Preventing NICU central line-associated bloodstream infection (CLABSI)

In current knowledge, strategies to promote improvement

Staphylococcus epidermidis biofilm colonization of a catheter

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University of Rochester Medical Center
Rochester, New York

Hospital Acquired Infection (HAI) in the NICU

- Increases Mortality
  - VLBW Infants - 18% vs 7% *
  - NICU patients - Attributable mortality 24% **

- Causes Morbidity
  - Prolonged length of stay - of 19d * - 25.1**
  - Neurodevelopmental Impairment
    - 30% greater risk of MDI < 70, cerebral palsy and head circumference < 10th percentile ***

* Stoll et al, Pediatrics, 2002
** Pessoa-Siva et al, European Journal of Epidemiology, 2001
*** Stoll et al, JAMA, 2004
CLABSI in the NICU

- Estimated to cause 25-60% of HAI*
- Iatrogenic
- Quality of Care Marker
  - “Getting to zero” campaigns


Preventing CLABSI In the NICU

- The Challenges
  - Identification of Best Practices
    - RCTs available
    - Individual practices vs. bundles of practices
  - Implementation
    - How best to introduce effective catheter insertion and care practices into an individual NICU in a reliable and sustainable way?
    - RCTs not available
  - Of the two, implementation is often the more difficult
Evidence-based Catheter Care Practices

**Catheter Insertion**

- Establish a central line kit or cart to consolidate all items necessary for the procedure.  
  
- Perform hand hygiene with alcohol-based product or antiseptic-containing soap before and after palpating insertion sites and before and after inserting central line.  
  
- Use maximal barrier precautions (including: sterile gown, sterile gloves, surgical mask, hat and large sterile drape).  
  
- Disinfect skin with appropriate antiseptic (for example, 2% chlorhexidine, 70% alcohol, povidone iodine) before catheter insertion.  
  
- Use either a sterile transparent semi-permeable dressing or sterile gauze to cover the insertion site.  
  
- Minimize number of catheter access ports

<table>
<thead>
<tr>
<th>Evidence Level</th>
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<tbody>
<tr>
<td>IA</td>
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</table>

Evidence-based Catheter Care Practices

**Catheter Maintenance**

- Perform hand hygiene with alcohol-based product or antiseptic-containing soap  
  
- Evaluate the catheter insertion site daily for signs of infection and to assess dressing integrity. At a minimum, if the dressing is damp, soiled or loose, change it aseptically  
  
- Develop and use standardized IV tubing setup and changes.  
  
- Maintain aseptic technique when changing IV tubing and when entering the catheter including “scrub the hub”.  
  
- Daily review of catheter necessity with prompt removal when no longer essential.  
  
- Heparin 0.5U/ml added to infusate reduces biofilm and incidence of CLABSI

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CLABSI Program Implementation

Realistic Evaluation

Ray Pawson and Nick Tilley

“Programmes are products of the foresight of policy-makers. Their fate though, ultimately always depends on the imagination of practitioners and participants. Rarely do these visions fully coincide. Interventions never work indefinitely, in the same way and in all circumstances, or for all people.”

CLABSI Program Implementation

Realistic Evaluation (a medical interpretation)

NICU QI programs are products of the foresight of medical directors. Their fate though, ultimately always depends on the imagination of providers and nurses. Rarely do these visions fully coincide......
Realistic Evaluation

- Programs successfully achieve **Outcomes** when they introduce ideas and opportunities (‘**Mechanisms**’) to organizations in the appropriate social and cultural conditions (‘**Contexts**’)

  “CMO”

  Context + Mechanism = Outcome

  Pawson and Tilley

Context + Mechanism = Outcomes

- **Outcomes**
  - Reliable, sustainable, reduction in CLABSIs
  - Typically requires standardized use of best practices

- **Context** –
  - Each NICU is a unique environment
    - Social, organizational, political structure
    - Beliefs among participants (“unit culture”)
    - Each NICU has its unique range of resources, talents among personnel and staffing models

- **Mechanisms**
  - Steps, strategies and methods used to introduce and sustain an intervention over time
Creating a Successful CLABSI Reduction Program

Strategies (Mechanisms) to Introduce Care Practices Into Individual NICUs (Contexts)

- Education and Training
- Checklists
- Catheter Team or Buddy System
- Evaluation, feedback, practice audits
- Incorporate QI Methodologies
  - Transformational Strategies (Six Sigma)
  - Plan – Do – Study Act Cycles
- Involve Leadership
- Resources (staff time, equipment, space)
- Create Culture of Safety
- Promote Teamwork and Team Learning
  - Quality Collaboratives
  - Spread awareness of results (Staff, families, public)
- Statistical process control methods
- Occurrence investigations

All supported with level 1B evidence

Creating a Successful CLABSI Reduction Program

* NICU Quality Collaboratives
  * A growing trend – 3 recent reports
    * California
    * Ohio
    * New York
  * Illustrate common methods used to introduce practice and work flow changes into the unique social environment of individual NICUs
Early in 2007, all 19 regional perinatal centers (RPCs) in New York State entered into a multidisciplinary collaboration to decrease CLABSI rates in their NICUs.
Building the NYS Collaborative

- RPCs shared **identified** NICU CLABSI rates
- Site visit to NICU with low indicator rate
  - All participants
  - Potential best practices
    - Identified through observation, discussion of literature
    - Bundle of practices selected
  - Revealing
    - Wide performance variation
    - Differing practices for similar patients in different centers
    - Made it impossible for all centers to claim they were doing the right things
Building the NYS Collaborative

- Designing the Implementation Mechanisms
  - Creation of a team identity
    - Monthly conference calls
      - Share practices, work flow process, strategies to promote change / overcome barriers
  - Twice yearly learning sessions
    - Centers came together to review progress, discuss challenges

Are there some things we all should be doing, all of the time?
Design Principle

Forgiveness

- Design helps people avoid errors and minimizes negative consequences when errors occur.

One of the tools used to design-in forgiveness: Checklist

- Create a safety net – process to minimize negative consequences of error or failure when it can’t otherwise be prevented.
- Good affordances – make the right way to do a task the easiest (and ideally, the only) way to do it.

Piloting a B-17: Forgiveness


Boeing Model 299
- 5-X bombs as Army asked
- Fly faster than previous bombers, ~2-X as far
- Newspaperman called it the "flying fortress"

Test flight
- Plane roared down tarmac, lifted off, climbed to 300 ft
- Then it stalled, turned on one wing, and crashed

Two of five crew members died
Piloting a B-17: Forgiveness

Nothing mechanical went wrong: “pilot error”

Much more complex than previous planes:
- 4 engines
- Retractable landing gear
- New wing flaps
- Electric trim tabs - continually adjusted at different airspeeds
- Constant-speed propellers whose pitch had to be regulated with hydraulic controls
- And lots more

“...too much airplane for one man to fly”

Pilot forgot to release a new locking mechanism on the elevator and rudder controls

Test pilots devised a brilliant, simple solution
- Pilot’s checklist: step-by-step checks for takeoff, flight, landing, and taxiing
- These routine processes had become too complicated to rely on human memory

Pilots subsequently flew 1.8 million accident-free miles
“Medicine today has entered its B-17 phase…”


“I.C.U. life support has become too much medicine for one person to fly.”

“…intensive care [is] now too complex to carry...out reliably from memory alone…”

**APPROVED B-17F and G CHECKLIST**

**BEFORE STARTING**

1. Tireiny footpins, CHECKED
2. Fuel in A & B tanks, CHECKED
3. Cowl flaps up, CHECKED
4. Ahead handbrake, CHECKED
5. Fuel gauges, CHECKED
6. Fuel pumps, CHECKED
7. All reject, CHECKED
8. Engine Start, CHECKED
9. Engine Start, CHECKED
10. Battery, CHECKED
11. Master switch, CHECKED
12. Master switch, CHECKED
13. Master switch, CHECKED
14. Engine oil pressure, CHECKED
15. Engine oil pressure, CHECKED
16. Engine oil pressure, CHECKED

**ENGINE RUN-UP**

1. Throttle, CHECKED
2. Throttle, CHECKED
3. Engine Test, CHECKED
4. Engine Test, CHECKED
5. Engine Test, CHECKED
6. Engine Test, CHECKED
7. Engine Test, CHECKED
8. Engine Test, CHECKED
9. Engine Test, CHECKED
10. Engine Test, CHECKED

**FINAL APPROACH**

14. Engage, CHECKED
15. Rudder, CHECKED
16. Rudder, CHECKED
17. Ejection, CHECKED
18. Ejection, CHECKED
19. Ejection, CHECKED
20. Ejection, CHECKED
21. Ejection, CHECKED
22. Ejection, CHECKED
23. Ejection, CHECKED
24. Ejection, CHECKED

57 elements to ensure safe flight

(NYS Collaborative has only 5 main elements for insertion; 6 for maintenance)
You mean you haven’t been doing this all along?

W.H.O. Issues a Checklist to Make Operations Safer

...when the checklist was discussed with nonmedical people, the most common reaction was the question:

along?'
<table>
<thead>
<tr>
<th>Date</th>
<th>Place Check Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Standard Safety Practice**
- Place Check Mark after completing standard safety practices.

**Indication for Dressing Change**
- Place Check Mark after completing standard safety practices.
- Standardized intravenous tubing setup

**Removal of Old Dressing**
- Put on mask and non-sterile gloves to remove old dressing.

**Placement of New Dressing**
- Put on sterile gloves.
- Prepared site with appropriate agent
- Used back and forth motion for 30 seconds
- Allowed 30 seconds to dry
- Sterile dressing applied
- Removed sterile gloves and performed hand hygiene with hospital approved product
- Dated sterile dressing

---

**Change Not Necessarily = Improvement**

We sought to determine whether

1. Adapting common insertion and maintenance bundles reduces NICU CLABSI rates
   - Institutional-level
   - Statewide
2. Using CL maintenance checklists in the NICU reduces CLABSI rates
Study Design/Methods

- Prospective cohort study:
  - Neonates with a CL, hospitalized in any of the NYS RPCs

- Study period: pre-intervention, Jan – Dec 2007; post-intervention, Mar - Dec 2009

- NYSDOH/HAI audited a sample of 2009 hospital records

- Each RPC reported its data aggregated by BW category

Study Design/Methods

Poisson regression: outcome CLABSI
- Accounted for possible correlation of outcomes within a site
- Checklist frequency (days of any reported maintenance checklist use per days of CL use)
- Birth weight category (BW)
- CL utilization rate
- Patient volume (average; post hoc cutpoint):
  - Low ≤ 700 Pt-days/month
  - High > 700 Pt-days/month
- Study site (RPC NICU)
### Characteristics of Study Periods

<table>
<thead>
<tr>
<th></th>
<th>2007 Before</th>
<th>2009 After (March – December)</th>
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<tbody>
<tr>
<td>CL-days</td>
<td>61,096</td>
<td>55,137</td>
</tr>
<tr>
<td>Patient-days</td>
<td>237,996</td>
<td>206,846</td>
</tr>
<tr>
<td>CL utilization rate</td>
<td>0.26</td>
<td>0.27</td>
</tr>
<tr>
<td>Checklist use</td>
<td>N/A</td>
<td>13/18 (72%)</td>
</tr>
<tr>
<td># RPCs reporting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Checklist use rate</td>
<td></td>
<td>10% to 100%</td>
</tr>
</tbody>
</table>

#### Effect of Bundles/Checklists on CLABSI Rate in NYS Regional Referral NICUs (RPCs)

Risk Ratio = 0.33; 95% CI 0.27, 0.41; *p* < 0.0005

↓ 67%
Hold On... Something Else Changed During the Same Time Period

- CDC CLABSI definition
  - Beginning in January 2008 one positive blood culture yielding a normal skin contaminant (e.g., \textit{S. epidermidis}) no longer fulfilled the case definition for CLABSI and "two or more positive blood cultures for a skin contaminant drawn on separate occasions" were required

- Adjusted for uniform CLABSI definition, statewide CLABSI rates declined by 40%
  - 3.5 CLABSI /1000 CL-days \rightarrow 2.1 CLABSI /1000 CL-days
    - (risk ratio = 0.60; 95\% CI 0.48, 0.75; p < 0.0005)
Unadjusted CLABSI rates ranged from reductions of 5% to 98%. Adjusted for 2008 CLABSI definition, performance was more variable, ranging from a 3-fold increased rate to a 97% reduced rate.

Effect of 2008 CLABSI Definition on Outcomes

2007 (Before)
Pre-intervention, January-December 2007. Same CLABSI Definition Applied as in 2009

2009 (After)
Post-intervention, March-December 2009

Adjusted for 2008 CLABSI definition, performance was more variable, ranging from a 3-fold increased rate to a 97% reduced rate.

BW is Associated with CLABSI Rate

Checklist Use Rate is Associated with CLABSI Rate

Per S.D. increment in checklist rate (30%), CLABSI rate ↓ 16.5% [coeff = -0.57, p = 0.04]
CLABSI rate (# infections/1000 CL days)

Low patient volume NICUs  
High patient volume NICUs

<751g, 751-1000g, 1001-1500g, 1501-2500g, >2500g, All Birthweights

IRR 0.58, p = 0.03

Site of NICU care (RPC) may still determine CLABSI risk in 10/18 NICUs:
IRR = 0.04, p < 0.0005 to IRR = 2.87, p < 0.0005

After accounting for BW, checklist use rate, and CL utilization rate...

Predicted number of CLABSI events

Observed number of CLABSI events

Obs. = Pred.
NYS CLABSI Rates Publicly Reported

Figure 25. Central Line-Associated Blood Stream Infection (CLABSI) Rates Regional Perinatal Center Intensive Care Units, New York 2009

<table>
<thead>
<tr>
<th>HOSPITAL</th>
<th># CLABSI</th>
<th>CLABSI CLDAYS</th>
<th>RATE</th>
<th>ADJUSTED RATE</th>
<th>95% CONFIDENCE INTERVAL</th>
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</thead>
<tbody>
<tr>
<td>Albany Medical**</td>
<td>1</td>
<td>4705</td>
<td>0.2</td>
<td>0.2</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
</tr>
<tr>
<td>Bellevue Hospital**</td>
<td>5</td>
<td>519</td>
<td>9.6</td>
<td>8.8</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>Cruze Hospital</td>
<td>9</td>
<td>3167</td>
<td>2.8</td>
<td>2.8</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
</tr>
<tr>
<td>Jacobi Medical</td>
<td>8</td>
<td>1471</td>
<td>4.1</td>
<td>3.8</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
</tr>
<tr>
<td>Long Island Jewish</td>
<td>6</td>
<td>3771</td>
<td>1.6</td>
<td>1.7</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>Maimonides</td>
<td>9</td>
<td>2190</td>
<td>4.1</td>
<td>3.9</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
</tr>
<tr>
<td>Montefiore-Finestein</td>
<td>3</td>
<td>2335</td>
<td>1.3</td>
<td>1.3</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>Mount Sinai</td>
<td>4</td>
<td>2487</td>
<td>1.8</td>
<td>1.7</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>NYP- Morgan Stanley</td>
<td>17</td>
<td>6959</td>
<td>2.6</td>
<td>2.5</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>NYP- Weill Cornell</td>
<td>7</td>
<td>2490</td>
<td>2.8</td>
<td>2.9</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>NYU Medical Center</td>
<td>3</td>
<td>666</td>
<td>5.0</td>
<td>5.7</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>North Shore</td>
<td>2</td>
<td>2370</td>
<td>0.8</td>
<td>0.9</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>Strong Memorial</td>
<td>10</td>
<td>3064</td>
<td>2.6</td>
<td>2.5</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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<tr>
<td>Univ Hosp Brooklyn*</td>
<td>0</td>
<td>678</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Univ Hosp StonyBrook`</td>
<td>10</td>
<td>1579</td>
<td>6.3</td>
<td>6.5</td>
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<tr>
<td>Westchester Medical</td>
<td>10</td>
<td>4485</td>
<td>2.2</td>
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<td>Winthrop University</td>
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<td>1653</td>
<td>0.5</td>
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<tr>
<td>Woman and Children</td>
<td>7</td>
<td>3075</td>
<td>1.8</td>
<td>1.0</td>
<td>COMPARED TO STATE AVERAGE OF 2.2</td>
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Conclusions

- **Standardized, evidence-based NICU CL care reduces CLABSI rates**

- *More frequent* reported use of checklists is associated with *lower* CLABSI rate

- Current bundles/checklists partially solve the problem of preventing CLABSI

- Many NICU CLABSI appear preventable
Conclusions

- A State-wide Quality Collaborative can facilitate practice and work flow changes leading to lower CLABSI rates.
- Individual center of care remains a significant predictor of risk of CLABSI
- Underscores CMO
  - Necessity of understanding NICU-specific context when designing a CLABSI program and mechanisms to introduce it

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- Funding provided by the NYS DOH
Questions?

And Be Mindful of How You Care for My Central Line

My Life Is In Your Hands

Mi Vida Esta en Sus Manos

FAVOR DE LAVÁRSELAS
Example

- Desired outcome – standardized catheter care and lower CLABSI rate

- Unit Context – nursing assignments tend to be isolated by geography – one nurse per 3 baby room

Two potential mechanisms to introduce change

A. New catheter care protocol in the same environment rolled out with mandatory in-service – likely to fail due to interruptions during procedure etc.

B. Introduction of a buddy system in which a second person joins the first for catheter tubing changes, no mandatory in-service – better chance for success because nurse can be protected from interruption to perform tubing changes
## Context, Mechanism and Outcomes

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<tr>
<th>Plausible Mechanisms</th>
<th>Potential Contexts</th>
<th>Possible Outcomes</th>
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<td>Standardized catheter care</td>
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<td>Harried unit, Belaeguered nurses</td>
<td>Lower CLABSI rates</td>
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<td>Physician non-compliance</td>
<td>Nursing resentment</td>
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<tr>
<td>Involve Leadership – unit, hospital</td>
<td>CLABSI Fatalism - Sick pts get CLABSI</td>
<td>Resistance to change</td>
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# Table 1: Possible Outcomes

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<tr>
<td>Checklists</td>
<td>Harried unit, - Nurses interrupted freq due to monitor alarms</td>
<td>Lower CLABSI rates</td>
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