5th World Congress on Pediatric Critical Care
Geneva - June 26, 2007

Neonatal Experience of Improving Ventilation

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Children's Hospital of Lucerne
5th World Congress on Pediatric Critical Care

Neonatal Intensive Care Unit
Mount Pilatus
Main Topics

- History of neonatal ventilation
  - Milestones in the treatment of neonatal lung disease

- Impact of improved mechanical ventilation strategies
  - The Lucerne experience

- Current strategies
  - State-of-the-Art
Historical Background

Hippocrates medic

Andreas Vesalius Anatomicus
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Philip Drinker & Louis Agassiz Shaw

HARVARD School of Public Health
Respiratory Support 1950s
Campbell K.

Intensive oxygen therapy as a possible cause of retrolental fibroplasia in premature infants.

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Poliomyelitis Epidemic

1952
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Poliomyelitis Epidemic

POLIOMYELITIS: Cases per year

- England and Wales
- Bristol

Year

1952
Donald I, Lord J.

Augmented respiration: Studies in atelectasis neonatorum.

Lancet 1953;1:9-17
Very Early Reports: Modified Drinker

Fig. 14—Apparatus for amplifying natural respiration.

1953

Positive-pressure ventilator treatment of severe pulmonary insufficiency in the newborn infant.

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Patrick Bouvier Kennedy

Patrick Bouvier Kennedy
born Aug. 7, 1963; died Aug. 9, 1963

1963
Usher R.

Reduction of mortality from RDS of prematurity with early administration of intravenous glucose and sodium bicarbonate.

Pediatrics 1963;32:966-975
Stowens D.


Am J Clin Pathol 1965;44:259-270

Last week Dr. Daniel Stowens, a Louisville pathologist, said he had found the explanation of H.M.D. and a simple, effective treatment: Epsom salts enemas.
Heese HD, Wittman W, Malan AF.
The management of the respiratory distress syndrome of the newborn with positive-pressure respiration.
Papadopoulos MD, Swyer PR.

Assisted ventilation in terminal hyaline membrane disease.

Arch Dis Child 1964;39:481-484
Stahlman MT, Young WC, Gray J, Shepard FM.

The management of respiratory failure in the idiopathic respiratory distress syndrome of prematurity.

Ann N Y Acad Sci 1965;121:930-941
Liggins GC, Howie RN.

A controlled trial of antepartum glucocorticoid treatment for the prevention of RDS in premature infants.

Pediatrics 1972;50:515-525
<table>
<thead>
<tr>
<th>Condition</th>
<th>OR (95% CI)</th>
<th>Comment</th>
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<tbody>
<tr>
<td>Death</td>
<td>0.60 (0.48-0.75)</td>
<td>14 trials (n=3544)</td>
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<tr>
<td>RDS</td>
<td>0.53 (0.44-0.63)</td>
<td>18 trials (n=3735)</td>
</tr>
<tr>
<td>IVH</td>
<td>0.48 (0.32-0.72)</td>
<td>6 trials (n=596)</td>
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Crowley PA. 2001 (18 trials)
**Glucocorticoids**

**Functional maturation**
- surfactant (PC, SP-A, SP-B)
- ACE (SOD, Cat, GP)

**Structural maturation**
- thinning of alveolar septa
- microvascular maturation

**Extrapulmonary effects**
- improved hemodynamics
Neonatal dexamethasone induces premature microvascular maturation of the alveolar capillary network
Neonatal dexamethasone induces premature microvascular maturation of the alveolar capillary network
High incidence of air leaks
High mortality associated with air leaks
Prophylactic chest tubes
Kuhns LR, Bednarek FJ, Wyman ML, Roloff DW, Borer RC.

Diagnosis of pneumothorax or pneumomediastinum in the neonate by transillumination.

Pediatrics 1975;56:355-360
Northway WH Jr, Rosan RC, Porter DY.

Pulmonary disease following respiratory therapy of hyaline membrane disease: Bronchopulmonary Dysplasia.

Gregory GA, Kitterman JA, Phibbs RH, Tooley WH, Hamilton WK

Treatment of the idiopathic respiratory-distress syndrome with continuous positive airway pressure.

Kattwinkel J, Fleming D, Cha CC, Fanaroff AA, Klaus MH

A device for administration of continuous positive airway pressure by the nasal route.

Pediatrics 1973;52:131-134
Fujiwara T, Maeta H, Chida S, Morita T, Watabe Y, Abe T

Artificial surfactant therapy in hyaline-membrane disease.

Lancet 1980;1(8159):55-59
High inflation pressure pulmonary edema. Respective effects of high airway pressure, high tidal volume, and positive end-expiratory pressure.

Am Rev Resp Dis 1988;132:1159-1164
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Barotrauma and/or Volutrauma

[Graphs showing data comparisons]
Kawano T, Mori S, Cybulsky M, Burger R, Ballin A, Cutz E, Bryan AC

Effect of granulocyte depletion in a ventilated surfactant-depleted lung.

J Appl Physiol 1987;62:27-33
Oxygen Toxicity and Biotrauma
To the Editor: Biotrauma hypothesis of ventilator-induced lung injury.

Dreyfuss D, Ricard JD, Saumon G

From the Authors
Am J Resp Crit Care Med 2003;167:315
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The Lucerne Experience
Berger TM, Bachmann II, Adams M, Schubiger G

Impact of improved survival of very low birth weight infants on incidence an severity of bronchopulmonary dysplasia.

Biol Neonate 2004;86:124-130

Study population

• retrospective single center cohort study
• three eras with distinct respiratory support strategies
• consecutive admissions of VLBW infants to the NICU
Era I: 1986-1990

Respiratory support

Surfactant
### Era I: 1986-1990

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<th>Cohort A</th>
<th>1986-1990</th>
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<tr>
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<td>(n=97)</td>
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**Respiratory support**: CPAP, cIMV

**Surfactant**: none
### Era II: 1993-1994

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<td><strong>Respiratory support</strong></td>
<td>CPAP, cIMV</td>
<td>CPAP, cIMV</td>
</tr>
<tr>
<td><strong>Surfactant</strong></td>
<td>none</td>
<td>Exosurf®</td>
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<td>CPAP, sIMV</td>
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<tr>
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<td>none</td>
<td>Exosurf®</td>
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<td>Survanta®</td>
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Results

All VLBW infants
(24 0/7 - 31 6/7 weeks)
- n=332
- median GA 29 1/7 weeks
- median BW 1220 g

- no BPD
- mild BPD
- moderate/severe BPD
- death

Cohort A
Cohort B
Cohort C
Results

ELBW infants
(24 0/7 to 27 6/7 weeks)
n=101

- Cohort A
- Cohort B
- Cohort C

- no BPD
- mild BPD
- moderate/severe BPD
- death
Results

VLBW infants (28 0/7 to 31 6/7 weeks) n=231

Cohort A

Cohort B

Cohort C

- no BPD
- mild BPD
- moderate/severe BPD
- death
Conclusion

Changes in neonatal care of VLBW infants in our institution, including increased use of antenatal corticosteroids and modified respiratory support strategies, have resulted in dramatically improved survival rates over the past 15 years without increasing the incidence of moderate to severe BPD.

Berger TM, Bachmann II, Adams M, Schubiger G

Impact of improved survival of very low birth weight infants on incidence and severity of bronchopulmonary dysplasia.

Biol Neonate 2004;86:124-130
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State-of-the-Art

[Images of medical equipment and patients]
1. Lung protection starts in the delivery room
   - ventilate gently
   - use an oxygen blender and pulse oxymetry
   - use early CPAP
   - use a (natural) surfactant (early)
2. Avoid atelecto- and volutrauma
Carney D, DiRocco J, Nieman G

**Dynamic alveolar mechanics and VILI.**

Crit Care Med 2005;33:S122-S128
Carney D, DiRocco J, Nieman G

**Dynamic alveolar mechanics and VILI.**

Crit Care Med 2005;33:S122-S128
Sick lungs are small lungs
Lung Protection

3. Do not normalize blood gases in a patient with sick lungs
   - avoid hypocapnia
   - consider permissive hypercapnia
   - consider permissive hypoxemia
4. Monitor tidal volumes and observe flow-time curves to choose optimal inspiratory times (remember: TC = C x R)

Sick premie lungs are fast lungs
5. Available modes of ventilation should be viewed as different options with none having been shown to be clearly superior to the others

- SIMV versus HFOV
- invasive versus non-invasive ventilation
6. The importance and potential impact of many recent technology refinements remain unclear

Today, we find ourselves surrounded by technologically advanced equipment with a veritable alphabet soup of neonatal ventilatory modes: IMV, SIMV, AC, PSV, VG, PCV, BiPAP, APRV, PRVC

Mark C. Mammel
J Perinatol 2005; 25:624-625
It's the driver, not the machine.

It's not what you use, but how you use what you use.
Technology Assessment
Technology Assessment
Thank You!