Maturation of the Premature Infant: Sleeping Breathing and Feeding

Anna Dusick, MD

Neurodevelopmental Pediatrician

Professor of Pediatrics, CHS

DEPARTMENT OF Pediatrics
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

WAISMAN CENTER
UNIVERSITY OF WISCONSIN-MADISON

Behavioral Objectives

- Identify the components of state control, breathing and oral control needed for feeding.
- Identify abnormal breathing and apnea that will interfere with feeding.
- Identify risk factors for aspiration and how to diagnose aspiration.

When do infants begin to feed?

- It is not how “old” you are from birth, but how mature you are from conception.

Gewolb, IH *Dev Med Child Neur* 2001

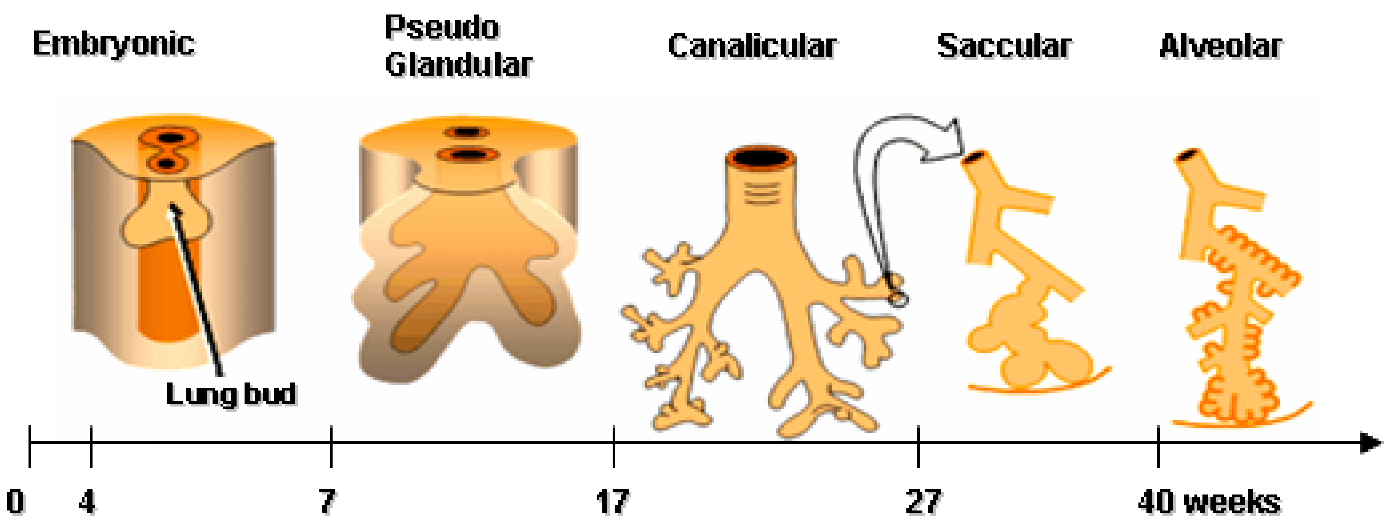
Maturation of the premature infant

- **Respiration**
- Sleep
- Early oromotor rhythms

Normal Maturation of Respiration

- Genetically determined
- Early fetal breathing movements are present and respiratory control must develop to ready the fetus for breathing at birth.
- Anatomically:
  - 18 weeks- conducting airways develop
  - 24 weeks- respiratory bronchioles ending in saccules
  - 40 weeks- mature microvasculature

Jobe A Pediatr Neonatol 2010;51(1):7-13



The stages of pulmonary development

Normal Maturation of Respiration

- Neurologic maturation of control -
- ***Central Pattern Generator (CPG)***– neuronal circuits that produce rhythmic patterns of neural motor output activity without sensory inputs.
- ***Respiratory CPG*** is composed of subnetworks with various stimuli acting on it.
- Ultimate control in the Brainstem between the CPG and the Vagus, Recurrent laryngeal, Glossopharyngeal, Hypoglossal and other nerves innervating the upper airway.

Carroll J Pediatr Resp Reviews 11 (2010) 199-207

Respiratory Distress Syndrome

- Immature airways:
  - Lack of surfactant
- Immature ventilatory control:
  - Brainstem rhymogenesis
  - Central Response to CO_2
  - Impaired Peripheral responses to hypoxia
  - Increase in inhibitory neurotransmitters

Respiratory Distress Syndrome

- Inflammation and lung edema
- Infection
- Injury from assisted ventilation
- 46-69% of premature infants have some RDS

Bronchopulmonary Dysplasia

- Multifactoral disorder associated with consequence of RDS, earlier GA, and oxygen requirement.
- Oxygen requirement at 36 weeks of PCA (moderate)

Bronchopulmonary Dysplasia

Birthweight	Incidence of BPD
501-750g	52%
751-1000g	34%
1001-1250%	15%
1251-1500%	7%

Ehrenkranz R. Pediatrics 116: 1350-1360,2005

Bronchopulmonary Dysplasia

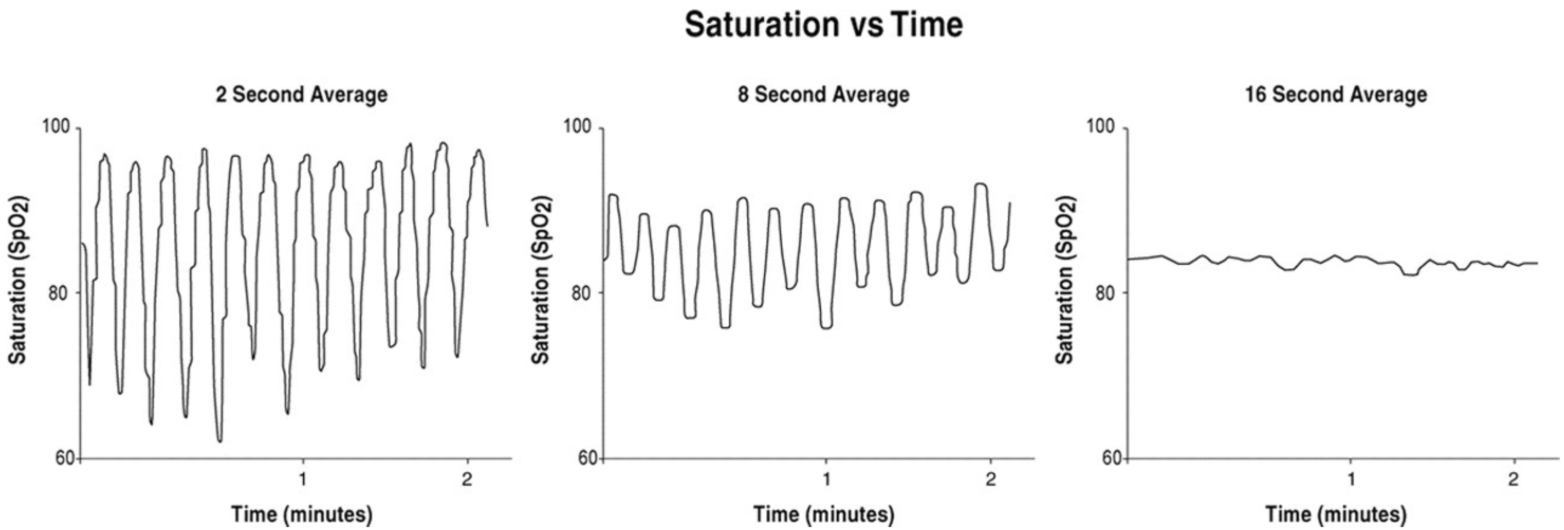
- Complications affecting feeding:
  - Rapid respiratory rate
  - Desaturations and fluctuating levels of oxygen
  - Atypical Lung growth affecting tidal volume/rate/rhythm
  - Increased respiratory symptoms to viral infection
  - Increase readmission to the hospital for pneumonia
  - Persistent pulmonary problems

Apnea of Prematurity

- Developmental disorder of respiratory control
- Immaturity rather than pathological
- Exact mechanism has not been clearly identified
- Impairment in central CO_2 response
- Late depression in ventilation from low O_2
- Can be associated with transient hypoxia

Abu-Shaweesh J Pediatr Pulmonol 2998;43:937-944.

Figure 2. Data from an infant diagnosed with apnea of prematurity.



Petterson M T et al. Anesth Analg 2007;105:S78-S84

Apnea of Prematurity

- Either enhanced or reduced peripheral chemoreceptors can lead to apnea, bradycardia or desaturations
- ***Laryngeal chemoreflex (LCR)***- activation of the laryngeal mucosa by liquid results in apnea, bradycardia, hypotension, closure of the airways,swallowing movements.
- Resolves by 43-44 weeks

Abu-Shaweesh J. Pediatr Pulmono 2008: 43:937-944

Treatment of Apnea of Prematurity

- *Methylxanthines (caffiene)*
- Increases minute ventilation
- Improves CO_2 sensitivity
- Decreases hypoxic depression of breathing
- Decreases periodic breathing
- Enhances diaphragmatic activity

Abu-Shaweesh, JM Pediatr Pulmon 2008

Treatment of Apnea of Prematurity

- *Methylxanthines (caffiene)*
- Side effects including
- Tachycardia
- Cardiac dysrhythmia
- Feeding intolerance
- Seizures

Abu-Shaweesh, JM Pediatr Pulmon 2008

Long Term Outcome of caffiene

- Barbara Schmidt and the Caffiene for Apnea of Prematurity Trial Group
- 937 preterm infants with BW<1250g at 18 Mo.
- Found the caffiene treated group improved in:
  - Less death
  - Less neurodevelopmental disability
  - Less Cerebral Palsy
  - Less Cognitive Delay compared to placebo

Schmidt B. NEJM 2007;357:19;1893-1902

Maturation of the premature infant

- Respiration
- **Sleep**
- Early oromotor rhythms

Normal Maturation of Sleep

- Neurophysiologists use EEG-polygraph studies
  - Functional Brain Maturation vs.
  - Encephalopathy
- Estimate maturity within 2 weeks in the preterm
- Cortical and subcortical neuronal networks mature with state changes seen on the EEG at:
  - 30 wks PMA
  - 36 wks PMA
  - 48 wks PMA

Scher M. Sleep Medicine 2008: 9;615-636

Normal Maturation of Sleep

- Physiologic behaviors also change at 36 wks PMA
- ***Rapid Eye Movement (REM)*** is a main featue of active sleep at 30-31 wks of gestation.
- Fetal movements change and decrease with maturation from 17% to 7% near term.
- Myoclonic and whole-body movements are seen in the preterm, with slower, smaller segmental movements are at term.
- Less cardiorespiratory variability with increasing postmenstrual age.

Scher M. Sleep Medicine 2008: 9;615-636

Normal Maturation of Sleep

- After 36 weeks PMA
- Visably identify sleep states
    - Active (REM)
        - Increased variability of Cardio respiratory rates
        - Low muscle tone
        - Increased body movements
  - Quiet (Non REM)
    - Decreased body movements
    - Increased muscle tone
    - Decreased variability in respiratory rates

Scher M. Sleep Medicine 2008: 9;615-636

Normal Maturation of Sleep

By term: 40 weeks:

- Sleep cycle with Active and Quiet Sleep (30-70min)
- Arousal peirods between the sleep states
- Full circadian rhythm is not present
- Circadian rhytjhm will mature after 48 weeks PMA

Scher M. Sleep Medicine 2008: 9;615-636

Sleep-Wake Transitions and Outcome of Premature Infants

- Weisman et al. Pediatrics 2001:128;4
- 143 LBW infants (1482g, 31.8 GA) Organization of sleep states with pattern of transitions between active/quiet sleep and cry and wake at 37 wks PMA.
- High- arousal Cluster (Active sleep and Cry)
- Organized Cluster (Quiet sleep and Wake)
- Disorganized Sleep
- Developmental Outcome at 6,12,24mo, 5 Yrs.

Sleep-Wake Transitions and Outcome of Premature Infants

Developmental Outcome at 5 years:

Those with the <u>Organized sleep-wake</u> patterns scored better than the <u>High Arousal</u> and the <u>Disorganized Sleep</u> in:

Executive Functioning

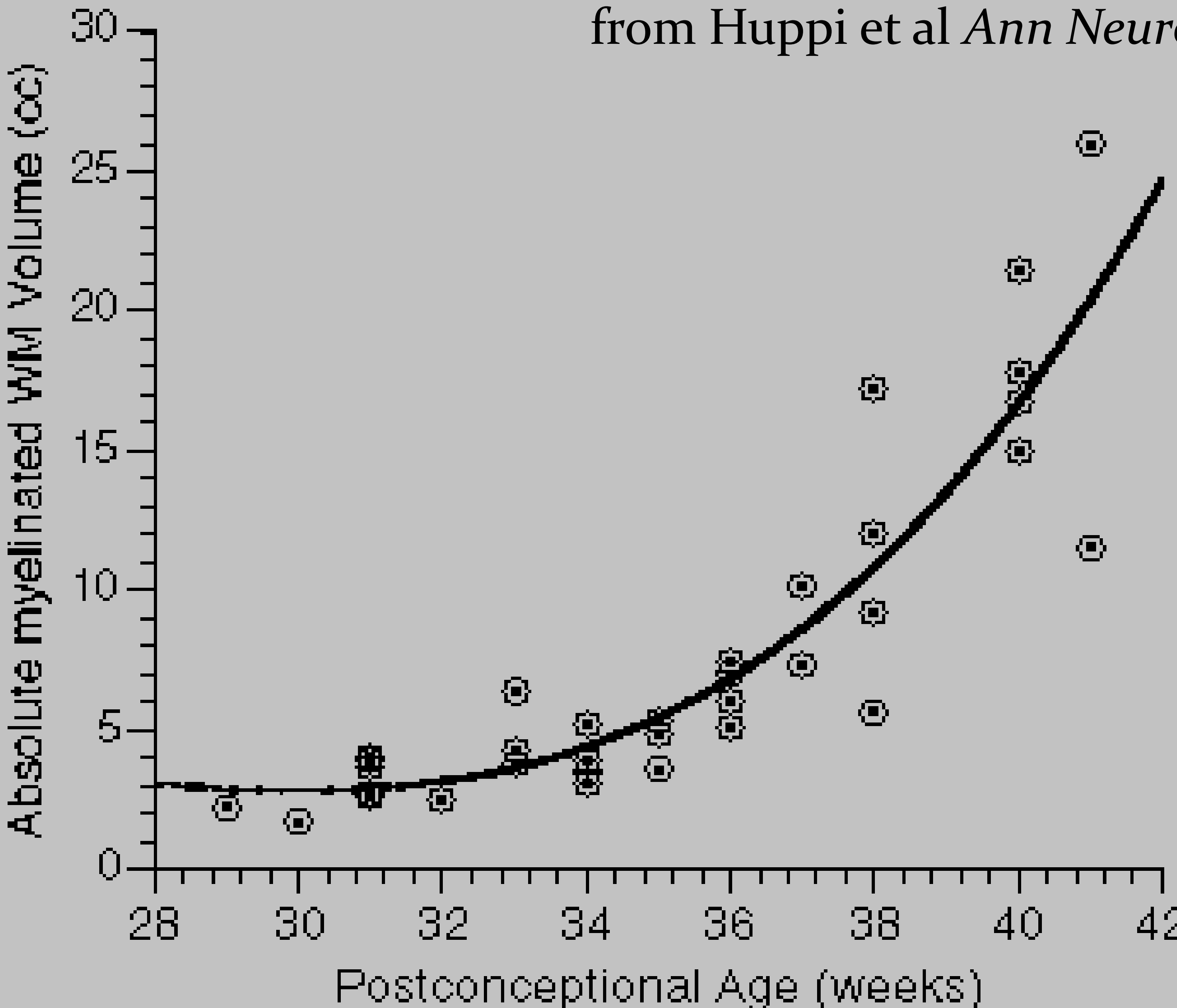
Symbolic competence

Verbal IQ (Organized vs Disorganized)

Weisman et al. Pediatrics 2001:128;4

3D brain model at 31 weeks from Huppi et al *Ann Neuro* 1998

3D brain model at 40 weeks from Huppi et al *Ann Neuro* 1998 from Huppi et al *Ann Neuro* 1998



Maturation of the premature infant

- Respiration
- Sleep
- **Early oromotor rhythms**

Early Oromotor Reflexes

- Gag Reflex
- Transverse Tongue Reflex
- Rooting Reflex
- Biting

Early Oromotor Reflexes

- Gag Reflex – stimulus to the posterior tongue results in a swallow at 18 weeks PMA.

- Transverse Tongue Reflex – light touch to the lateral aspect of the tongue results in ipsilateral tongue deviation, anterior-posterior tongue movements and mouth closing beginning at 28 weeks.

Early Oromotor Reflexes

- Rooting Reflex – perioral light touch results in head orientation to the stimulus, mouth opening, lip arching, tongue protrusion and grooving, and labial grasping ("the latch").
- Beginning at 28 weeks the rooting reflex matures by 38 weeks.

Shephard JJ *Child Dev* 1984

Early Oromotor Reflexes

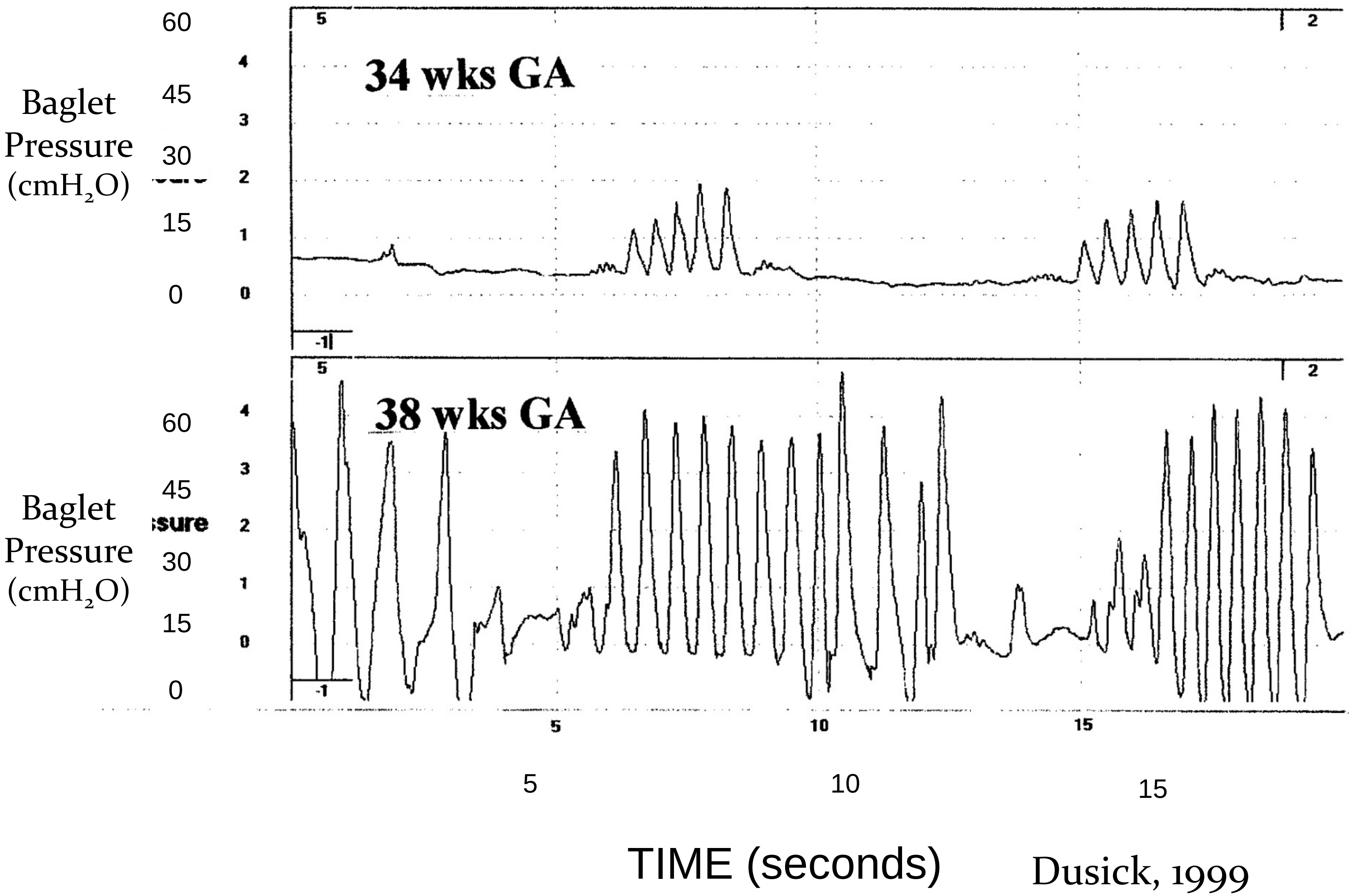
- Bite Reflex – First described in 1959. Stimulus of light touch to the biting surface of molar, mandibular gingiva will elicit a bite down. (Mysak '59)

Shephard JJ *Child Dev* 1984

Early Oromotor Rhythms

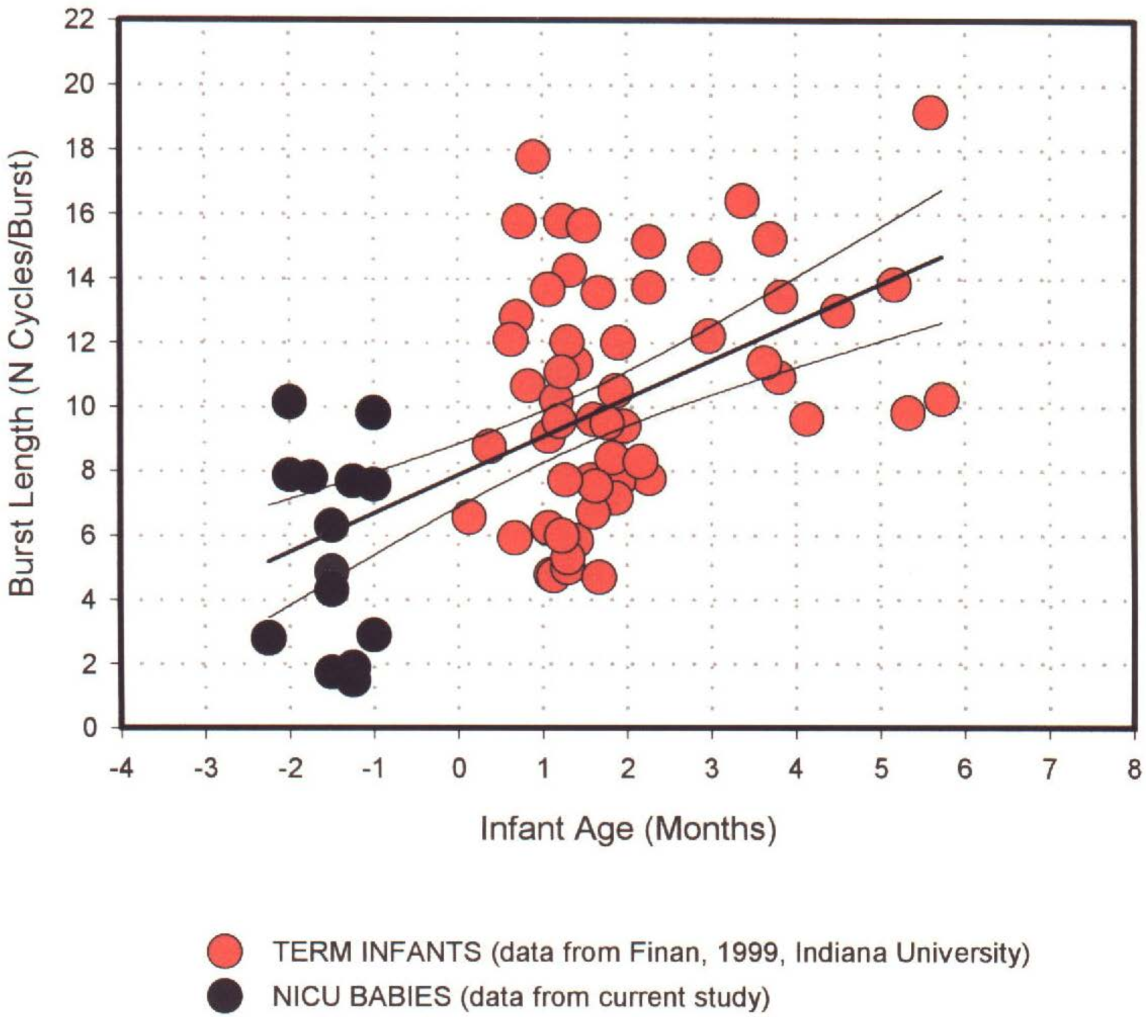
- Coordination of 3 rhythmic motor behaviors
  - Sucking
  - Swallowing
  - Breathing

NNS 34 & 38 wks



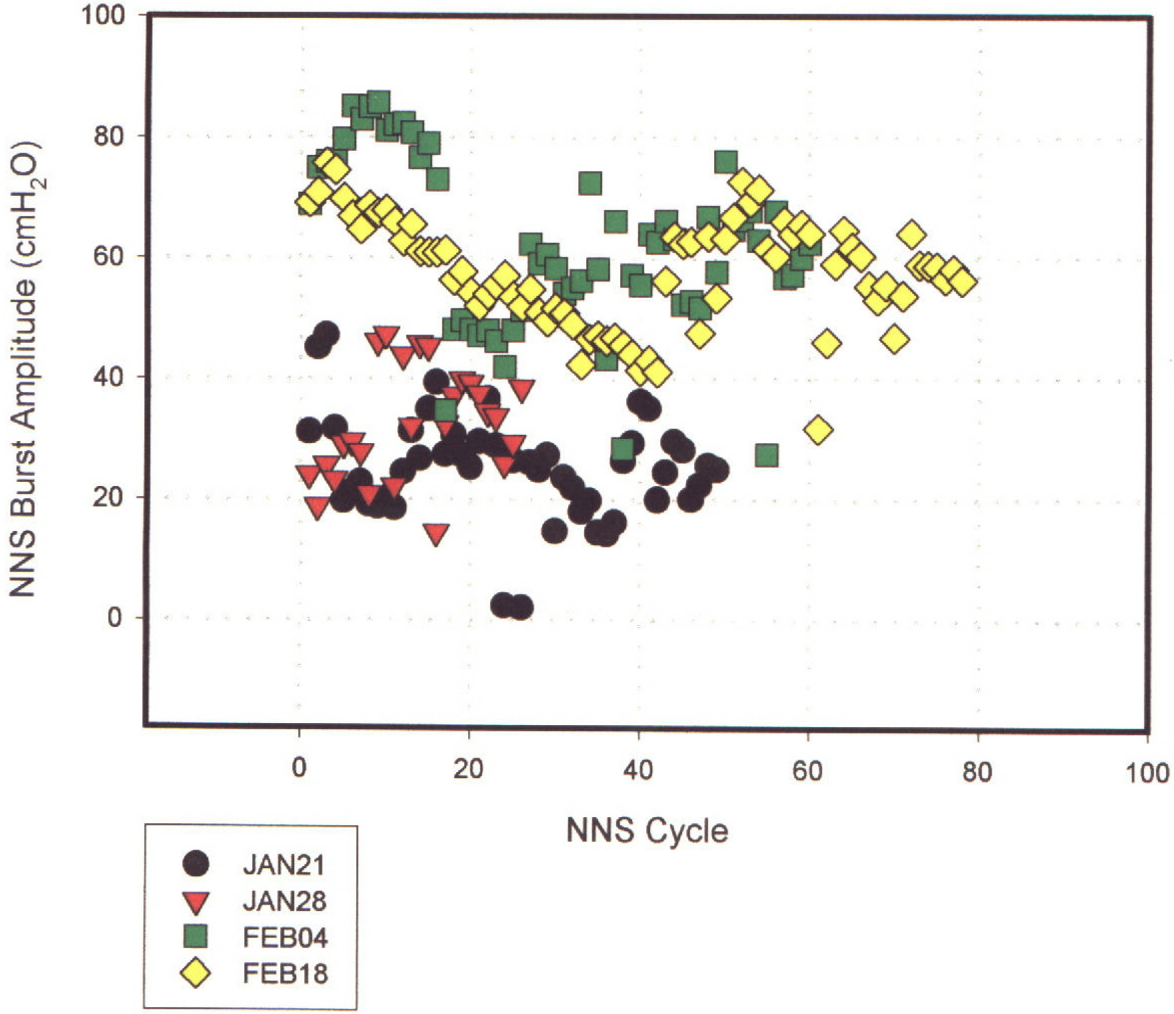
Dusick, 1999

NNS Burst Length Ontogenesis



Barlow, Finan, Dusick 1999

Non-nutritive Suck Amplitude in One Patient 34-38 Weeks



Dusick, 1999

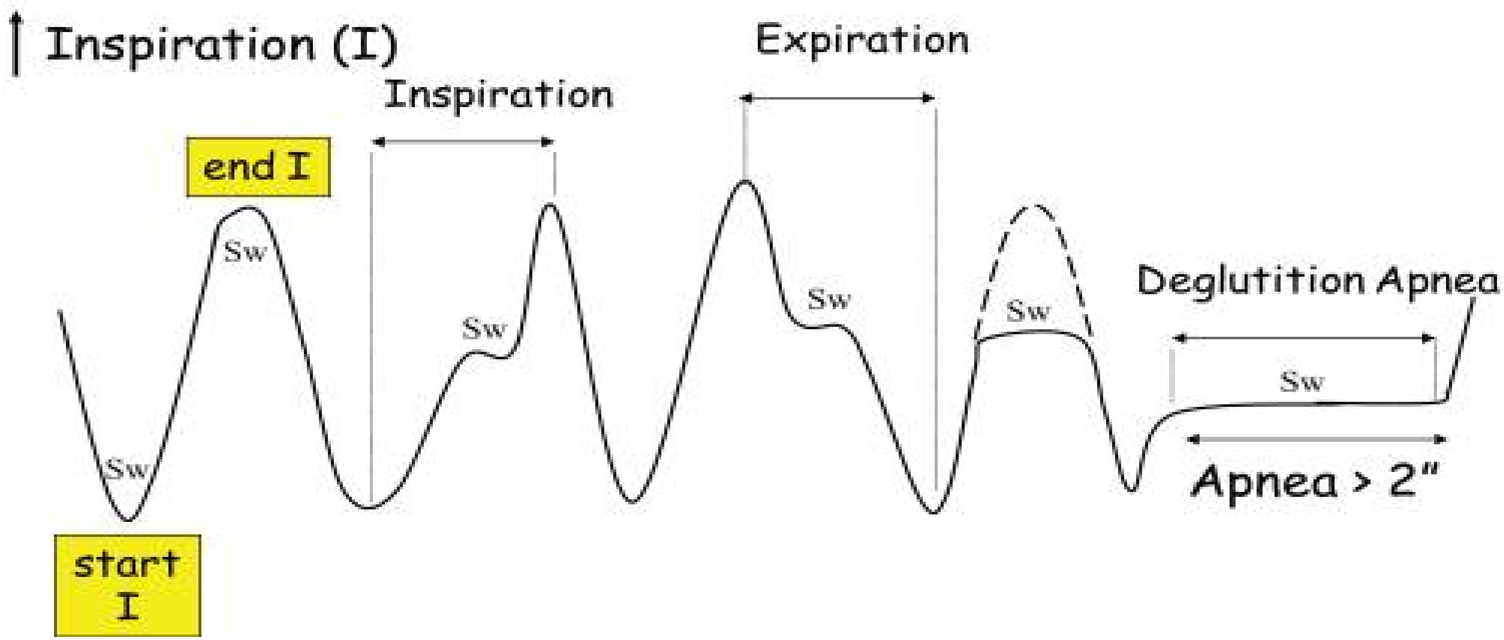
Non-nutritive Sucking Rhythm

- Is seen in a burst-pause pattern.
- The bursts lengthen with age.
- The pauses are less variable with age.
- Strength of the suck matures with age.

Swallowing and Breathing

- Ventilation ceases during swallow termed: deglutition apnea.
- Single swallow deglutition apnea is
  - 350-700 milliseconds.
- Suck-swallow-breath cycle is typically 1/second at earlier PMA and increases to 2/second near maturity.
- This depends on the maturity and coordination of three Central Pattern Generators: suck, swallow and respiration.

Swallow-respiration interfacings



Amaizu,N. Acta Paediatr 2008;97:61-67

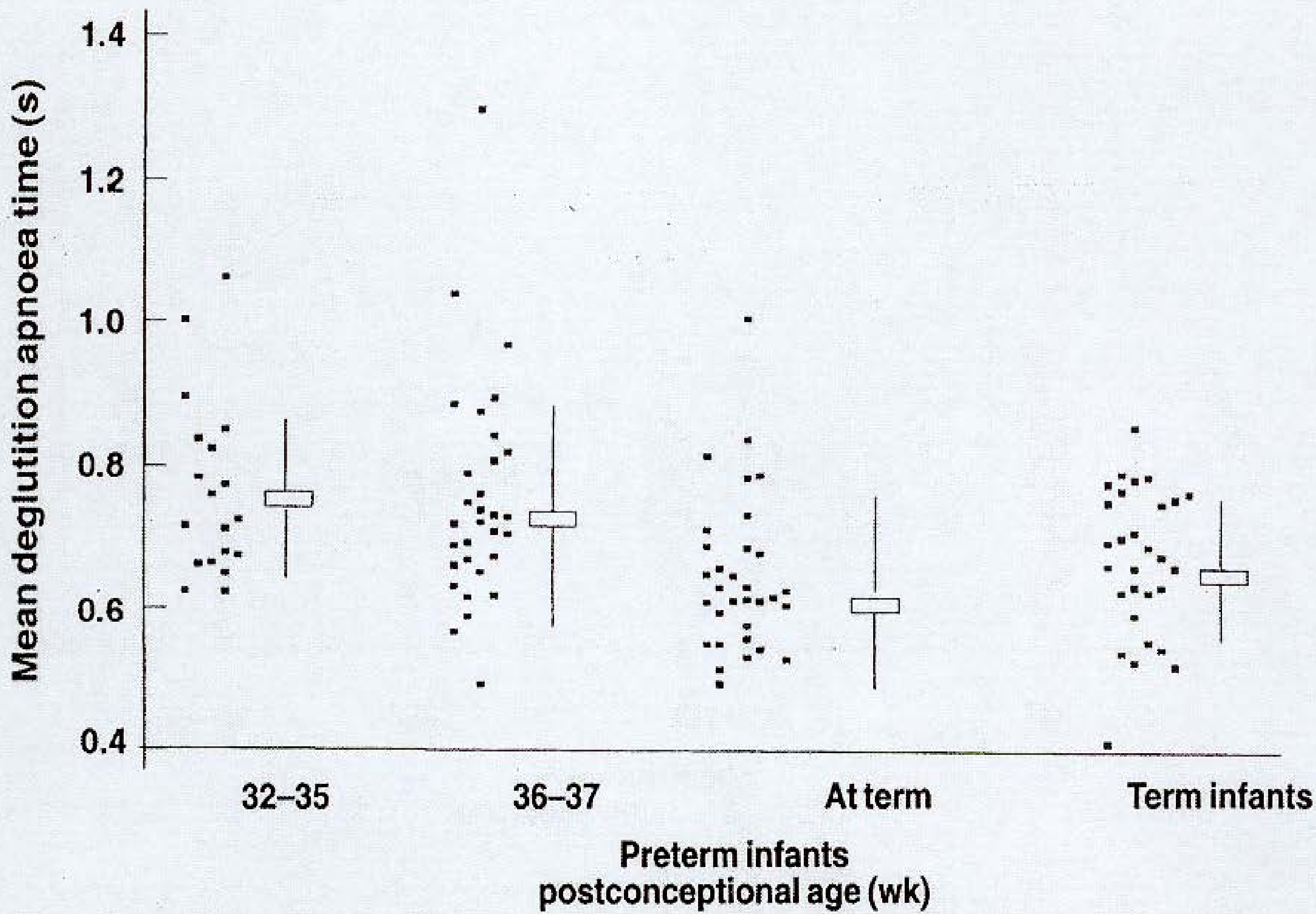


Figure 3: *Mean duration in seconds of single-swallow deglutition apnoea for preterm infants at different postconceptional ages and the term comparison group. Averaged data from three to five runs of 10 deglutition apnoeas during periods of rhythmic feeding pattern. Data reaveraged where an infant was tested more than once in a single postconceptional age period. Mean ± 1SD bars shown for groups.*

Hanlon MB *Deglutition Apnoea in Bottle fed Preterm Infants*

Swallowing and Breathing

- Preterm infants have greater deglutition apnea than term infants.
- This matures at term age equivalent.
- Percent time of multiple swallow apnea decreases with maturation.

Diagnosis of Aspiration

- Video fluoroscopic Evaluation of Swallow (VFES)
- Fiber optic Endoscopic Evaluation of Swallow (FEES)

Diagnosis of Aspiration

- Video fluoroscopy (VFES)
  - Still test of choice
  - Done in the upright position under typical feeding conditions
  - Uses a variety of textures
  - Easily involves the parent

Diagnosis of Aspiration

- Interpretation of Videofluoroscopic Studies
  - Laryngeal Pooling
  - Aspiration is frequently silent
  - Deep Laryngeal Penetration is associated with aspiration
  - Nasopharyngeal reflux
  - Cricopharyngeous stricture

Diagnosis of Aspiration

- Fiber optic Endoscopy
- An endoscope is passed into the nasopharynx for direct visualization of the swallow
  - Dye is used to increase visualization
  - Less well tolerated by children and parents
  - Limited studies
  - Visualizes anatomic defects
  - Observe GER related erythema in the tissues

Aspiration Findings in Pediatrics

- Neuman, LA 2001
- 43 pts. referred for dysphagia
- Mean 5.25mo.(0.25-11.5mo)
- 16=premature
- 40% penetration alone
- 9% aspiration (89% was silent)
- 29% nasopharyngeal reflux

Summary

- The premature infant is undergoing rapid neurological maturation that is evidenced by the maturation of
- Respiration
- Sleep
- Suck
- Swallow
- In addition, disorders caused by prematurity and adaptation to the extra-uterine environment can add further negative influences to development of feeding in the infant.