

Neonatal Transport

*The Newsletter of the Maryland Regional Neonatal Transport Program
June 2008*

Respiratory System: Embryologic Lung Development and Birth Transition

The diagnosis of the greatest number of neonates admitted to the NICU and Special Care Nurseries is respiratory distress. The most common is respiratory distress syndrome, transient tachypnea, aspiration syndrome, air leak and pneumonia. Keep in mind that no matter what the etiology of a disease, very often respiratory symptoms will be evident.

Abnormalities with cardiac, neurologic, metabolic and genetic origins may also present with various degrees of respiratory distress. Thus, non-pulmonary disease must always be in the differential diagnosis. To adequately assess and care for these neonates, one must understand the normal pulmonary embryology/physiology.

1) Embryonic Phase (through week 5)

During embryonic development, airways begin to differentiate. Branching of the airways also occurs, so any anomalies (such as pulmonary agenesis) occur early in fetal life. The pulmonary arteries follow the airways and divide with the airways. Pulmonary veins develop independently from lung tissue and return to the left atrium so that the pulmonary circuit is complete. The trachea is developed during this time.

The single ventral out pocketing forms two lung buds. The right bud contains three divisions, while the left contains two. These divisions eventually develop into the lobes of the lung.

2) Pseudo glandular period (5-16 weeks)

The Pseudo glandular Phase begins with progressive airway branching to form the bronchi and terminal bronchioles. Cartilage, muscle fibers and elastic tissue appear along the

tracheobronchial tree. The capillary bed is formed with connecting bronchial blood supply. The diaphragm also develops and closes during weeks 8 -10. Large diaphragmatic defects that occur during this time may impact lung development by decreasing the amount of subdivisions that will ultimately form. By week 17 all major elements of the lungs have formed except for those involved with gas exchange. The lungs look like an endocrine organ. No respiration is possible!

3) Canalicular period (17-24 weeks)

The lumen of the bronchi and terminal bronchioles become larger and the lungs become vascularized. By week 24, respiratory bronchioles have developed and respiration becomes possible, although the chances of survival are slim.

4) Terminal sac period (Saccular stage) (24 weeks to 37 weeks)

Terminal sacs develop and capillaries enter into close relationship with them. They are lined with Type 1 alveolar cells or pneumocytes. Type II pneumocytes secrete surfactant counteracting the surface tension forces and facilitating expansions of the terminal sacs. Surfactant reaches adequate levels 2 weeks before birth. Adequate pulmonary vasculature and sufficient surfactant are critical to the survival of premature infants.

5) Alveolar period (late fetal period to 8 years)

Over 95% of the mature alveoli develop after birth. A newborn infant has only 1/6 to 1/8 of the adult number of alveoli and the

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lungs look denser in an x-ray. Developing lungs at birth are half filled with amniotic fluid. The fluids in the lungs are cleared: through mouth and nose by pressure on the thorax during delivery then with movement into the pulmonary capillaries, the lymphatics and pulmonary arteries and veins. During fetal life, pulmonary blood flow is low, with less than 10% of the combined cardiac output directed to the lungs. In fetal life, numerous factors, including hypoxia, maintain high pulmonary vascular resistance (PVR). After birth, PVR decreases, and pulmonary blood flow increases dramatically as the lungs assume the function of gas exchange. The combination of rhythmic ventilation of the lung and increased alveolar oxygen tension stimulate these changes. Each stimulus, by itself, decreases PVR and increases pulmonary blood flow, but effects are greatest when the 2 events occur simultaneously. In some newborns, the normal decrease in pulmonary vascular tone does not occur, and the result is persistent pulmonary hypertension of the newborn (PPHN). This syndrome causes substantial morbidity and mortality in otherwise healthy, term newborns.

Just like a rubber band, there is a tendency for anything that is stretched to return to its resting state. The alveoli are stretched with inspiration and return to their normal volume upon exhalation (normal lung). Lung compliance refers to how "elastic" the lung is. If the lung is compliant, there will be a large volume change with a small pressure change. See figure. The normal lung requires very little pressure for the lung to open, and the volume of gas contained in that inspiration is large. Contrast that with the compliance shown for the baby with RDS. It requires much more pressure for the lung to open, and when it does, the volume of air that is moved is much smaller.

Please also note that with the healthy lung, there is a functional residual capacity (the resting volume never returns to zero). There is always air in the alveoli. The lung with RDS, a surfactant deficient state, has very little air left upon exhalation and begins from zero at the start of inspiration. Consider how much energy the neonate needs to spend attempting to open that lung to execute gas exchange.

Lung resistance is the relationship between a given change in pressure and a given change in flow. Airway resistance occurs due to the friction between the gas molecules and the walls of the airways. Tissue resistance occurs due to friction between the tissue of the lung and the chest wall. The greater the resistance, the greater the time needed for the gas to reach the alveoli. In addition, a greater flow of gas will be needed to overcome the resistance.

High flows create turbulence in the airways and make it difficult for the gas to reach the alveoli. Remember that with inspiration, the airway diameters are increased just as the alveoli are increased. This acts to decrease some of the airway resistance. Endotracheal tubes cause airway resistance due to their narrow lumens. It will take greater pressure to force air through a smaller tube than one with a larger lumen. Endotracheal tube size is estimated based on weight and postmenstrual age as established by the American Academy of Pediatrics NRP guidelines.

References

(Askin & Diehl-Jones, 2004; Hansen & Corbet, 2005)
Reprinted with permission from Elsevier from Harris, T. R., & Wood, B. R. (1996). Physiologic principles. In J. P. Goldsmith & E. H. Karotkin, Eds., *Assisted ventilation of the neonate*, 3rd Ed., Figure 2-10, p. 32.

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MRNTP Community Initiatives

MOD-March for Babies

May 3, 2008

On May 3, 2008, the MRNTP participated in the Baltimore City based four mile walk to support the March of Dimes. This was the fourth year of team involvement. The walk which was recently renamed the "March for Babies" began in 1970 and is one of the oldest and most popular walk events in the nation. It is held in 1,100 communities across the nation. Funds generated from the March for babies support prenatal education efforts, parent education for NICU graduates, smoking cessation classes for pregnant women and research initiatives to discover the genetic basis for many birth defects. This year, the team raised a total of \$685.00. Thanks to all for supporting the MRNTP.



From Left: Mike Norton, Colby Millen, Bill Tippet, JoAnn Bernard, Teddy Baldwin

Transport Issue/X-ray request

Most community hospitals, like JHH & UMMS, have converted to various systems for X-ray archival. While many vendors claim to have universal application, this has not always been the case. For now, when infants are transported, we ask that a hard copy of radiographs be available to the transport staff for use during their assessment and to accompany the infant on transport.

Outreach Education

STABLE

07.02.08- Easton Memorial
Pediatricians only

STABLE- CARDIAC

6.11.08-Peninsula Regional Medical Center

6.18.08-Frederick Memorial Hospital

NRP

6.10.08- UMMS Peds Residents

6.12.08-JHH Lifeline/MEC-

6.27.08- UMMS OB Residents

7.24.08- BWMC & MEC

NRP Instructor Retreat

10.24.08

For more information contact Webra

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Welcome and Welcome Back New Employees

Jodi Cox is based at Johns Hopkins Hospital as a NNP/NTN. Jodi was a previous 3 year employee of Johns Hopkins but relocated to the Chicago area in 2001. It is a pleasure to welcome her back to Maryland. Jodi and her husband Joe have three children.



Teddy Baldwin is a new MRNTP medic. He has worked for Best ambulance and most recently was a dispatcher for Life star ambulance. He is a paid employee of the Jacksonville Fire department in Baltimore County. He is also captain of the Hereford Volunteer Fire Dept in Baltimore County.



Joan Lewis is based at the University of Maryland Medical Center. Joan has worked at UMMS since 1995 and previously functioned as a transport nurse from 1997 to 2000. Joan obtained a Bachelor's degree in Business in 1989 from Penn State University. She then completed her diploma in nursing from Chester County Hospital School of Nursing. She and her husband have two children, ages 7 and 5. Joan is happy to be back on the transport team after an 8 year hiatus.



Bronwyn Willet is based at the University of Maryland Medical Center. Bronwyn has been working more transport shifts. Recently she even worked her first day shift in 8 years! She lives in Baltimore with her husband and 4 children.

