ANESTHESIA FOR THE EX-PREMATURE INFANT:
Considerations throughout childhood

Laura Siedman, MD
PREMATURE (<37 weeks)

**Extreme Low Birth Weight (ELBW)**
- <750 g! < 25 weeks
- 750-1000 g! 26-28 weeks

**Very Low Birth Weight (VLBW)**
- 1000-1500 g! 29-32 weeks
Prematurity = Life-long Diagnosis

Anesthetic considerations: age-related

- 40-60 weeks PCA
- 60 weeks PCA-1 year
- 1-2 years
- 2-5 years
- 5-10 years
- > 10 years-adult
• “disorders relating to short gestation and low birth weight” are the second leading cause of infant death (16-17%), second only to congenital malformations, deformations, and chromosomal abnormalities

National Vital Statistics report April, 2010

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### Extreme prematurity: Life-long diagnosis

<table>
<thead>
<tr>
<th>BIRTH WEIGHT</th>
<th>#/YEAR</th>
<th>% SURVIVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000-1500 g (VLBW)</td>
<td>50,000</td>
<td>90%</td>
</tr>
<tr>
<td>500-999 g (ELBW)</td>
<td>10,000</td>
<td>70%</td>
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</table>
ELBW: Survival vs. Complications


Survival without short term complications (BPD, IVH, NEC) still largely dependent on degree of prematurity.
LONG- & SHORT-TERM OUTCOME
• Chronic lung disease
• IROP
• Neuropsychological
### Table 1. Causes of Chronic Lung Disease and Definition of Bronchopulmonary Dysplasia.

<table>
<thead>
<tr>
<th>Causes of chronic lung disease</th>
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<tbody>
<tr>
<td>Premature newborns</td>
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<tr>
<td>Bronchopulmonary dysplasia (old or new)</td>
</tr>
<tr>
<td>Prematurity</td>
</tr>
<tr>
<td>Status after respiratory distress syndrome</td>
</tr>
<tr>
<td>Term and near-term newborns</td>
</tr>
<tr>
<td>Bronchopulmonary dysplasia (old)</td>
</tr>
<tr>
<td>Pneumonia or sepsis</td>
</tr>
<tr>
<td>Aspiration syndromes</td>
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<tr>
<td>Persistent pulmonary hypertension of the newborn</td>
</tr>
<tr>
<td>Pulmonary hypoplasia</td>
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<tr>
<td>Diaphragmatic hernia</td>
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<tr>
<td>Congenital heart disease</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Current definition of bronchopulmonary dysplasia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagnosis</strong></td>
</tr>
<tr>
<td>Oxygen dependence for at least 28 postnatal days</td>
</tr>
<tr>
<td><strong>Grading at 36 postmenstrual wk for infants born at &lt;32 wk or at 56 days of life for infants born at ≥32 wk</strong></td>
</tr>
<tr>
<td>Mild — FiO₂ 0.21</td>
</tr>
<tr>
<td>Moderate — FiO₂ 0.22–0.29</td>
</tr>
<tr>
<td>Severe — FiO₂ ≥0.30 or continuous positive airway pressure or mechanical ventilation required</td>
</tr>
</tbody>
</table>

*FiO₂ denotes fraction of inspired oxygen. The definition of bronchopulmonary dysplasia was adapted from Jobe and Bancalari.*

CHRONIC LUNG DISEASE: “Old” vs “New”

• OLD: severe epithelial injury, extensive fibrosis, Smooth muscle hyperplasia, over-inflation + atelectasis:
  \[O_2\], mechanical ventilation; rare
• NEW: negligible epithelial lesions, fewer, larger alveoli, decreased dysmorphic capillaries, variable interstitial fibroproliferation:
  gentle ventilation (CPAP), surfactant
FEV1 Values in Children, Adolescents, and Young Adults Who Were Born Prematurely and Had Bronchopulmonary Dysplasia, as Compared with Controls Born at Term
“Regardless of surfactant therapy &/or BPD, bronchial obstruction associated with bronchial lability & increased bronchial responsiveness remain common in school children (7-12 yo) born very prematurely.”

Prophylactic: 53%
Rescue: 36%
Placebo: 67%

C.L.D.: 91%
No C.L.D.: 35%

Pelkonen AS: Am J Respir Crit Care 156:1178-1184, 1997
RESPIRATORY OUTCOME: BEYOND INFANCY

**ELBW Infants 8-9 years later**

240 ELBW + 208 Controls: Airflow + Air-trapping
- FVC, FEV₁, FEF₂₅₋₇₅%: ELBW vs control
- BPD > no BPD
- Comparable to data from pre-surfactant era


**VLBW Infants 18-19 years later**

Lung function variables reflecting airflow lower in VLBW
- Those with BPD lower than without BPD

RESPIRATORY OUTCOME: BEYOND INFANCY

• Symptoms include cough & wheeze
• Airway obstruction/hyperinflation
• Airway hyper-responsiveness
• Impaired cardioventilatory performance during exercise
• CLD Premature without CLD Term Control
Recent/Future Strategies

• Target Lower oxygen saturation
• Nasal CPAP vs intubation
• Intubation + surfactant, CPAP
• “Minimal ventilation”: outcome?
• High frequency: no benefit
• Pharmacologic intervention
BRAIN INJURY IN THE PRETERM INFANT

- Germinal matrix-IVH
- IVH-Post-hemorrhagic hydrocephalus
- Periventricular leukomalacia

"encephalopathy of prematurity"

signal abnormalities, loss of volume, cystic abnormality, enlarged ventricles, thinning of the CC, delayed myelination

Severity of abnormalities is associated with adverse early ND outcome
~1/3 of cohort: moderate to severe (GA: 24-28 w)
Early lesions associated with impaired cerebral development: GM + WM
Ventriculomegaly: no IVH implying parenchymal tissue loss
Neurodevelopmental effects of prematurity: Long term

<table>
<thead>
<tr>
<th>Condition</th>
<th>ELBW (~30 M)</th>
<th>TERM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebral Palsy</td>
<td>10-18%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Developmental II, &gt;2SD mean</td>
<td>26-37%</td>
<td>2-3%</td>
</tr>
<tr>
<td>Sensorineural Hearing Loss</td>
<td>2-3%</td>
<td>0.1-0.3%</td>
</tr>
<tr>
<td>Visual (&lt;20/200) Strabismus*</td>
<td>2%</td>
<td>0.1%</td>
</tr>
<tr>
<td>19%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Problems (school age)</td>
<td>50%</td>
<td>??</td>
</tr>
</tbody>
</table>

Msall ME: JAMA 292:2399-2401, 2004
Selected Neurodevelopmental and Medical Complications at 8 to 9 Years of Age in Children with Extremely Low Birth Weight (ELBW) but No Apparent Neurosensory Abnormalities at Initial Hospital Discharge (Termed "Normal" ELBW), as Compared with Term Controls
PRE-OPERATIVE EVALUATION

- Chronic lung disease
  - infancy
  - beyond infancy
- Neurologic deficits
  - seizures, cerebral palsy, vision and hearing impairments
Factors associated with adverse respiratory events in children with URI:

- ETT
- Parental smoking
- History of RAD
- Isoflurane, maintenance
- Prematurity
- Surgery involving the airway
- Nasal congestion
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The Expremature Infant:
Common procedures

- Hernia repair
- MRI
- Tappable CSF reservoir (Ommaya) and/or VP shunt
- Eye surgery for ROP
- Bowel surgery - stricturoplasty/ reanastamosis of stomas from NEC
- Airway procedures
Timing of hernia repair

- Still on ventilator
- Days prior to d/c
- As an outpatient?
Postanesthesia apnea in the premature infant

- Gestational age at birth and postconceptual age (PCA) at time of anesthesia statistically significant impact on incidence of postoperative apnea
  - The risk of apnea for a baby born at 35 weeks is not less than 5% until a PCA of 48 weeks and not less than 1% until 54 weeks
  - For a baby born at 32 weeks, the incidence is not less than 5% until a PCA of 50 weeks and not less than 1% until 56 weeks.

*Cote et al, 1995*
The Expremature Child: Common procedures

- VP shunt revisions
- Orthopedic procedures for spasticity
- ENT surgery - cochlear implants, T&A
- Ophthalmologic surgery - strabismus
PRE-OPERATIVE EVALUATION

“He is 6 yo, ex-27 GA scheduled for T&A, “BPD” as an infant, is now healthy, only mild RAD.”

• weight/growth
• meds
• symptoms
• consultants?
PRE-OPERATIVE EVALUATION

“She is 3 yo, ex-24 week GA for strabismus repair, “BPD” as infant, is now healthy, URI a week ago.”

• wheezing?
• meds
• RSV
• CLD?
PITFALLS IN PRE-OPERATIVE EVALUATION

Chronic Disease

• "Parental protection of ELBW children at age 8 years": higher rates of over protection
• Personality traits of ex-prematures
• Pre-operative evaluation: takes time!


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PULMONARY CONSIDERATIONS

• RAD
• Less responsive to bronchodilators
• Structural airway problems- subglottic stenosis
• More susceptible to viral illnesses
NEUROLOGIC CONSIDERATIONS

Implications for Perioperative Care:

• Altered responses to sedatives/anesthetic agents
• Pre-medication
• Post-operative pain control
• NPO guidelines in the setting of GERD
Anesthetic Management

- Induction techniques
- Intubation? and ventilation
- Fluid management
- Positioning challenges
- Pain Management strategies
- Postoperative care
The Ex-Premature: “Life long Diagnosis”