Evidence for a Small Baby Unit: Creating Expertise by Experience

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• I have no conflicts of interest to disclose
Goals

• Briefly discuss the successes made with extremely premature infants over the last several decades
• Review the history of critical care medicine and the creation of specialized ICUs
• Highlight the seminal article published in 2015 for the creation of a small baby unit (SBU) as well as other supporting evidence
• Outline Greenville Hospital System’s approach to creating a SBU
Major Mortality Successes for Extremely Premature Infants

Trends in Extremely Premature Infant Survival from 1993 to 2012

Figure 3. Infant Survival to Discharge By Birth Year and Gestational Age

- 22 Weeks
  - Adjusted RR (95% CI), change per year 2009-2012: 1.06 (0.89-1.25)

- 23 Weeks
  - Adjusted RR (95% CI), change per year 2009-2012: 1.09 (1.05-1.14)

- 24 Weeks
  - Adjusted RR (95% CI), change per year 2009-2012: 1.05 (1.03-1.07)

- 25 Weeks
  - Adjusted RR (95% CI), change per year 2009-2012: 1.02 (1.01-1.03)

- 26 Weeks
  - Adjusted RR (95% CI), change per year 2009-2012: 1.00 (0.996-1.015)

- 27 Weeks
  - Adjusted RR (95% CI), change per year 2009-2012: 1.01 (1.002-1.016)

- 28 Weeks
  - Adjusted RR (95% CI), change per year 2009-2012: 1.00 (0.998-1.011)

JAMA 2015;314 (10): 1039-1051
Trends in Extremely Premature Infant Morbidity from 1993 to 2012

Figure 4. Infant Survival to Discharge Without Major Morbidity by Birth Year and Gestational Age

23 Weeks:
Adjusted RR (95% CI), change per year
1.00 (0.95-1.05)

24 Weeks:
Adjusted RR (95% CI), change per year
0.99 (0.97-1.01)

25 Weeks:
Adjusted RR (95% CI), change per year
1.02 (1.01-1.03)

26 Weeks:
Adjusted RR (95% CI), change per year
1.02 (1.01-1.03)

27 Weeks:
Adjusted RR (95% CI), change per year
1.02 (1.02-1.03)

28 Weeks:
Adjusted RR (95% CI), change per year
1.03 (1.02-1.03)

JAMA 2015;314 (10): 1039-1051
Unique Risks

ELBW Infant

- Skin integrity
- Immunocompromised
- Respiratory compromise
- Intraventricular hemorrhage
- Neurodevelopmental care
- Highest risk of mortality
- Infant/parental bonding
### Significant Innovations for Extremely Premature Infants

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPAP, Mechanical Ventilation</td>
<td>1980s</td>
</tr>
<tr>
<td>Exogenous Surfactant</td>
<td>Early 1990s</td>
</tr>
<tr>
<td>Antenatal Steroids</td>
<td>Mid/Late 1990s</td>
</tr>
<tr>
<td>Avoiding Postnatal Steroids</td>
<td>Early 2000s</td>
</tr>
<tr>
<td>Targeted Oxygen Therapy</td>
<td>Mid 2000s</td>
</tr>
<tr>
<td>Systematic Care/Experience</td>
<td>Continuous</td>
</tr>
</tbody>
</table>
“To know your future, you should study your past.”
History of Critical Care

• Rationalization of critical care medicine
  – Seriously ill require closer attention
  – Advancements in technology requires increasing levels of specialized training
• 1850s- Florence Nightingale placed the seriously ill closer to the nursing station for proximity
• 1923- Dr Walter Dandy opened a three-bed unit for postoperative neurosurgical patients at Johns Hopkins Hospital with specially trained nurses
• 1930- Dr Martin Kirschner built the first postoperative recovery ward for surgical patients at the University of Tubingen
• Second world war led to shock units for severely injured soldiers and the 1950s polio epidemics led to large respiratory units
Early Culture in ICUs

- Mysterious and frightening place
  - Restricted visitation hours
  - Staff and visitors wore gowns and masks
  - Patients heavily sedated
  - Open units where patients managed by primary care providers

St. Paul’s Hospital ICU, Circa 1964
Gaining of Experience

- As ICUs were created, patients were cohoarted and knowledge was gained
  - Increase in critical care research
  - Specialized training of physicians, nurses, and respiratory therapists
  - Advancement and evolution ICU technology
  - Critical care recognized as a discipline in 1950

Koch A et al Jour Thor Disease. March 2017
ICU: Past to Future

- Increasing age of population
  - Use of ICU by individuals who die in the US - 47%
- Increasing complexity in patient care through development of technology
- Increasing acuity of patients
- Change in hospital demographics
  - From 1985 to 2000, there was a 26% increase in the number of ICU beds vs a 31% decrease in other inpatient beds

Adhikari N, Fowler R et al. Lancet 2010; 375
Halpern NA et al. Crit Care Med 2004; 32
Halpern NA et al. Crit Care Med 2016; 44
## Trends in Critical Care Beds - 2000 to 2010

<table>
<thead>
<tr>
<th>Population (millions)</th>
<th>Year</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult (≥18)</td>
<td>209.8</td>
<td>222</td>
</tr>
<tr>
<td>Pediatric (1-17)</td>
<td>68.5</td>
<td>69.5</td>
</tr>
<tr>
<td>Neonatal (&lt;1)</td>
<td>3.9</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ICU Bed Types</th>
<th>Year</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult ICU</td>
<td>71978</td>
<td>76904</td>
</tr>
<tr>
<td>Pediatric ICU</td>
<td>1866</td>
<td>1906</td>
</tr>
<tr>
<td>Neonatal ICU</td>
<td>14391</td>
<td>15490</td>
</tr>
</tbody>
</table>

Evidence for Better Outcomes with Specialized ICUs?

• Several studies published with mixed outcomes
  – Management of intra-cranial hemorrhage in Neuro ICU vs MICU
    • Two studies with 1150 patients
    • Lower mortality, lower cost, and shorter hospital length of stay
  – CV ICU managed by a cardiac intensivist vs general cardiologist
    • 2431 patients
    • Decreased mortality
  – Largest study of 124 ICUs across a range of hospitals examining specialty specific ICUs vs general critical care units
    • 84182 patients
    • No difference is mortality for CVA, acute coronary syndrome, abdominal surgery, or CABG surgery

Mirski M et al. J Neurosurg Anesth 2001
Na SJ et al. J Am Coll Cardiol Dec 20 2016
“Thus would be brought about—

1. The grouping together of the healthy weaklings.
2. The isolation of the sick and suspects.
3. The absolute separation of the wet-nurses’ infants from contact with the weaklings.”

Budin P. *The Nursling*. 1907
“Clinics for Nurslings”

Pierre Budin
(1846 to 1907)

- French obstetrician
- Focused on infant mortality by studying rules of hygiene and nutrition
- Clinics for “nurslings”- 1892
  - “le galactophore”
  - Designed an apparatus to pump breast milk
- Pavilion for “weaklings”
  - Specialized infant care for premature and SGA infants

www.neonatology.org
Further NICU Advancements

• Etinne Tarnier
  – First incubator to help infants remain warm
  – The gavage tube for the too feeble to suck

• Martin Couney, Tarnier’s pupil, brought the incubator to the US in 1901
  – “Incubator Doctor”
  – “Incubator Baby Side-Shows” for 50 years
  – Luna Park Incubator Exhibition was the longest running exhibit at Coney Island

Budin P. *The Nursling*. 1907
Jorgensen A. Born in the USA. NICU Currents June 2010
Birth of Neonatology

- **August 7th, 1963**
  - Patrick Bouvier Kennedy born at 34 5/7 weeks, 2.112 kg
  - Died at 39 hours of life from hyaline membrane disease
  - Magnified public need for neonatal care
- First newborn intensive care unit in 1965 opened at Yale Hospital by Dr Louis Gluck
- In 1975, neonatology established as a subspecialty by the American Board of Pediatrics

- **Toward Improving the Outcome of Pregnancy, 1975**
  - ACOG and AAP recommended centralization of neonatal care by trained neonatology staff
- "Decade of the Micropreemie" ~ 90s
  - Surfactant replacement therapy
  - Antenatal steroids
  - Improved ventilator support

Jorgensen A. Born in the USA. NICU Currents June 2010
“Practice makes perfect”

“You can shoot eight hours a day, but if your technique is wrong, all you become is good at shooting the wrong way. Get the fundamentals down and the level of everything you do will rise.”
- Michael Jordan

“Practice does not make perfect, only perfect practice makes perfect”
- Vince Lombardi
Creating Expertise with an SBU?

Small Baby Unit Improves Quality and Outcomes in Extremely Low Birth Weight Infants
Mindy Morris, John Patrick Cleary and Antoine Soliman
Pediatrics 2015;136:e1007; originally published online September 7, 2015;
DOI: 10.1542/peds.2014-3918
SBU at CHOC

• Children’s Hospital of Orange County
  – 67 bed level 4 NICU
  – Average daily census of 40
  – ~700 annual admissions
  – 55-60 ELBW infants per year
• Retrospective cohort quality improvement project
• Established a separate unit and team to care for the ELBW infants less than 29 weeks.

• Interventions
  – Cohort ELBW infants in a physically separate location from the main NICU
  – Progressive change in unit culture using evidence-based guidelines, protocols, and checklists
  – Designation of lead physician, NNP, RN, and RRT as program coordinators
  – Multidisciplinary project champions in key areas

Core Team Members

• Core team selected based on experience and interest
• Team members completed independent study before attending an 8 hour class (didactic and hands-on)
• CE credits and compensation for attending classes
• Direct care was NNP led but residents were included with a reduced footprint and oversight by NNP/physicians
• Continued education and communication
  – Quarterly 3 hour meetings including relevant topics and outcome data
  – Twice per week informal talks to discuss care practices and concerns

CHOC- SBU Guidelines

• Provide consistent and uniform practice
  – Guidelines for Three phases of care
    • Birth through 10 days
    • Days 11 to 30
    • 1 month to discharge
  – Guideline development integrated best evidence and included input from multidisciplinary team
  – Available in hardcopy and on intranet
  – Checklists for processes or procedures to limit variation, standardize care, and improve safety

• Developmental Support
  – Quieter, darker, and environmentally encouraging atmosphere

### Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Preintervention, %</th>
<th>Postintervention, %</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 61</td>
<td>n = 161</td>
<td></td>
</tr>
<tr>
<td>CLD</td>
<td>47.5</td>
<td>35.4</td>
<td>.097</td>
</tr>
<tr>
<td>Home on oxygen</td>
<td>23.0</td>
<td>18.0</td>
<td>.41</td>
</tr>
<tr>
<td>Successful extubation first wk</td>
<td>47.5</td>
<td>65.2</td>
<td>.016</td>
</tr>
<tr>
<td>CPAP alone&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.8</td>
<td>30.1</td>
<td>.006</td>
</tr>
<tr>
<td>Nosocomial infection&lt;sup&gt;c&lt;/sup&gt;</td>
<td>39.3</td>
<td>19.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Growth restriction</td>
<td>62.3</td>
<td>37.3</td>
<td>.001</td>
</tr>
</tbody>
</table>

<sup>a</sup> P value based on χ² test statistic.

<sup>b</sup> CPAP alone results are for inborn patients, preintervention n = 26, postintervention n = 93.

<sup>c</sup> Late-onset sepsis results include all SBU admissions.

<table>
<thead>
<tr>
<th></th>
<th>Preintervention</th>
<th>Postintervention</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. laboratories, mean</td>
<td>224</td>
<td>82</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Total no. radiographs, mean</td>
<td>45</td>
<td>22</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<sup>a</sup> P value based on independent t test for continuous variables.

Improved Staff Perceptions with SBU

- Staff Satisfaction with SBU care
  - 10 question Likert Scale survey
    - Initial training, one year and four year post implementation
    - Sustained improvement in team perception of quality of care for ELBW infants
      - Skills and equipment available for optimal care:
        Agreed or strongly agree- 67% to 90% to 93%
      - Actively contributed and felt apart of the team:
        Agreed or strongly agree- 69% to 90% to 86%
      - Quality of care felt to be high-quality:
        Agreed or strongly agree- 60% to 96% to 98%

Standardizing SBU Practice Guidelines Improves Outcomes

- Multidisciplinary guideline driven care of ELBW infants
  - Nationwide Hospital
  - Guidelines for routine daily care for the first week of life for infants <27 weeks and 7 days of age
  - Implemented November 2004
  - Retrospective one year cohort study (40 patients pre- and 37 patients post-)

Table 3 Combined outcome in survivors

<table>
<thead>
<tr>
<th></th>
<th>Comparison</th>
<th>Small baby</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survived without BPD</td>
<td>3/35 (9%)</td>
<td>9/37 (24%)</td>
<td>0.037</td>
</tr>
<tr>
<td>Survived without severe IVH</td>
<td>15/40 (38%)</td>
<td>24/37 (65%)</td>
<td>0.008</td>
</tr>
<tr>
<td>Survived without BPD or severe IVH</td>
<td>2/35 (6%)</td>
<td>10/37 (27%)</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Number/group size (percent).

Nankervis CA et al Acta Paediatrica 2010; 99: 188-193
Comprehensive Developmental Care Training Also Improves Outcomes

- Good Samaritan and Bethesda North Hospitals in Cincinnati, Ohio
  - NICU renovation and comprehensive developmental training program for medical staff (Wee Care Children’s Medical Ventures)
  - Data collected one year pre and post implementation consisting with 419 and 433 VLBW infants respectively
  - Staff Training
    - 5 Day didactic and hands on training
    - Focuses on 4 aspects of care

<table>
<thead>
<tr>
<th></th>
<th>1998 (419 infants)</th>
<th>2000 (433 infants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total ventilator days</td>
<td>2351</td>
<td>1898</td>
</tr>
<tr>
<td>ROP: Grade 3 or 4</td>
<td>14%</td>
<td>8%</td>
</tr>
<tr>
<td>IVH: Grade 3 or 4</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>Length of Stay: 24-27 weeks GA</td>
<td>79 days</td>
<td>58 days</td>
</tr>
</tbody>
</table>

Summary

• Extremely low birth weight and extremely premature infants are unique
  – “They are not little 40 weekers”
• They are at the highest risk for mortality and morbidity in the modern NICU where we have the most opportunity for improvement
• They need experienced staff that focus on this less common subset of neonatal patients
• They need focused research to improve the paucity of evidence based practices for this population
GHS SBU Implementation

• 50-60 ELBW infants born at GHS per year
  – Highest risk for morbidity and mortality including CLABSIs
    • Chronic lung disease, ROP, and late onset sepsis are our areas of opportunity

• Our Vision for a Small Baby Unit
  – Care provided by a core multidisciplinary team invested in best outcomes of our highest risk patients
  – Most experienced and enthusiastic staff
  – Standardization and uniform evidence based practice
  – Provide continued education to discuss care practices, research, and outcomes
  – Improve patient/parent satisfaction through consistency with a small primary team
  – Move from competency and proficiency to specialization and life-long learning
Greenville Memorial Hospital’s SBU

• Planning began in fall of 2016
• Official Start Date 1/1/2017
  – Designated RN and RRT staff pool to maximize experience and expertise
  – Monthly one hour meetings for education, planning, and development
  – Weekly casual SBU rounds to discuss patient care questions and management
  – Creating small task forces to focus on individual morbidities and practices
  – Culture change
Interventions

• 2016 Successes
  – Implementation of a 100% Bubble CPAP utilization
  – Volume targeted ventilation on all extremely premature infants

• 2017
  – Creation of the SBU quality improvement initiative
  – IVH protocol for the first 72 hours of life
  – Ventilator weaning program and earlier use of bubble CPAP
  – CLABSI initiatives
    • Prevantics, CLABSI huddles, standardization of PICC line team and care
IVH Protocol

IVH Bundle

For infants < 28 weeks or < 1000 g until 72 hours of life AND umbilical lines discontinued

Birth date/time: __________

Projected end date/time if umbilical lines discontinued: __________

- Mildly elevate HOB approximately 30 degrees
- Keep head midline
  - Preferably supine with positioning aids to keep head midline
  - Positioned on side with head midline is acceptable
  - Do NOT position prone
  - Hips should never be higher than shoulders
- Minimize handling
  - Assessments/hands-on care Q6h, VS off monitor Q1h
  - No bath for 72 hours
  - Use 2 staff members to obtain weights and change linens/developmental aids
  - Change diapers by shifting lower body to side and sliding diaper beneath infant while keeping head midline
  - If UAC in place and blood pressure accurately monitored, only 1 NIBP per shift
- No routine suctioning
  - No routine NG placement/care patentcy assessment with admission
- Minimize sensory stimulation by providing a calm, quiet, relatively dark environment
- Give bolus infusions over at least 30 minutes
  - If UAC in place, draw and flush slowly
Conclusions

- Specialized intensive care units intuitively improve care but evidence remains scarce
- Consistency in practice and standardized guidelines improve outcomes
- Staff education, experience, and satisfaction improve outcomes
- Development of the GMH SBU will hopefully improve survival without morbidity in our highest risk patients
"My dear friends,
The fate of French children rests on you. I count on you to be the first to do the necessary work to develop infant clinics and later delegate this task to your students".

Budin.