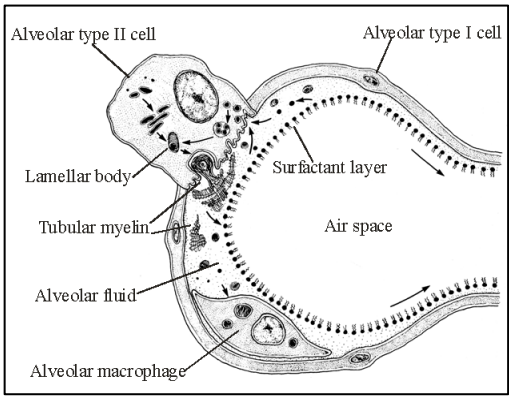
Pediatric Respiratory Physiology

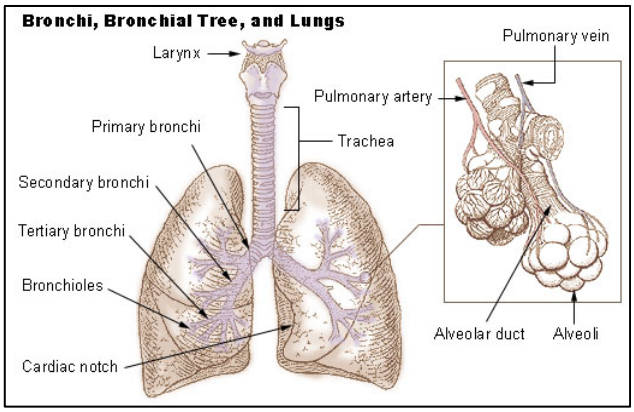
Anesthetic Pearls: Anesthetic Implications and Management of the Neonatal Respiratory System

Development:



- Development of the fetal lung begins during the fourth week of gestation.
- Conducting airways are formed by week 16.
- From the 24th week until term, the terminal sacs are formed.
- At term, neonates have a primitive alveolar structure (alveolar maturation is not complete until 8-10 years of age).
- Type-II pneumocytes begin to differentiate at 24 weeks gestation.
- A marked synthesis of surfactant does not begin until 34-36 weeks gestation.

Mechanics:



- The neonatal lung is less compliant because of differences in alveolar architecture, elastin, and surfactant.
- Alveoli are small and many of the airspaces are in the pre-alveolar or saccular stage of development with thickened walls.
- Less elastin results in less elastic recoil and more likely collapse of airways and alveoli.
- Immaturity or damage to the surfactant system results in decreased compliance.
- Airway resistance is greater in children than adults.
- Conductance (1/resistance) of the small peripheral airways is low in young children and dramatically increases after 5 y/o.
- The increased resistance results in increased work of breathing and increased vulnerability to diseases affecting the small airways.
- Neonatal chest configuration differs from that of the adult.
    1. The neonate chest is "box-like", with ribs positioned at nearly right angles to the vertebral column.
    2. The adult chest is flattened dorsoventrally and has ribs that slant in the caudal direction (mechanically more efficient configuration).
    3. The neonate chest wall is more compliant because the ribs are cartilaginous rather than bony.
- Negative intrapleural pressure with low lung compliance or high airway resistance can result in chest wall collapse with the movement of very little air.
- Decreased number of high oxidative muscle fibers in the diaphragm that are capable of sustained work.

Physiology:

- Increased O_2 consumption: greater than 6 ml/kg/min in the neonate (~ 2 times greater than adult on a weight basis).
- Increased CO_2 production in the neonate, but pCO_2 is near normal because of increased minute ventilation.
- Decreased PaO_2: initially lower due to decreased FRC and perfusion of fluid filled alveoli
- Increased minute ventilation: TV on a weight basis is the same as adult, therefore increased minute ventilation is due to increased respiratory rate. Because of respiratory mechanics, this is more efficient than increasing TV.
- High closing volumes predispose to airway closure and alveolar collapse during TV ventilation. (esp. during GA when FRC decreases.)
- High minute ventilation and lower FRC leads to rapid de-nitrogenation and inhalational induction.

Respiratory Control:

- Response to hypoxia: ventilation initially increases but then decreases ("biphasic" response is more exaggerated in the preterm neonate).
- Irregular respiration ("periodic breathing") suggests incomplete development of the medullary respiratory centers.
- Hypercarbia is not as potent a respiratory stimulant in neonates (? respiratory depressant in preterm neonates).
- Apnea frequently occurs with prematurity, infection, hypothermia, hypoglycemia, and GA.
- Neonates less than 60 weeks estimated gestational age having general anesthesia should be admitted to the hospital and observed for 23 hours due to immature development of the respiratory centers and increased risk of apnea.