1

Neonatal/Pediatric
Cardiopulmonary Care

Disease

2

Consequences of Premature Birth

- Major factor in the severity of disease & mortality in premature neonates = degree that organ systems have not yet developed
- Of all organ systems, the most vulnerable to premature delivery & its complications is the pulmonary system

3

IRDS

4

Baby John

A 24 yowf, gravida 2, para 1, approximately 31 weeks pregnant, was admitted with a c/o lower back pain. She had received prenatal care with regular visits. Medications taken during her pregnancy included only prenatal vitamins. She had been in a car accident 2 weeks earlier; she had been seen by her obstetrician after the accident but had had no difficulty until an hour before admission.

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Baby John

Upon arrival to the hospital, she had been determined to be in premature labor and had spontaneous rupture of membranes. The amniotic fluid was clear. Delivery occurred 8 hours after the onset of labor via normal vaginal delivery. A 31-week estimated gestational age boy was born who weighed 1750 g. The weight was appropriate for the gestational age of the infant. The Apgar scores were 6 at 1 minute and 8 at 5 minutes.

6

Baby John

The mother received no meperidine (Demerol) before the delivery and presentation of the infant was cephalic. No complications were documented by the delivery team.

- Why is it important to know the color of the anmiotic fluid?

- What is the significance of an Apgar score of 8 at 5 minutes?

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Baby John

- Does the fact that there was a normal vaginal delivery have any bearing on the respiratory status of the infant?
- What significance is there in knowing that the mother did not receive Demerol before the infant's delivery?
- Is 31 weeks' gestational age considered to be premature?

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Baby John

Vital Signs	T 36.8°, HR 168/min., RR 64/min., BP 53/31, SpO2 93%
Lungs	Subcostal and internal retractions; breathing irregular; inspiratory crackles in both lungs
Skin	Acrocyanosis present; initial capillary refill 3 seconds
Neurologic	Good muscle tone; good activity

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Baby John

- How do you interpret the vital signs?
- What is indicated by the retractions and inspiratory crackles?

10

Baby John

- What differential diagnosis of this infant is the most likely diagnosis?
- What diagnostic tools would be useful in confirming the diagnosis?

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Baby John

- The patient's clinical status began to deteriorate over the next hour with substernal retractions in addition to the subcostal and intercostal retractions that were observed earlier. A chest radiograph was obtained. The infant exhibited nasal flaring and audible grunting. The pulse oximeter saturation was 86% on room air. The infant became cyanotic and required a 30% oxygen hood in order to improve his color. Vital signs were as follows: HR 160/min., RR 72/min., BP 52/29 mmHg. An ABG was drawn after the placement of a UAC. The results were: pH 7.31, PaCO2 37 mmHg, PaO2 47 mmHg, HCO3 18 mEq/L.

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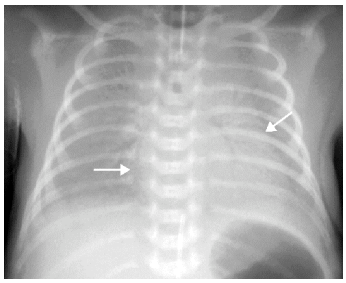
Baby John



- Bilateral under-aeration
- Opacity, described as:
  - **Ground-glass**
  - Clouded
  - Opaque
  - **Reticulogranular**
  - Frosted
- As atelectasis worsens - air bronchograms appear in lung periphery (next CXR)

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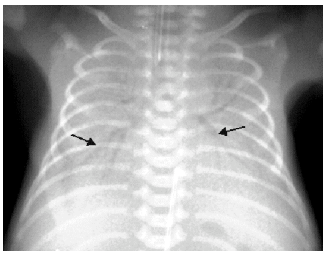
Baby John



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Baby John

- Interpret the ABG.
- What is the cause of the nasal flaring and the audible grunting?
- How did Baby John get to this point? →→→

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RDS

- = Idiopathic Respiratory Distress Syndrome (IRDS)
- = Infant Respiratory Distress Syndrome (IRDS)
- = Neonatal Respiratory Distress Syndrome (NRDS)
- = Hyaline Membrane Disease (HMD)
- = Surfactant Insufficiency Disease
- 30% of neonatal deaths

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Etiology

- Name HMD arises from the change in the alveolar membrane with progression of the disease
- Scar-like tissue replaces the normal alveolar tissue
  ↓
  hyaline membrane
- Etiology of RDS is well understood:
  – Known that the underlying cause of RDS is:

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Surfactant Production

- Week 17-26
  - Terminal & respiratory bronchioles
  - Vascularization
  - Alveoli begin to appear
  - Epithelial tissue
    ↓ ↓
    Type I Type II

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Surfactant Production

- Week 17-26
  – Capillaries are present during week _____ but

  it is not until week _____ that they are close

  enough to the alveoli to allow gas exchange

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Surfactant Production

- 1st appearance of surfactant
  - Coincides with development of
  - Composed of
  - In early stage, surfactant production is easily inhibited by
    -
    -
    -

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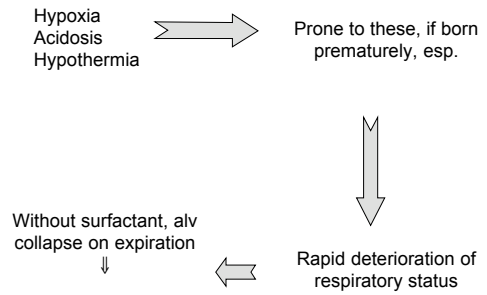

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Surfactant Production

- Measurement of surfactant & lung maturity
  - Can be measured in
  - Lung fluid contributes to amniotic fluid
  - Compare ratio of Lecithin to Sphingomyelin (L/S ratio) to determine

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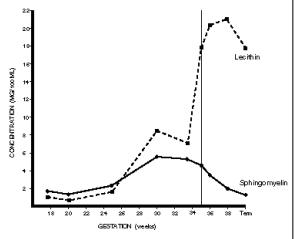
Surfactant Production

- Level of Lecithin varies throughout gestation
- Level of Sphingomyelin remains fairly stable
- **Lungs are mature when L/S ratio =**
- Usually happens at _____weeks when mature alveoli are lined with Type I & II cells *and* alveolar capillaries are in close contact with alveoli



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Surfactant Production

- Factors exist that may delay or accelerate surfactant production, i.e.
  - L/S ratio may not correlate with
  - L/S ratio still predicts

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Surfactant Production

- Factors that delay surfactant production (≥ 34 wks with ↓ surfactant)
  - acidosis
  - hypoxia
  - hypercarbia
  - shock
  - overinflation
  - underinflation
  - pulm edema
  - mechanical ventilation
  - diabetic moms
  - smaller of twins
  - fetal Rh disease

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Surfactant Production

- maternal heroin addiction
- premature rupture of membranes
- maternal hypertension
- maternal infection, toxemia
- placental insufficiency
- abruptio placentae
- maternal administration of betamethasone

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Surfactant Production

- Simple method of determining lung maturity = shake or foam test
  - Mix amniotic fluid with ethanol
  - Shake for 15 sec
  - Wait 15 min
  - If bubbles are still present -- enough lethicin is present to form stable foam

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Surfactant Production

- New techniques in predicting lung maturity
  - Concentration of lamellar bodies in amniotic fluid (storage site of surfactant in Type II cells)
  - SAR
    - surfactant-albumin ratio in amniotic fluid
  - TDx-FLM assay
  - FP
    - Fluorescence polarization

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Surfactant Production

- Lung maturation can be artificially induced
  - Administration of glucocorticosteroids
  - Increases rate of
  - Decreases severity of
  - Betamethasone, Celestone, dexamethasone (Decadron), indomethicin (Indocin)

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Surfactant Production

- Artificially-induced lung maturation
  - Must be given
    -
    -
    -
  - Usually doesn't eliminate RDS but does

30

Summary

- 2 major factors necessary for normal lung function
  1.
  2.
- Both peak at about same time:
- If born <34 weeks --

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Summary

- Also, some infants born >35 weeks who are stressed or whose neonatal transition has not been smooth (asphyxia) may have depressed production of surfactant 2° to hypoxia & acidosis

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Risk Factors for Development of RDS

- Prematurity (<34 weeks)
- Low birth weight (<1200 g)
- Male gender (2:1 ratio)
- PFC
- Atelectasis
- Twins, triplets, quads, etc.
- Maternal diabetes

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Risk Factors for Development of RDS

- Prenatal maternal complications
  - Hypoxia
  - Hemorrhage
  - Shock
  - Hypotension, hypertension
  - Anemia
- Abnormal placental conditions
- Umbilical cord disorders

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Pathophysiology of RDS

- Con't research demonstrates that ↓ surfactant is not the only contributing factor in cause of RDS

1. Overall immaturity of other organ systems
2. Immaturity of terminal air sacs
3. Capillaries *not* in close contact with alveoli

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Pathophysiology of RDS

5. Immaturity of chest wall -- very little stabilization →
6. Immaturity of diaphragm →
7. Immaturity of CNS →
8. Hypothermia, hypoxia, acidosis →

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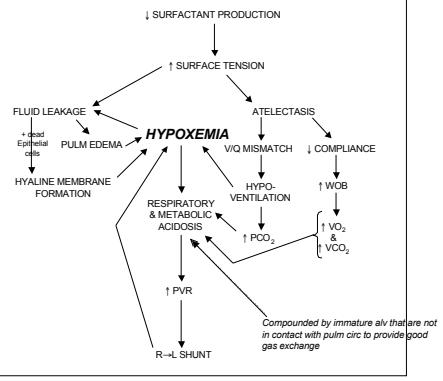

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Signs & Symptoms

- Begins at birth or within hours
- RR >
- Grunting
- Nasal flaring
- Chest retractions which worsen over time
- Cyanosis may be present

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Signs & Symptoms

- Worsening PaO_2, mixed acidosis
- $PaCO_2$ initially OK but may climb as patient tires

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Signs & Symptoms

- Non-respiratory signs
  - Hypothermia
  - Pallor of skin
  - Flaccid muscle tone
  - General hypoactivity

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Signs & Symptoms

- Symptoms gradually worsen for 1st 48-72 hrs followed by a stabilization & slow recovery
- Highest incidence of mortality from RDS is in 1st 72 hrs
- If death occurs >72 hrs, it is usually 2° to complications
  - –
  - –
  - –
- Back to Baby John →→

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Baby John

The infant's oxygen requirement continued to increase. He was breathing an FiO2 of 0.60 by oxyhood with an SpO2 of 88%. The ABG results are: pH 7.26, PaCO2 50 mmHg, PaO2 40 mmHg. The patient was placed on 4 cmH2O CPAP via nasal prongs with an FiO2 of 0.65. The SpO2 continued to be low and the FiO2 was increased to 0.80.

After increasing the CPAP to 6 cmH2O and the FiO2 to 0.80, the ABG results were: pH 7.25, PaCO2 53 mmHg, PaO2 39 mmHg, HCO3 21 mEq/L, BE -3.

42

Baby John

- Interpret the most recent ABG.
- What treatment is indicated at this time?

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Baby John

The respiratory therapist intubated the infant with a 3.5 mm ETT. Auscultation of the chest and abdomen suggested proper placement of the tube. The infant was manually ventilated to determine the optimal pressures for chest expansion. The ventilator was set at a peak pressure 22 cmH2O, PEEP 4 cmH2O, SIMV mode with a rate of 40/min., and an FiO2 of 0.80. Within 1 hour, the SpO2 was 96%. The infant was pink and had increased activity. The HR was 145/min., RR 50/min., BP 65/36 mmHg, and skin temp was 37.2°C.

44

Baby John

- Why was Baby John given CPAP and not directly placed on pressure-controlled ventilation?
- What is the cause of the mixed acidosis and hypoxemia in this patient?
- Is this patient a candidate for exogenous surfactant replacement therapy?

45

Treatment

-
-
-

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Treatment

- The difficulty in treating RDS is in maintaining adeq alv ventilation w/o inflicting damage on lungs
- Goal = support respiratory system while minimizing complications
- Over-riding rule is to treat symptoms quickly with pressures & F_IO_2's as low as possible

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Treatment

- PaO_2 - mmHg
- $PaCO_2$ - mmHg
- pH
- If not retaining CO_2 -
- Regardless of CPAP or MVS - early intervention is essential

48

Treatment

- Administration of albuterol, ipratropium has been shown to give short-term improvement
- Adequate hydration & electrolyte balance
- Thermoregulation vital

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SRT History

- Known for a long time surfactant could be replaced
- Problem was
  - Surfactant = several phospholipids + proteins with each having special characteristics & functions
  - Difficult to reproduce

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SRT History

- Early studies discouraging
  - Could not find right combination of components
  - Could not find best dosage
  - Method of delivery didn't work (nebulized)
- Finally discovered direct instillation to ETT with high dosage has dramatic effects

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Composition of Surfactant

- 90% = phospholipid
  - 85% = phospatidylcholine (PC)
    - 60% = dipalmitoyl phosphatidylcholine (DPPC)
  - 15% = phosphatidylglycerol (PG)
    phosphatidylinositol (PI)
    cholesterol
- 10% = proteins: SP-A (surfactant protein A)
  SP-B
  SP-C
  SP-D
- *All elements essential for proper function*

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SRT Indications

- Prophylactic
  - –
  - –
  - –
  - –
- Therapeutic
  - – Infant already showing signs of RDS

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SRT Contraindications

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Types of Surfactant

Natural	*Modified Natural*	*Artificial*
•Recovered from lung or amniotic fluid	•Extracts of minced lung or alveolar lavage	•Mixtures of synthetic compounds but no actual protein
•Excellent surface active properties	•Add or remove compounds to improve surface activity	•Less effective
•Difficult to manufacture	•Lose SP-A & SP-D in extraction process	•Inexpensive
•Infection risk	•Sterile	•No infection risk

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Types of Surfactant

- New category, *synthetic natural*, on horizon
- Artificial surfactant with genetically engineered proteins added
- Clinical trials with KL_4-surfactant *(approved Oct. 2006 as Surfaxin)*
- Behave like modified natural

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Types of Surfactant

- Differences in composition is important - all surfactants do not have same response
- Modified naturals
  - Spread more rapidly at alv surface
  - Better at
    - Improving oxygenation
    - Decreasing mortality
    - Lowering incidence of ROP & BPD

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Surfactants

- Survanta
  - Modified natural
  - Bovine lung mince extract (CLSE) with added DPPC, tripalmitin, palmitic acid to improve surface activity
  - Does not require reconstitution
    - Dose - 100 mg/kg BW
    - Can be given q6°

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Surfactants

- Infasurf
  - Modified natural
  - Bovine lung wash (CLSE)
  - Chloroform-methanol extract to improve surface activity
  - No reconstitution needed
    - Dose - 3 ml/kg BW
    - Repeated q6-12° up to X 2

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Surfactants

- Curosurf
  - Modified natural
  - Porcine lung mince
  - Chloroform-methanol extract to improve surface activity
  - No reconstitution needed
    - Dose - 2.5 ml/kg BW
    - Repeat 1.25 ml/kg q1° X 2
    - Max recommended dose - 5 ml/kg

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Surfactants

- Exosurf
  - Artificial
  - DPPC with 9% hexadecanol, 6% tyloxapol
  - Reconstitution needed
    - Dose - 5 ml/kg BW given as 2 divided doses of 2.5 ml/kg
    - Repeat 5 ml/kg q12° X 2

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Delivery of Surfactants

- Direct instillation
- Through 5 Fr. Catheter in ETT
- Mechanically ventilated in
- No Sx for
- Postural positioning during administration

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Results

↑	↓
oxygenation	vent press needed
a/A gradient	RR
	incidence of BPD
	incidence of pneumothorax
	Staph sepsis
	death (by 50%)

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Results

- Effects can be immediate (min to hrs)
- Vent changes need to be made accordingly
- Cannot prevent RDS but does reduce severity
- Does not reduce incidence of other complications of prematurity (IVH, NEC)

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Warnings & Complications

- Acute effects - can *rapidly* affect blood gases & lung compliance
  - Lung compliance - peak vent pressures must be quickly decreased to avoid barotrauma
  - Hyperoxia - same as above
  - Hypocarbia - decrease vent rate

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Warnings & Complications

- Pulmonary hemorrhage
  - 10% incidence in infants <700 g
- Mucus plugs
  - Seen if have increased secretions prior to surfactant administration
  - Sx prior to drug delivery

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Warnings & Complications

- Doesn't always work
  - 50% have dramatic & long-term response
  - 25% some improvement
  - 25% little effect
- What does this mean?
  - Perhaps 25% of infants diagnosed with RDS have pulmonary problems which are ***not*** due to surfactant insufficiency
- Could this be used as a diagnostic tool?
  - Probably (SRT to r/o RDS)

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Baby John

The patient improved and by day 4 was extubated and given an FiO2 of 0.30 by oxyhood. He was weaned to room air on day 8. Baby John remained in the hospital for 3 more weeks until he gained an appropriate amount of weight. There were no other respiratory complications and he was discharged at a weight of 2510 g.

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Complications of RDS

- IVH (intraventricular hemorrhage)
  - Occurs in 40% of infants < 1500 g
  - Incidence increases if MVS
- Barotrauma
- DIC (disseminated intravascular coagulation)
  - Caused by disruption of coagulation factors → profuse bleeding

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Complications of RDS

- Infections
  - Pneumonias
  - Usually due to presence of ETT
- PDA (patent ductus arteriosus)
  - Severe R→L shunt
  - During healing - shunt goes L→R (blood aorta → pulm artery → ↑ PVR due to ↑ volume → right heart failure