters in adults
  - Ultrasound guidance
  - Daily review of line necessity with prompt removal of unnecessary lines

Institute for Healthcare Improvement
An Intervention to Decrease Catheter-Related Bloodstream Infections in the ICU

Pronovost, Peter, et al. NEJM 2006

Objectives: To improve the rate of catheter-related bloodstream infections (CRBSI) in ICUs.

Methods: A multifaceted intervention aimed at improving catheter care was implemented in 18 ICUs from a baseline of 108 ICUs in Michigan.

Interventions: Handwashing, full barrier precautions, chlorhexidine prep, avoiding femoral lines, asking about removal on rounds.

CRBSI Prevention

Pronovost et al, NEJM 2006

Table 2. Baseline Data.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of ICUs</th>
<th>No. of Infections</th>
<th>Catheter-Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>median (Interquartile range)</td>
<td></td>
</tr>
<tr>
<td>All hospitals</td>
<td>55*</td>
<td>2 (1–3)</td>
<td>511 (220–1091)</td>
</tr>
<tr>
<td>Teaching status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching</td>
<td>33</td>
<td>2 (1–4)</td>
<td>744 (377–1134)</td>
</tr>
<tr>
<td>Nonteaching</td>
<td>22</td>
<td>1 (0–2)</td>
<td>306 (194–604)</td>
</tr>
<tr>
<td>No. of beds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;200</td>
<td>13</td>
<td>1 (0–1)</td>
<td>247 (75–377)</td>
</tr>
<tr>
<td>200–299</td>
<td>12</td>
<td>2 (1–6)</td>
<td>595 (328–1670)</td>
</tr>
<tr>
<td>300–399</td>
<td>12</td>
<td>2 (1–3)</td>
<td>902 (184–1376)</td>
</tr>
<tr>
<td>≥400</td>
<td>18</td>
<td>2 (1–3)</td>
<td>616 (424–1102)</td>
</tr>
</tbody>
</table>

Follow-up study

- Questions were raised about sustainability
- 90 ICU included from the original 108
- Maintained low rates with median of 0 infections per 1000 catheter-days

Reduction in CRBSI

Pronovost et al, NEJM 2006

Table 1. Rates of Catheter-Related Bloodstream Infection from Baseline (before implementation of the Study Intervention) to 18 Months of Follow-up.*

<table>
<thead>
<tr>
<th>Study Period</th>
<th>No. of ICUs</th>
<th>No. of bloodstream infections per 1000 Catheter-Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall</td>
<td>Teaching Hospital</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nonteaching Hospital</td>
</tr>
<tr>
<td>Baseline</td>
<td>55</td>
<td>2.7 (1.3–4.6)</td>
</tr>
<tr>
<td>During implantation</td>
<td>95</td>
<td>1.1 (0–4.9)</td>
</tr>
<tr>
<td>After implantation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–3 mos</td>
<td>96</td>
<td>0 (0–3.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 (0–1.0)</td>
</tr>
<tr>
<td>4–6 mos</td>
<td>96</td>
<td>0.6 (0–7.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 (0–4.0)</td>
</tr>
<tr>
<td>7–9 mos</td>
<td>95</td>
<td>0.0 (0–2.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 (0–0.5)</td>
</tr>
<tr>
<td>10–12 mos</td>
<td>90</td>
<td>0.0 (0–11.9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 (0–0.5)</td>
</tr>
<tr>
<td>13–15 mos</td>
<td>85</td>
<td>0 (0–1.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 (0–0.5)</td>
</tr>
<tr>
<td>16–18 mos</td>
<td>70</td>
<td>0 (0–2.0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 (0–0.5)</td>
</tr>
</tbody>
</table>
Sustained low rates

Impact of this initiative

- Implementation of the Keystone project was associated with a reduction in hospital mortality
- Not powered sufficiently to demonstrate decrease in length of stay
- Recommended similar pursuits on a larger scale

<table>
<thead>
<tr>
<th>Study period</th>
<th>No. of UHC</th>
<th>Median (95%CI)</th>
<th>Median (95%CI)</th>
<th>Median (95%CI)</th>
<th>Median (95%CI)</th>
<th>Incidence (95%CI #/1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>55</td>
<td>2.5 (-0.9-5.5)</td>
<td>4.7 (-0.9-8.4)</td>
<td>2.7 (-0.9-6.2)</td>
<td>0.2 (-0.9-6.2)</td>
<td>7.1 (-9.1 to 23.3)</td>
</tr>
<tr>
<td>During implementation</td>
<td>96</td>
<td>1.0 (0.5-1.5)</td>
<td>3.0 (1.5-5.5)</td>
<td>0.3 (0.1-0.6)</td>
<td>0.1 (0.0-0.5)</td>
<td>4.1 (3.0 to 10.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After implementation</td>
<td>96</td>
<td>0.5 (0.3-0.7)</td>
<td>1.0 (0.5-1.5)</td>
<td>0.1 (0.0-0.3)</td>
<td>0.0 (0.0-0.3)</td>
<td>1.0 (0.7 to 1.3)</td>
</tr>
<tr>
<td>3-6 months</td>
<td>75</td>
<td>0.5 (0.3-0.7)</td>
<td>1.0 (0.5-1.5)</td>
<td>0.1 (0.0-0.3)</td>
<td>0.0 (0.0-0.3)</td>
<td>1.0 (0.7 to 1.3)</td>
</tr>
<tr>
<td>7-9 months</td>
<td>96</td>
<td>0.5 (0.3-0.7)</td>
<td>1.0 (0.5-1.5)</td>
<td>0.1 (0.0-0.3)</td>
<td>0.0 (0.0-0.3)</td>
<td>1.0 (0.7 to 1.3)</td>
</tr>
<tr>
<td>9-12 months</td>
<td>75</td>
<td>0.5 (0.3-0.7)</td>
<td>1.0 (0.5-1.5)</td>
<td>0.1 (0.0-0.3)</td>
<td>0.0 (0.0-0.3)</td>
<td>1.0 (0.7 to 1.3)</td>
</tr>
<tr>
<td>12-15 months</td>
<td>60</td>
<td>0.5 (0.3-0.7)</td>
<td>1.0 (0.5-1.5)</td>
<td>0.1 (0.0-0.3)</td>
<td>0.0 (0.0-0.3)</td>
<td>1.0 (0.7 to 1.3)</td>
</tr>
</tbody>
</table>

CRBSI Reduction at UCSF

- In 2004: 19,536 patient days, 12,052 line days
  - CRBSI rate = 3.7/1000 line days, 47 CRBSI’s
  - Attributable deaths => 16
- Program implemented in 2005
- In 2006: 24,408 patient days, 12,769 line days
  - CRBSI rate = 1.7/1000 line days, 22 CRBSI’s
  - Attributable deaths => 8
- Estimated 8 lives saved

<table>
<thead>
<tr>
<th>Year</th>
<th>CRBSI’s x $80K</th>
<th>Estimated Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>47</td>
<td>$3,760,000</td>
</tr>
<tr>
<td>2006</td>
<td>22</td>
<td>$1,760,000</td>
</tr>
</tbody>
</table>

Additions to the bundle

- Closed manifold system
- Luer lock systems
- Antibiotic impregnated catheters
  - Effective but cost savings variable
- New 2011 CDC guidelines now treat arterial lines with CRBSI and have similar guidelines
  - Cap, mask, sterile gloves, chloroprep
- Chlorhexidine impregnated sponges
Chlorohexidene sponge

- Ruschulte et al – heme/onc patient (11.3 vs 6.3)
- Use of chlorohexidine sponge able to reduce baseline rates of infection from 1.3 to 0.4/1000
- Potential savings of $83-$197 depending on interval of dressing changes

Zero risk?

- Reasonable goal?
- New South Wales, Australia (ICUs)
- No zero risk, but was able to identify the lowest cumulative probability (1 in 100 chance)
- Able to reduce rates from 3.8 to 1.6 /1000
- The insertion bundle is able to increase the lowest risk from 7 => 9 days

Quality of Surveillance

- Publishing infection rates
- 20 ICU at 4 medical centers
- Institutional versus computer generated results
  - 3.3 versus 9.0 /1000 central line days
- In the future, electronic medical records may improve the quality of surveillance

Zero Risk? (cont)

- Risk is never zero
- Key is to remove central line when no longer needed
- Insertion bundle was successful in minimizing placement risk
Ventilator Associated Pneumonia

- A leading cause of death among hospital acquired infections
- Increased length of time on ventilator, LOS in both the ICU and hospital.
- Mortality with VAP 46% versus 32%
- Estimated cost is > $40,000 (2004)

CDC Definition

Variable reportability

- 50 retrospective chart review (3 assessors + 1 physician)
- Results for the assessors:
  - Agreed on 7 patients with VAP and 24 without VAP
  - Disagreed on remaining 19 (62% agreement on components)
- Physician was able to diagnose 7 patients, 3 uniformly agreed by the assessors and 1 patient who did not meet criteria

Criteria for ventilator associated complications (VAC)

- An increase in the patient’s daily minimum PEEP by 2.5 cm H₂O sustained for ≥ 2 days or an increase in the daily minimum FiO₂ by ≥ 15% sustained for ≥ 2 days after a minimum of 2 days of stable or decreasing values.
- Patients with persistently elevated PEEP (≥ 7.5 cm H₂O) or FiO₂ (≥ 70%) during the first 3 days of mechanical ventilation were only eligible if they stabilized and required minimal ventilator support.

New streamlined surveillance definition

Table 2. A new streamlined surveillance definition for ventilator-associated pneumonia

<table>
<thead>
<tr>
<th>Any one of the following</th>
<th>Any one of the following</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Opacity, infiltrate, or consolidation that appears, evolves, or persists over &gt;72 hrs</td>
<td>1. Temperature &gt;100.4°F within past 24 hrs</td>
</tr>
<tr>
<td>2. Cough</td>
<td>2. White blood cell &lt;4,000 or &gt;10,000 white blood cells/mm³ within past 24 hrs</td>
</tr>
<tr>
<td>Both of the following</td>
<td>Both of the following</td>
</tr>
<tr>
<td>1. Two days of stable or decreasing daily minimum Pao₂ followed by increase in daily minimum Pao₂ &gt;15 points sustained for ≥ 2 calendar days or 2 days of stable or decreasing daily minimum positive end-expiratory pressure followed by increase in daily minimum positive end-expiratory pressure by ≥2.5 cm H₂O sustained for ≥ 2 calendar days</td>
<td>1. Gram-negative stain of respiratory secretions with moderate (2+) or more neutrophils per low-power field within 72 hrs</td>
</tr>
</tbody>
</table>

HOB Interventions Implemented

- Made a “standing order” on ICU admission
- Incorporated assessment of HOB and intervention into the Adult Critical Care Standards of Care
- Utilized data: HOB gauge vs. visual assessment
- Documentation/Flowsheet prompt added
- Signage added
- Intensivist, RCP & RN focus on ICU rounds
- Monitored compliance and reinforced practice

Ventilator Bundle

- Elevation of the Head of the Bed
- Daily "Sedation Vacations" and Assessment of Readiness to Extubate
- Peptic Ulcer Disease Prophylaxis
- Deep Venous Thrombosis Prophylaxis
- Daily Oral Care with Chlorohexidine

Institute for Healthcare Improvement

Helman et al Crit Care Med 2003 31(9):2285-90
Nurse/Therapist-Driven Weaning Protocols

- Randomized, controlled trial of 300 patients
- Physician order versus RN and RT driven weaning trials
- Duration of mechanical ventilation and cost were both lower
- Less complications in intervention group
- Fewer reintubations


Daily Interruption of Sedative Infusions

- 128 mechanically ventilated patients
- Intervention: Daily interruption of sedative infusions
- Duration of mechanical ventilation: 4.9 days vs 7.3 days (p=0.004)
- ICU median LOS: 6.4 days vs 9.9 days (p=0.02)


Awakening and Breathing Controlled Trial

- 336 mechanically ventilated patients
- Combined SAT with SBT
- More self-extubations in intervention group, but equivalent number or reintubations
- More days without assistance (3.1 days)
- Fewer ICU days (9.1 versus 12.9)
- Decreased mortality – NNT 7


Other components of the bundle

- Peptic Ulcer Prophylaxis
  - Five fold increase in mortality for patients with GI bleed
  - Address the subject
- DVT prophylaxis
  - Higher incidence of venous thrombosis in sedentary patients
- When all components of bundle implemented, demonstrated significant reduction in VAP rates.
Oral decontamination

- 2007 meta-analysis
  - 11 trials, 3242 patients
- VAP reduced by oral mouthwash only
- Less VAP, same mortality same length of ventilation
- Chlorhexidine most extensively studied oral antiseptic
- Safe, cheap and easy to apply

Chan, E et al. BMJ 2007 334: 889-900

Wide scale application

- The 5 evidence based recommendations from the IHI were implemented
- 71% reduction in VAP rates, sustained up to 2.5 years.


Graphical interpretation

Impact of this initiative

- Implementation of the Keystone project was associated with a reduction in hospital mortality
- Not powered sufficiently to demonstrate decrease in length of stay
- Recommended similar pursuits on a larger scale

**Micro-Aspiration**
- Aspiration still occurs despite having endotracheal tube, as secretions channel through folds in cuff.
- Experiments with cuff profile
- Taper shaped cuff
- Cuff material is minimized
- Limited pathway for aspiration

*Lorente et al. AJRCCM Vol 176 pp 1079–1081, 2007*

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**Cuff Technology**
- Unique tapered shape
- Reduction in folds and channels
- Even lower occlusive pressures (20% lower)
- Improvement in quality of seal (reducing microaspiration by 95%)
- Not 100% occlusive

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**Continuous aspiration of subglottic secretions**
- Continuous aspiration of subglottic secretions (CASS)
- 5 studies, 896 patients intubated
  - Continuous aspiration
  - Halved incidence VAP
  - Reduced length of ICU stay
  - Reduced antibiotic use

Continuous Aspiration of Subglottic Secretions

- Requires intubation with special tube
- Separate dorsal lumen that opens into subglottic area
- Aspiration may be continuous or intermittent
- Requires frequent monitoring
- Cost is approximately 25% higher than standard endotracheal tubes

Preventable?

- No clear objective determinant of the clinical diagnosis
- Many of the studies have other confounders which may represent the perceived improvement
- “Immortal Time Bias”
  - Must be event-free and alive until enrollment
- Need more outcome measures demonstrating use of bundles

Pressure Ulcers

Incidence and Cost

- Incidence ranging from 0.4% to 38%
- 2.5 million patients treated annually in US acute care facilities for pressure ulcers related complications
- Once pressure ulcer develops, mortality is increased by 2-6 fold with 60,000 deaths
- Total annual cost $11 billion
Pressure Ulcers

- Localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure or in combination with shear or friction.
- Identifying patients at risk and identifying early skin changes can allow early intervention to prevent a pressure ulcer from developing.

Function of both time and \textbf{pressure} (hyperbolic curve)
- 32 mmHg sufficient to disrupt blood flow
- 70mmHg \textbf{pressure} for two hours produces irreversible injury

Staging

Sites

- \textbf{Sacrum} - most common site (30%)
  - Slouching in bed or chair
  - Higher risk in incontinent pts
- \textbf{Heels} - 2\textsuperscript{nd} most common (20%)
  - Immobile or numb legs
  - Higher risk with PVD & diabetes neuropathy
- Trochanter
- Device related
**Pressure Ulcer Bundle**

- Conduct a pressure ulcer admission assessment for all patients
- Reassess risk for all patients daily
- Inspect skin of at-risk patients daily
- Manage Moisture
- Optimize nutrition/hydration
- Minimize pressure

**Risk identification**

- Norton: 1-4 point scoring system rating patients (physical condition, mental status, activity, mobility, and incontinence) – score of 14 or less indicates risk of PU development.
- Braden: 1-4 point scoring system rating patients (sensory perception, moisture, activity, mobility, nutrition and friction/shear) – score of 18 or less indicates risk PU development.

**Braden Scale**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory</td>
<td>Completely Limited</td>
<td>Very Limited</td>
<td>Slightly Limited</td>
<td>No Impairment</td>
</tr>
<tr>
<td>Perception</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>Constantly Moist</td>
<td>Very Moist</td>
<td>Occasionally Moist</td>
<td>Rarely Moist</td>
</tr>
<tr>
<td>Activity</td>
<td>Bedfast</td>
<td>Chairfast</td>
<td>Walks Occasionally</td>
<td>Walks Frequently</td>
</tr>
<tr>
<td>Mobility</td>
<td>Completely immobile</td>
<td>Very Limited</td>
<td>Slightly Limited</td>
<td>No Limitation</td>
</tr>
<tr>
<td>Nutrition</td>
<td>Very Poor</td>
<td>Probably Inadequate</td>
<td>Adequate</td>
<td>Excellent</td>
</tr>
<tr>
<td>Friction &amp; Shear</td>
<td>Problem</td>
<td>Potential Problem</td>
<td>No Apparent Problem</td>
<td></td>
</tr>
</tbody>
</table>

**Braden Scores:**

- < 9 indicates severe risk
- 10-12 indicates high risk
- 13-14 indicates moderate risk
- 15-18 indicates mild risk
Minimize pressure

- Frequent small position changes (every 1.5 to 4 hrs)
- Keep reclining chair and bed below 30 degree angle to decrease pressure load
- Sitting: may need hourly position changes
- Increase mobility/Consult PT/OT

Minimize pressure (Support surfaces)

- Order air mattress if turning protocols are ineffective
- Reposition off of any know ulcers
- Use pillows to pad bony prominences
- Float heels with pillow lengthwise under calves

Minimize friction and shear

- Use draw sheet under patient to assist with moving
- Do not drag over mattress when lifting up in bed
- Avoid mechanical injury- use slide boards, turn sheet, trapeze, corn starch

Manage Moisture

- Cleanse skin at time of soiling and use absorbent
- Provide a non-irritating surface
- Barrier ointments and pads
- Utilize appropriate fecal/urinary collection devices
Nutrition/hydration

- Skin condition reflects overall body function
- Skin breakdown may be evidence of general catabolic state
- Increase hydration & caloric needs
- Nutritional goals: ↑ protein intake 1.2-1.5 gm/kg body weight daily—unless contraindicated
- Consider vitamin supplementation

Education and Quality Initiatives

- Prospective cohort study
- Implemented prevention guidelines
- Educate all players
- Multidisciplinary approach
- Timely transfer to a specific pressure reducing device
- 40% reduction in pressure ulcers


Quality Initiatives

- Expensive but can expand coverage or outcomes
- University of Massachusetts
  - Academic setting covering 2+ years
  - Already established ICU structure

Tele-medicine

- Expensive but can expand coverage or outcomes
- University of Massachusetts
  - Academic setting covering 2+ years
  - Already established ICU structure

Performance Measures

- Improved compliance and adherence to processes
- Decreased complication rates

Outcomes (Tele-medicine)
**Constant review of processes**

- Adverse events occurred in up to 16% of hospitalized patients with 57% preventable
- Morbidity/Mortality Conferences
  - Prospective review of all mortalities and adverse events (cardiac arrest, unplanned extubation, reintubation within 24 hrs and readmission within 48 hrs)
  - Multidisciplinary group (including nurses and physicians)


**Conclusion**

- Improve surveillance
- Improve uniform adherence to practice guidelines
- Switch focus from surrogate measures to improved patient care

**Prevention Teamwork**

- RN’s
- MD’s
- Others

Patients