Feeding Infants with Lung Function Impairment

Presenters:

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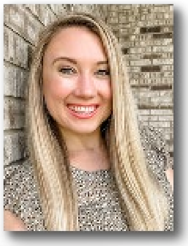
Jennifer Daughtry, MPH, RD, CSPCC Senior Clinical Dietitian Houston, TX

Live event date: January 17, 2024 - *Recording on* *NutriciaLearningCenter.com*



Learning Objectives:

- Identify challenges when feeding infants with lung function impairment
- Review infant critical care nutrition management guidelines
- Describe evidence on energy- and nutrient-dense formula in infants with acute exacerbation of lung condition
- Review case study of energy- and nutrient-dense formula use in an infant with Bronchopulmonary Dysplasia

Notes:

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Nutricia North America supports the use of human milk wherever possible.

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Feeding Infants with Lung Function Impairment

January 17th, 2024

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Medical Science Liaison
Nutricia North America

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Medical Science Liaison, West Region
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Disclosures

Jennifer Daughtry, MPH, RD, CSPCC honorarium provided by Nutricia

None pose any conflict of interest for this presentation

Liz Bacon MS, RDN, LDN is employed by Nutricia North America as a Medical Science Liaison

The opinions reflected in this presentation are those of the speaker and independent of Nutricia North America

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Nutricia North America supports the use of human milk wherever possible.

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Objectives

1. Identify challenges when feeding infants with lung function impairment
2. Review infant critical care nutrition management guidelines
3. Describe evidence on the use of energy- and nutrient-dense formula in infants with acute exacerbation of lung conditions
4. Review case study of energy- and nutrient-dense formula use in an infant with bronchopulmonary dysplasia

4

Review of Normal Lung Function and Development

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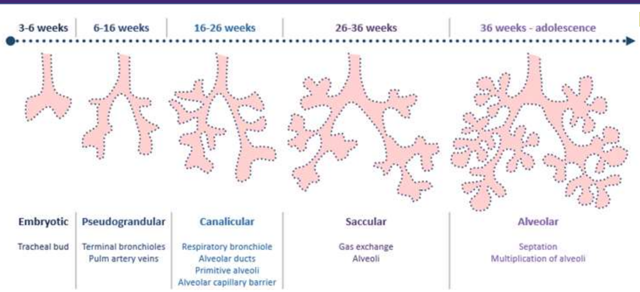
Stages of lung development



Pulm = pulmonary
Thébaud B, et al. Bronchopulmonary dysplasia. Nat Rev Dis Primers. 2019;5(1):78. Iliodromiti Z, et al. Acute lung injury in preterm fetuses and neonates: mechanisms and molecular pathways. J Matern Fetal Neonatal Med. 2013;1-9.

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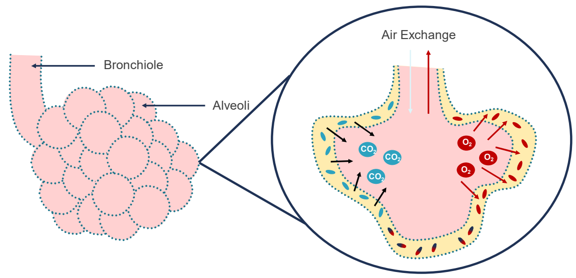
Mechanics of Respiration



Thébaud B, et al. Bronchopulmonary dysplasia. Nat Rev Dis Primers. 2019;5(1):78. Iliodromiti Z, et al. Acute lung injury in preterm fetuses and neonates: mechanisms and molecular pathways. J Matern Fetal Neonatal Med. 2013;1-9.

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Key micronutrients for lung development

- Vitamin A — Retinoic acid plays a role in many aspects of lung development
- Vitamin D — Regulates several genes involved in lung development
- Vitamin E — Antioxidant that protects against oxidation

Arigliani M, Spinelli AM, Liguoro I, Cogo P. Nutrition and Lung Growth. *Nutrients*. 2018;10(7):919. Published 2018 Jul 18.

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COMMON LUNG CONDITIONS IN INFANCY

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Common lung conditions in infancy

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- **Bronchopulmonary Dysplasia**
- Pulmonary Hypertension
- Respiratory Syncytial Virus

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POLL #1

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What pediatric lung conditions do you currently see in your practice?

- A Bronchopulmonary dysplasia (BPD)
- B Pulmonary Hypertension (PH)
- C Respiratory Syncytial Virus (RSV)
- D I do not currently see patients with these conditions

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Bronchopulmonary dysplasia

What is bronchopulmonary dysplasia (BPD)?

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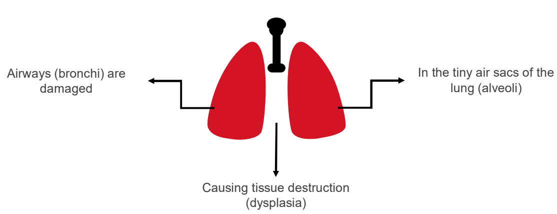

Miller AN, et al. A review and guide to nutritional care of the infants with established bronchopulmonary dysplasia. J Perinatol. 2023;43:402-410. Gillfillan M, et al. Diagnosis and management of bronchopulmonary dysplasia. BMJ. 2021;375:n1974.

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Bronchopulmonary dysplasia

National Institute of Health Diagnostic Criteria

At least 28 days of <21% O_2, or
Need for continued supplemental O_2 at ≥36 weeks postmenstrual age

Mild	No oxygen requirement
Moderate	< 30% supplement oxygen
Severe	≥30% supplemental oxygen and/or the need for positive pressure ventilation

Miller AN, et al. A review and guide to nutritional care of the infants with established bronchopulmonary dysplasia. J Perinatol. 2023;43:402-410.

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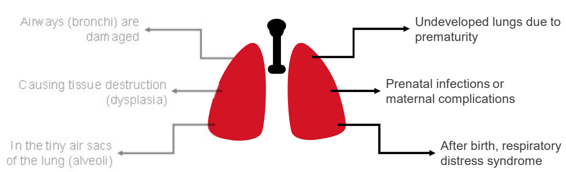
Bronchopulmonary dysplasia

Etiology of disease



Miller AN, et al. A review and guide to nutritional care of the infants with established bronchopulmonary dysplasia. J Perinatol. 2023;43:402-410. Gillfillan M, et al. Diagnosis and management of bronchopulmonary dysplasia. BMJ. 2021;375:n1974.

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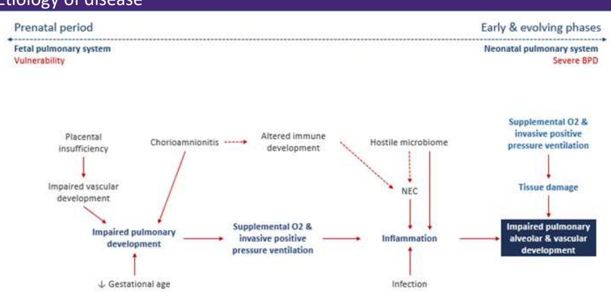
Bronchopulmonary dysplasia

Etiology of disease



NEC = necrotizing enterocolitis
Gillfillan M, et al. Diagnosis and management of bronchopulmonary dysplasia. BMJ. 2021;375:n1974.

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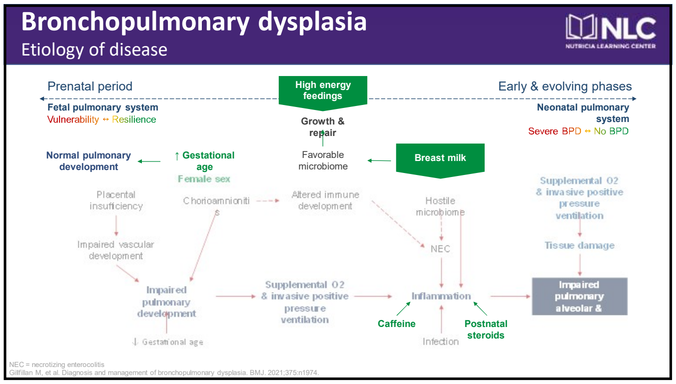
Bronchopulmonary dysplasia
Etiology of disease
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Prenatal period
High energy feedings
Early & evolving phases
Fetal pulmonary system
Vulnerability ↔ Resilience
Growth & repair
Neonatal pulmonary system
Severe BPD ↔ No BPD
Normal pulmonary development
↑ Gestational age
Female sex
Favorable microbiome
Breast milk
Placental insufficiency
Chorioamnionitis
Altered immune development
Hostile microbiome
Supplemental O2 & invasive positive pressure ventilation
Impaired vascular development
NEC
Tissue damage
Impaired pulmonary development
Supplemental O2 & invasive positive pressure ventilation
Inflammation
Impaired pulmonary alveolar &
Caffeine
Postnatal steroids
↓ Gestational age
Infection
NEC = necrotizing enterocolitis
Gillfillan M, et al. Diagnosis and management of bronchopulmonary dysplasia. BMJ. 2021;375:n1974.

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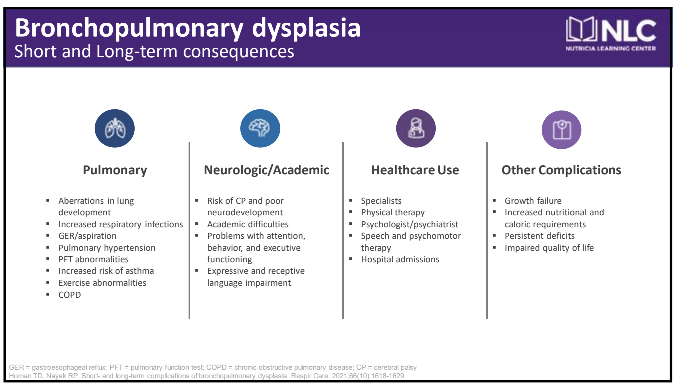
Bronchopulmonary dysplasia
Short and Long-term consequences
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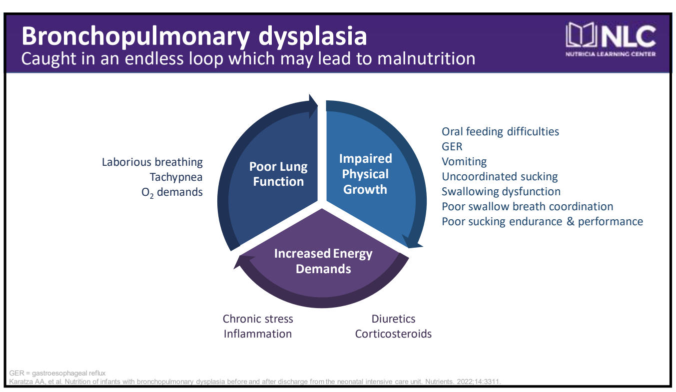
Pulmonary
Aberrations in lung development
Increased respiratory infections
GER/aspiration
Pulmonary hypertension
PFT abnormalities
Increased risk of asthma
Exercise abnormalities
COPD
Neurologic/Academic
Risk of CP and poor neurodevelopment
Academic difficulties
Problems with attention, behavior, and executive functioning
Expressive and receptive language impairment
Healthcare Use
Specialists
Physical therapy
Psychologist/psychiatrist
Speech and psychomotor therapy
Hospital admissions
Other Complications
Growth failure
Increased nutritional and caloric requirements
Persistent deficits
Impaired quality of life
GER = gastroesophageal reflux; PFT = pulmonary function test; COPD = chronic obstructive pulmonary disease; CP = cerebral palsy
Homan TD, Nayak RP. Short- and long-term complications of bronchopulmonary dysplasia. Respir Care. 2021;66(10):1618-1629.

17


Bronchopulmonary dysplasia
Caught in an endless loop which may lead to malnutrition
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Laborious breathing
Tachypnea
O2 demands
Poor Lung Function
Impaired Physical Growth
Oral feeding difficulties
GER
Vomiting
Uncoordinated sucking
Swallowing dysfunction
Poor swallow breath coordination
Poor sucking endurance & performance
Increased Energy Demands
Chronic stress
Inflammation
Diuretics
Corticosteroids
GER = gastroesophageal reflux
Karatza AA, et al. Nutrition of infants with bronchopulmonary dysplasia before and after discharge from the neonatal intensive care unit. Nutrients. 2022;14:3311.

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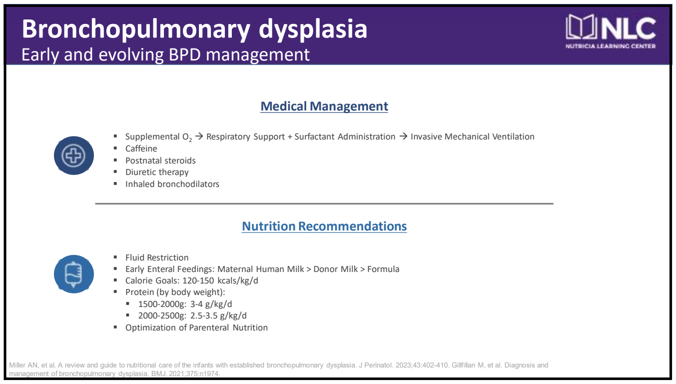
Bronchopulmonary dysplasia
Early and evolving BPD management
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Medical Management
Supplemental O2 → Respiratory Support + Surfactant Administration → Invasive Mechanical Ventilation
Caffeine
Postnatal steroids
Diuretic therapy
Inhaled bronchodilators
Nutrition Recommendations
Fluid Restriction
Early Enteral Feedings: Maternal Human Milk > Donor Milk > Formula
Calorie Goals: 120-150 kcals/kg/d
Protein (by body weight):
1500-2000g: 3-4 g/kg/d
2000-2500g: 2.5-3.5 g/kg/d
Optimization of Parenteral Nutrition
Miller AN, et al. A review and guide to nutritional care of the infants with established bronchopulmonary dysplasia. J Perinatol. 2023;43:402-410. Gillfillan M, et al. Diagnosis and management of bronchopulmonary dysplasia. BMJ. 2021;375:n1974.

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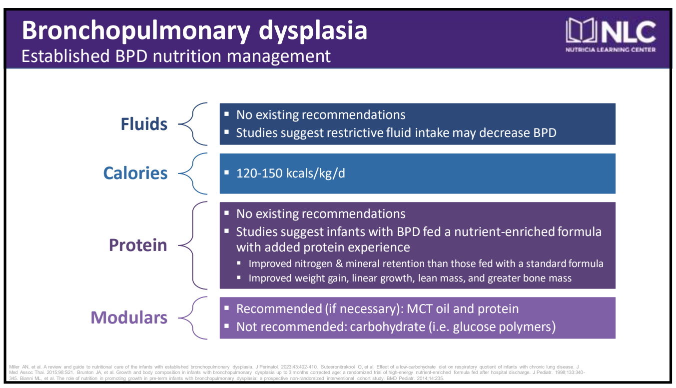
Bronchopulmonary dysplasia
Established BPD nutrition management
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Fluids
No existing recommendations
Studies suggest restrictive fluid intake may decrease BPD
Calories
120-150 kcals/kg/d
Protein
No existing recommendations
Studies suggest infants with BPD fed a nutrient-enriched formula with added protein experience
Improved nitrogen & mineral retention than those fed with a standard formula
Improved weight gain, linear growth, lean mass, and greater bone mass
Modulars
Recommended (if necessary): MCT oil and protein
Not recommended: carbohydrate (i.e. glucose polymers)
Miller AN, et al. A review and guide to nutritional care of the infants with established bronchopulmonary dysplasia. J Perinatol. 2023;43:402-410. Suteeronitrakool O, et al. Effect of a low-carbohydrate diet on respiratory quotient of infants with chronic lung disease. J Med Assoc Thai. 2015;98:S21. Brunton JA, et al. Growth and body composition in infants with bronchopulmonary dysplasia up to 3 months corrected age: a randomized trial of high-energy nutrient-enriched formula fed after hospital discharge. J Pediatr. 1998;133:340-345. Bianni ML, et al. The role of nutrition in promoting growth in pre-term infants with bronchopulmonary dysplasia: a prospective non-randomized interventional cohort study. BMD Pediatr. 2014;14:235.

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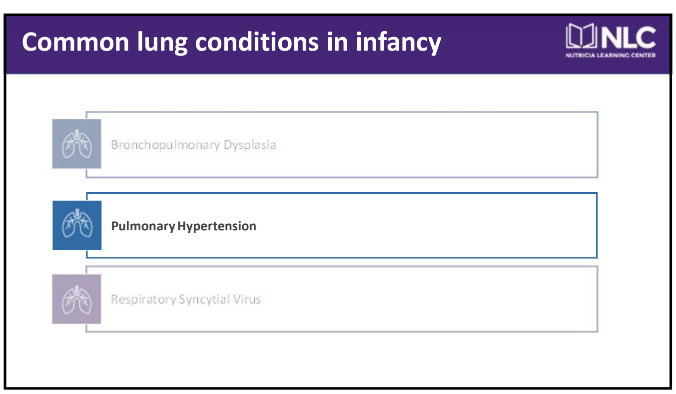
Common lung conditions in infancy
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Bronchopulmonary Dysplasia
Pulmonary Hypertension
Respiratory Syncytial Virus

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Pulmonary Hypertension
What is pulmonary hypertension (PH)?

Failure in the normal circulatory transition that is inborn in babies

- Hypoxemia
- Right-to-left intracardiac shunting of blood

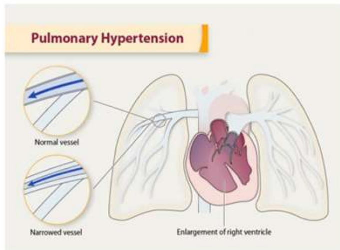

Photo credit: Centers for Disease Control and Prevention, Heart Disease

Mukherjee D, Konduri GG. Pediatric Pulmonary Hypertension: Definitions, Mechanisms, Diagnosis, and Treatment. *Compr Physiol*. 2021;11(3):2135-2190. Published 2021 Jun 30. doi:10.1002/cphy.c200023

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Pulmonary hypertension
Main pediatric etiologies

- Persistent Pulmonary Hypertension of the Newborn (PPHN)
- Congenital heart diseases
- Developmental lung diseases
- Idiopathic pulmonary arterial hypertension

Mukherjee D, Konduri GG. Pediatric Pulmonary Hypertension: Definitions, Mechanisms, Diagnosis, and Treatment. Compr Physiol. 2021;11(3):2135-2190. Published 2021 Jun 30. doi:10.1002/cphy.c200023

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Persistent pulmonary hypertension of the newborn

Increased pulmonary vascular resistance
↓
Decreased pulmonary blood flow
↓
Decreased oxygenated blood returning to left side of heart
↓
Hypoxia, decreased end organ perfusion, acidosis, cyanosis

Mukherjee D, Konduri GG. Pediatric Pulmonary Hypertension: Definitions, Mechanisms, Diagnosis, and Treatment. *Compr Physiol*. 2021;11(3):2135-2190. Published 2021 Jun 30. doi:10.1002/cphy.c200023

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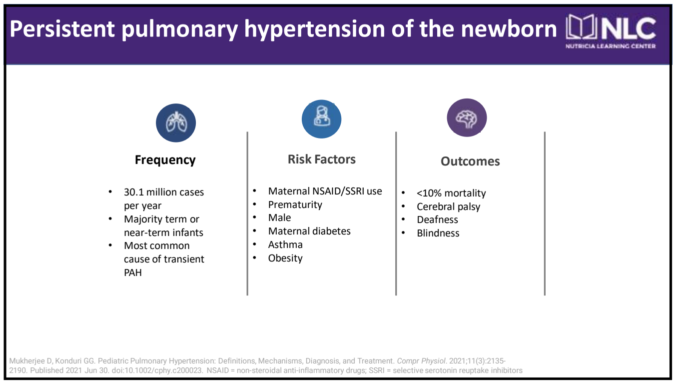
Persistent pulmonary hypertension of the newborn
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Frequency
• 30.1 million cases per year
• Majority term or near-term infants
• Most common cause of transient PAH
Risk Factors
• Maternal NSAID/SSRI use
• Prematurity
• Male
• Maternal diabetes
• Asthma
• Obesity
Outcomes
• <10% mortality
• Cerebral palsy
• Deafness
• Blindness
Mukherjee D, Konduri GG. Pediatric Pulmonary Hypertension: Definitions, Mechanisms, Diagnosis, and Treatment. Compr Physiol. 2021;11(3):2135-2190. Published 2021 Jun 30. doi:10.1002/cphy.c200023. NSAID = non-steroidal anti-inflammatory drugs; SSRI = selective serotonin reuptake inhibitors

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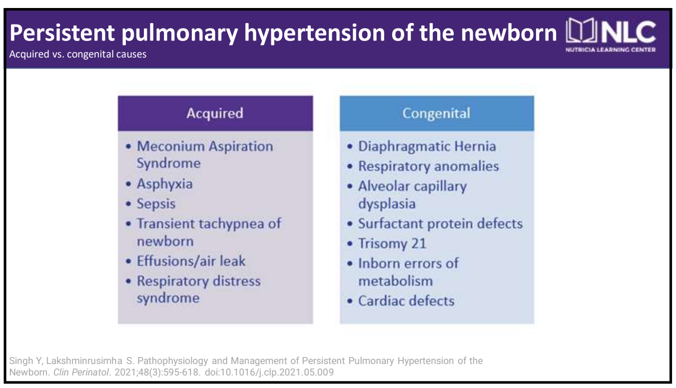
Persistent pulmonary hypertension of the newborn
Acquired vs. congenital causes
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Acquired
• Meconium Aspiration Syndrome
• Asphyxia
• Sepsis
• Transient tachypnea of newborn
• Effusions/air leak
• Respiratory distress syndrome
Congenital
• Diaphragmatic Hernia
• Respiratory anomalies
• Alveolar capillary dysplasia
• Surfactant protein defects
• Trisomy 21
• Inborn errors of metabolism
• Cardiac defects
Singh Y, Lakshminrusimha S. Pathophysiology and Management of Persistent Pulmonary Hypertension of the Newborn. Clin Perinatol. 2021;48(3):595-618. doi:10.1016/j.clp.2021.05.009

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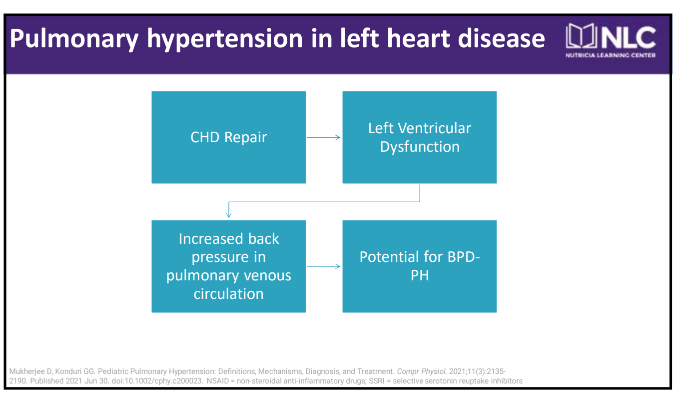
Pulmonary hypertension in left heart disease
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CHD Repair
Left Ventricular Dysfunction
Increased back pressure in pulmonary venous circulation
Potential for BPD-PH
Mukherjee D, Konduri GG. Pediatric Pulmonary Hypertension: Definitions, Mechanisms, Diagnosis, and Treatment. Compr Physiol. 2021;11(3):2135-2190. Published 2021 Jun 30. doi:10.1002/cphy.c200023. NSAID = non-steroidal anti-inflammatory drugs; SSRI = selective serotonin reuptake inhibitors

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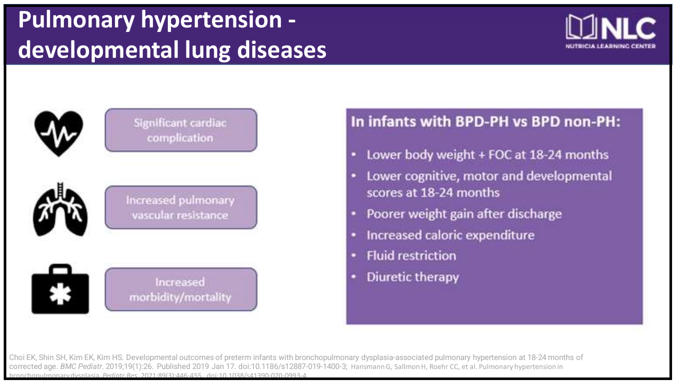
Pulmonary hypertension - developmental lung diseases
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Significant cardiac complication
Increased pulmonary vascular resistance
Increased morbidity/mortality
In infants with BPD-PH vs BPD non-PH:
Lower body weight + FOC at 18-24 months
Lower cognitive, motor and developmental scores at 18-24 months
Poorer weight gain after discharge
Increased caloric expenditure
Fluid restriction
Diuretic therapy
Choi EK, Shin SH, Kim EK, Kim HS. Developmental outcomes of preterm infants with bronchopulmonary dysplasia-associated pulmonary hypertension at 18-24 months of corrected age. BMC Pediatr. 2019;19(1):26. Published 2019 Jan 17. doi:10.1186/s12887-019-1400-3; Hansmann G, Sallmon H, Roehr CC, et al. Pulmonary hypertension in bronchopulmonary dysplasia. Pediatr Res. 2021;89(3):446-455. doi:10.1038/s41390-020-0993-4

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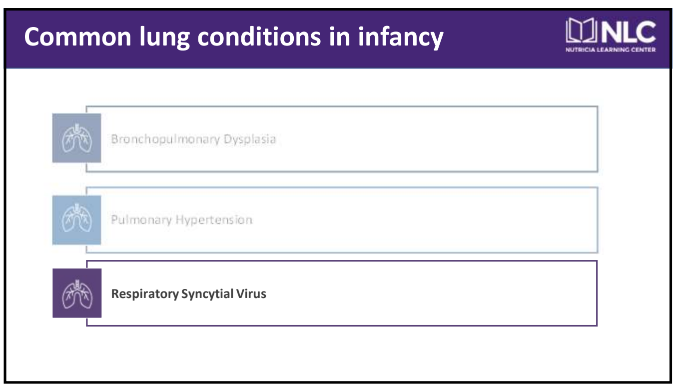
Common lung conditions in infancy
NLC
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Bronchopulmonary Dysplasia
Pulmonary Hypertension
Respiratory Syncytial Virus

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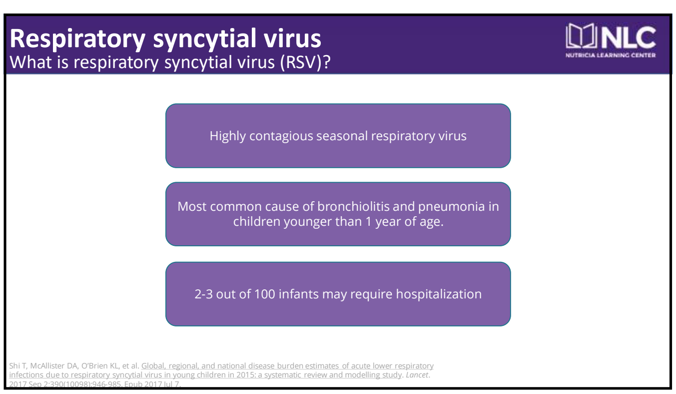
Respiratory syncytial virus
What is respiratory syncytial virus (RSV)?
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Highly contagious seasonal respiratory virus
Most common cause of bronchiolitis and pneumonia in children younger than 1 year of age.
2-3 out of 100 infants may require hospitalization
Shi T, McAllister DA, O'Brien KL, et al. Global, regional, and national disease burden estimates of acute lower respiratory infections due to respiratory syncytial virus in young children in 2015: a systematic review and modelling study. Lancet. 2017 Sep 2;390(10098):946-985. Epub 2017 Jul 7.

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Respiratory syncytial virus

Symptoms:

- Runny nose
- Cough
- Eating or drinking less
- Irritability
- Apnea
- Decreased activity

Those at Increased Risk:

- Preterm infants
- Infants less than 12 months of age, especially under 6 months of age
- CLD or CHD
- Weakened immune systems
- Neuromuscular disorders

Management May Include:

- Oxygen
- IV fluids
- Tube feeding
- Mechanical ventilation
- Neuromuscular disorders

Centers for Disease Control and Prevention. Respiratory Syncytial Virus. Symptoms and Care of RSV (Respiratory Syncytial Virus) | CDC September 6 2023. Accessed January 4 2023.

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CRITICAL CARE NUTRITION MANAGEMENT CONSIDERATIONS

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Malnutrition in the PICU

"14% to 32% of critically ill infants already suffer from acute or chronic malnourishment upon admission to the PICU"

↑ **Length of stay**

↑ **Mortality**

↑ **Length of mechanical ventilation**

Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10

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Mechanical ventilation

Nutrition considerations and challenges

Non-invasive respiratory support

1. Gaseous distension
2. Mucosal inflammation due to cytokine release
3. Imbalance in the intestinal microflora
4. Can affect gastric emptying, GER, and mesenteric flows

Invasive respiratory support

1. Mechanical ventilation and ventilator-induced lung injury
2. Underfeeding is prevalent in children who are mechanically ventilated
3. Swallowing dysfunction and pulmonary aspiration
4. Delayed feeding experiences

GER = gastroesophageal reflux

Cresi F, et al. Effect of nasal continuous positive airway pressure vs. heated humidified high-flow nasal cannula on feeding intolerance in preterm infants with respiratory distress syndrome. The ENTARES randomized controlled trial. JAMA New Open. 2023;6(7):e2323052. Dankhara N, et al. Bronchopulmonary dysplasia: pathogenesis and pathophysiology. J Clin Med. 2023;12(13):4207. Amirjani S, et al. Undernutrition and 60-day mortality in critically ill children

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Phases of Critical Illness

Acute Phase

- Catabolic
- Risk of overfeeding
- Consider nutrient restriction

Stable/Recovery Phase

- Anabolic
- Increase protein/energy intake
- Support catch-up growth

De Cosmi V, Milani GP, Mazzocchi A, et al. The Metabolic Response to Stress and Infection in Critically Ill Children: The Opportunity of an Individualized Approach. *Nutrients*. 2017;9(9):1032. Published 2017 Sep 18. doi:10.3390/nu9091032

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Enteral Nutrition Goals

Target energy intake: 100-130 kcals/kg/d

Target protein intake: 2-3 g/kg/day

Kleinman RE, Greer KKF (eds). American Academy of Pediatrics. Committee on Nutrition. Pediatric Nutrition Handbook 7th edition. Academy of Pediatrics, Elk Grove Village, Illinois. 2014; Mehta NM, Compher C, A.S.P.E.N. Board of Directors. A.S.P.E.N. Clinical Guidelines: Nutrition Support of the Critically Ill Child. J Parenter Enteral Nutr.

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Feeding challenges in presence of respiratory conditions

- Fluid restriction
- Higher protein/energy needs
- Feeding intolerance
- Decreased oral ability

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POLL #2

What feeding challenges do you currently experience with your patients who have respiratory conditions? (Select all that apply)

- A Fluid restriction
- B Higher protein/energy needs
- C Feeding intolerance
- D Decreased oral ability
- E I don't currently work with this population

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WHAT IS AN ENERGY- AND NUTRIENT-DENSE FORMULA?

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Malnutrition: Nutrition Management Abroad

Energy and nutrient dense formula

- 30kcal/oz term infant formula
- High protein/nutrient content
- 2.6 grams protein/100 kcal
- Lower osmolarity (<400 mOsm/kg)
- Ready to feed/sterile
- Nutritionally complete
- Well tolerated and supports growth
- Can be used to supplement infants consuming breast milk

A.S.P.E.N. Nutrition Management of Term Infants with Growth Failure. www.nutritioncare.org. Published 2022. Accessed January 16, 2024. https://www.nutritioncare.org/uploadedFiles/Documents/Guidelines_and_Clinical_Resources/EN_Resources/Infant-Growth-Failure-Factsheet.pdf

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POLL #3

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Have you utilized an ENDF? If so, in which populations?

- A I have utilized an ENDF for patients with respiratory conditions.
- B I have utilized an ENDF, but not in patients with respiratory conditions.
- C I have heard of an ENDF, but have not utilized it.
- D This is my first time learning about an ENDF?

ENDF = energy- and nutrient-dense formula

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Nutrient comparison on fluid restriction

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Nutrients provided at 130 ml/kg/day

Nutrient	20 kcal/oz SIF	24 kcal/oz SIF	30 kcal/oz ENDF
Energy (kcals/kg/day)	87	104	130
Protein (g/kg/day)	1.8 (1.4 g/dL)	2.2 (1.7 g/dL)	3.4 (2.6 g/dL)

mL = milliliter; kg = kilogram; SIF = standard infant formula; kcals = kilocalories; g = grams; ENDF = energy- and nutrient-dense formula; dL = deciliter

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Breastfeeding supplementation

Ratio of feedings	Characteristics, if blended
4:1 (Breast milk / ENDF)	22 kcal/fl oz; 0.73 kcal/mL
Raises protein intake by ~+0.4 g/100 mL[†]	
~295 mOsm/kg[†]	~86.6% Free water[†]
3:2 (Breast milk / ENDF)	24 kcal/fl oz; 0.80 kcal/mL
Raises protein intake by ~+0.7 g/100 mL[†]	
~310 mOsm/kg[†]	~86.2% Free water[†]
2:3 (Breast milk / ENDF)	26 kcal/fl oz; 0.87 kcal/mL
Raises protein intake by ~+1.0 g/100 mL[†]	
~330 mOsm/kg[†]	~85.8% Free water[†]
~1:2 (Breast milk / ENDF)	27 kcal/fl oz; 0.90 kcal/mL
Raises protein intake by ~+1.1 g/100 mL[†]	
~335 mOsm/kg[†]	~85.7% Free water[†]
1:4 (Breast milk / ENDF)	28 kcal/fl oz; 0.93 kcal/mL
Raises protein intake by ~+1.3 g/100 mL[†]	
~345 mOsm/kg[†]	~85.4% Free water[†]

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Review of evidence: energy and nutrient-dense formula (ENDF)

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Eveleens, et al. 2019.

ERASMUS MC SOPHIA CHILDREN'S HOSPITAL

Study design: Retrospective Cohort Study
Duration: 2+ weeks

Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10

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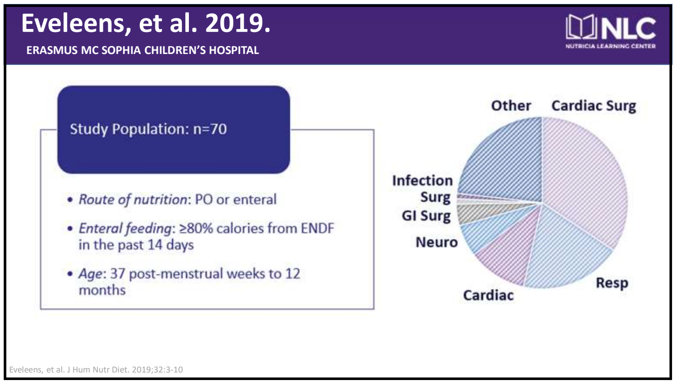
Eveleens, et al. 2019.
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL
NLC
Study Population: n=70
Route of nutrition: PO or enteral
Enteral feeding: ≥80% calories from ENDF in the past 14 days
Age: 37 post-menstrual weeks to 12 months
Other
Cardiac Surg
Infection
Surg
GI Surg
Neuro
Cardiac
Resp
Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10

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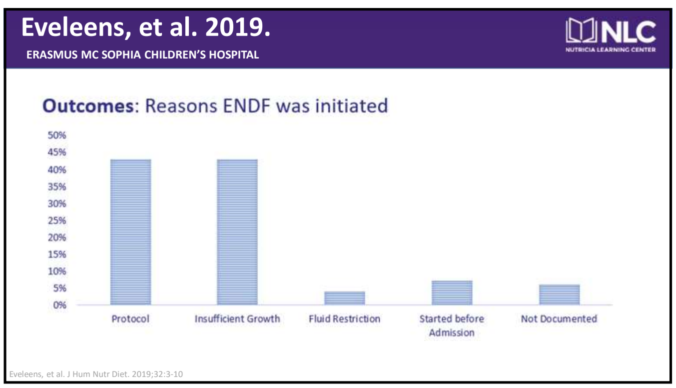
Eveleens, et al. 2019.
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL
NLC
Outcomes: Reasons ENDF was initiated
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Protocol
Insufficient Growth
Fluid Restriction
Started before Admission
Not Documented
Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10

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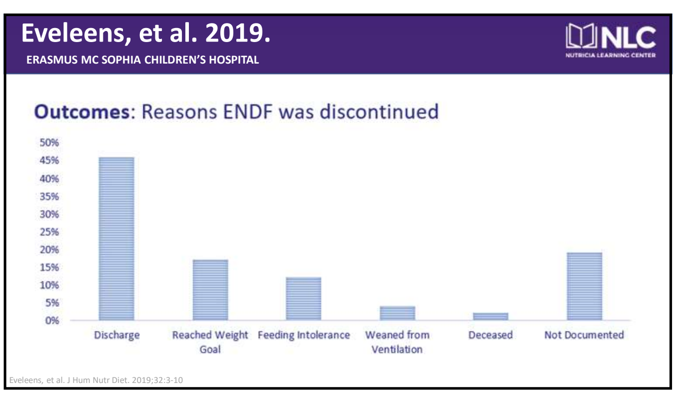
Eveleens, et al. 2019.
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL
NLC
Outcomes: Reasons ENDF was discontinued
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Discharge
Reached Weight Goal
Feeding Intolerance
Weaned from Ventilation
Deceased
Not Documented
Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10

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Eveleens, et al. 2019.

ERASMUS MC SOPHIA CHILDREN'S HOSPITAL

Outcomes: Nutritional Intake

Route of Nutrition:

- Post-pyloric: 45 (64%)
- Feeding strategy
  - Continuous: 27 (39%)
  - Bolus: 10 (14%)
  - Both: 33 (47%)

Nutrient Intake:

- Energy: 104.6±19.4 kcal/kg/d
- Protein: 2.72±0.50g/kg/d

Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10

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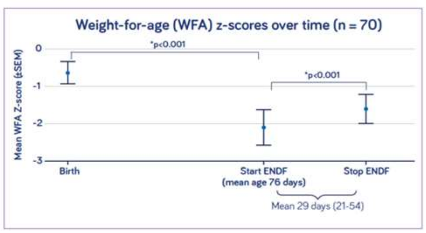
Eveleens, et al. 2019.

ERASMUS MC SOPHIA CHILDREN'S HOSPITAL

Outcomes: Growth



Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10; ENDF = energy- and nutrient-dense formula

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Eveleens, et al. 2019.

ERASMUS MC SOPHIA CHILDREN'S HOSPITAL

"In the present study, PE-formula was well tolerated because signs of intolerance only occurred in few of the infants."

ENDF was discontinued in eight patients due to intolerance:

- Vomiting n=4
- Gastric Retention n=2
- Signs of discomfort n=2

Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10; ENDF = energy- and nutrient-dense formula

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Eveleens, et al. 2019.
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL
NLC
NUTRICIA LEARNING CENTER
Tolerance
Well-tolerated by infants in the PICU
Growth
Supports catch-up growth
Safety
Safe and well tolerated in critically ill infants
Eveleens, et al. J Hum Nutr Diet. 2019;32:3-10; ENDF = energy- and nutrient-dense formula; PICU = pediatric intensive care unit

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NLC
NUTRICIA LEARNING CENTER
Protein metabolism using energy and nutrient dense formula.
van Waardenburg DA, de Betue CT, van Goudoever, et al. Clin Nutr. 2009;28:249-255.
de Betue CT, van Waardenburg DA, Deutz NE, et al. Arch Dis Child. 2011;96:817-822.
de Betue CT, Joosten KF, Deutz NE, et al. Am J Clin Nutr. 2013;98:907-916.

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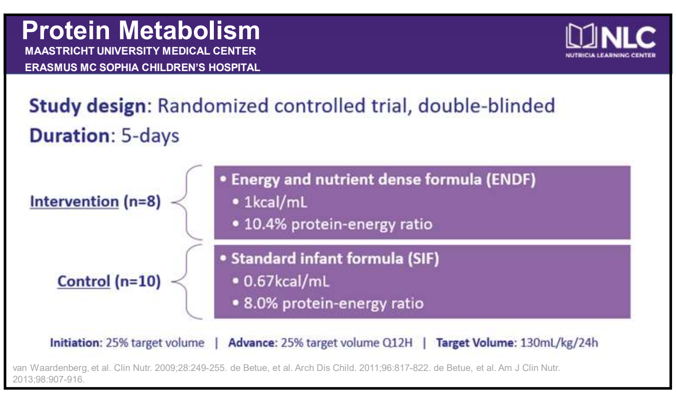
Protein Metabolism
MAASTRICHT UNIVERSITY MEDICAL CENTER
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL
NLC
NUTRICIA LEARNING CENTER
Study design: Randomized controlled trial, double-blinded
Duration: 5-days
Intervention (n=8)
• Energy and nutrient dense formula (ENDF)
• 1kcal/mL
• 10.4% protein-energy ratio
Control (n=10)
• Standard infant formula (SIF)
• 0.67kcal/mL
• 8.0% protein-energy ratio
Initiation: 25% target volume | Advance: 25% target volume Q12H | Target Volume: 130mL/kg/24h
van Waardenburg, et al. Clin Nutr. 2009;28:249-255. de Betue, et al. Arch Dis Child. 2011;96:817-822. de Betue, et al. Am J Clin Nutr. 2013;98:907-916.

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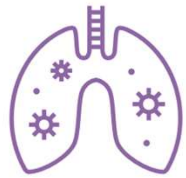
Protein Metabolism

MAASTRICHT UNIVERSITY MEDICAL CENTER
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL

NLC NUTRICIA LEARNING CENTER

Study Population: n=18

- *Route of nutrition*: enteral
- *Age*: 4 weeks to 12 months
- *Gestation*: term or preterm, **but** >40 weeks postmenstrual age
- *Diagnosis*: respiratory syncytial virus



van Waardenberg, et al. Clin Nutr. 2009;28:249-255. de Betue, et al. Arch Dis Child. 2011;96:817-822. de Betue, et al. Am J Clin Nutr. 2013;98:907-916.

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Protein Metabolism

MAASTRICHT UNIVERSITY MEDICAL CENTER
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL

NLC NUTRICIA LEARNING CENTER

Outcomes: Nutrient Intake and Tolerance

Intake	ENDF	SIF
Volume	No difference	
Energy (kcal/kg/d)*	112±19	82±4
Protein (g/kg/d)*	2.8±0.3	1.5±0.1

*p<0.01

Tolerance	ENDF	SIF
Stooling	No difference	
Emesis	No difference	

van Waardenberg, et al. Clin Nutr. 2009;28:249-255
ENDF = energy and nutrient dense

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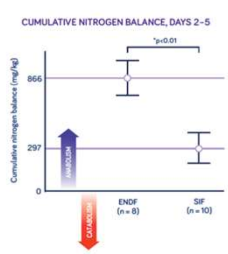
Protein Metabolism

MAASTRICHT UNIVERSITY MEDICAL CENTER
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL

NLC NUTRICIA LEARNING CENTER

Outcomes: Protein Anabolism

Nitrogen balance	ENDF	SIF
Day 5 (mg/kg/d)*	297±41	123±23
All in positive nitrogen balance	by Day 2	by Day 4



van Waardenberg, et al. Clin Nutr. 2009;28:249-255
ENDF = energy and nutrient dense; SIF = standard infant formula

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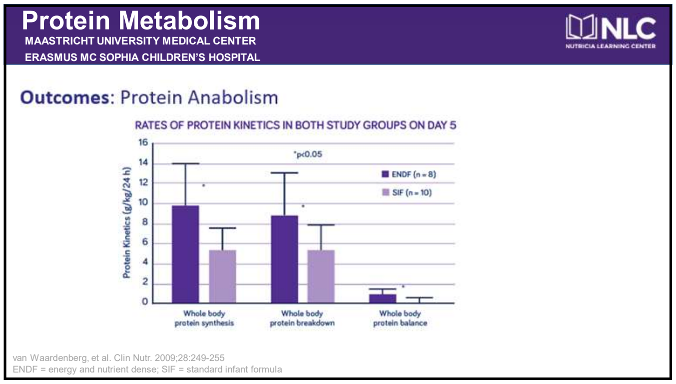
Protein Metabolism
MAASTRICHT UNIVERSITY MEDICAL CENTER
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL
NLC
NUTRICIA LEARNING CENTER
Outcomes: Protein Anabolism
RATES OF PROTEIN KINETICS IN BOTH STUDY GROUPS ON DAY 5
Protein Kinetics (g/kg/24 h)
16
14
12
10
8
6
4
2
0
*p<0.05
ENDF (n = 8)
SIF (n = 10)
Whole body protein synthesis
Whole body protein breakdown
Whole body protein balance
van Waardenberg, et al. Clin Nutr. 2009;28:249-255
ENDF = energy and nutrient dense; SIF = standard infant formula

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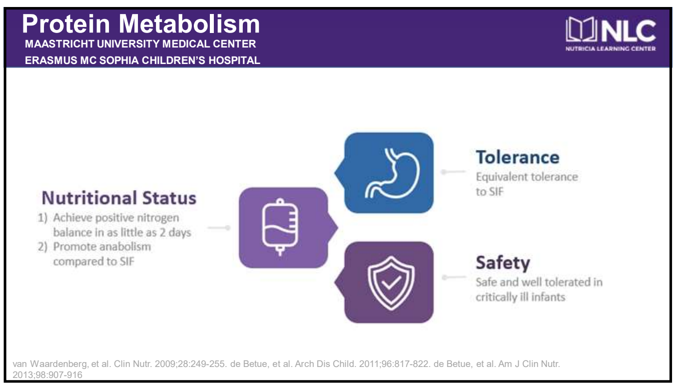
Protein Metabolism
MAASTRICHT UNIVERSITY MEDICAL CENTER
ERASMUS MC SOPHIA CHILDREN'S HOSPITAL
NLC
NUTRICIA LEARNING CENTER
Nutritional Status
1) Achieve positive nitrogen balance in as little as 2 days
2) Promote anabolism compared to SIF
Tolerance
Equivalent tolerance to SIF
Safety
Safe and well tolerated in critically ill infants
van Waardenberg, et al. Clin Nutr. 2009;28:249-255. de Betue, et al. Arch Dis Child. 2011;96:817-822. de Betue, et al. Am J Clin Nutr. 2013;98:907-916

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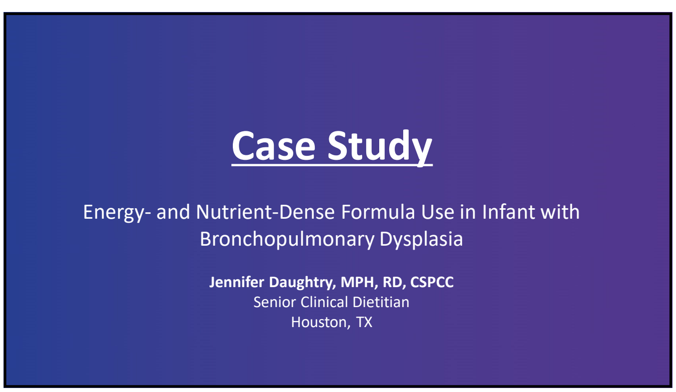
Case Study
Energy- and Nutrient-Dense Formula Use in Infant with Bronchopulmonary Dysplasia
Jennifer Daughtry, MPH, RD, CSPCC
Senior Clinical Dietitian
Houston, TX

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Case Study

NLC NUTRICIA LEARNING CENTER

HISTORY

BIRTH HISTORY

- 4-month old, female with hx of NICU stay.

ADMISSION

- Admitted to PICU: BPD, PDA/ASD with concern for over-circulation

FEED HISTORY

- Transitional formula 22 kcal/oz at 150 ml/kg/day (110 kcal/kg/day)

Hx = history; NICU = neonatal intensive care unit; PICU = pediatric intensive care unit; BPD = bronchopulmonary dysplasia; PDA = patent ductus arteriosis; ASD = atrial septal defect; kcal = kilocalorie; oz = ounce; ml = milliliter; kg = kilogram;

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Case Study

NLC NUTRICIA LEARNING CENTER

NUTRITION THERAPY TIMELINE

10/31: Admitted to PICU

11/1: Initial assessment: Goal to increase feeds to 145 ml/kg/day

11/2: Feeds initiated 24 hours later

11/3: Volume restricted to 75 ml/kg/day; goal to increase to 30 kcal/oz. Feeds increased to 24 kcal/oz at 75 ml/kg/day (60 kcal/kg/day) prior to hospital transfer

PICU = pediatric intensive care unit; ml = milliliter; kg = kilogram; kcal = kilocalorie; oz = ounce

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Case Study

NLC NUTRICIA LEARNING CENTER

NUTRITION THERAPY TIMELINE

11/6: New assessment: meeting 40% of needs x 5 days; feeds advanced to 27 kcal/oz at 95 ml/kg/day

11/7: Fluid restriction of 95 ml/kg/day remains – feeds switched to ENDF

11/8: ENDF advanced to 110 ml/kg/day via continuous feeds (110 kcal/kg/day)

11/9: Feeds held for procedure; resumed at 110 ml/kg/day

Kcal = kilocalorie; oz = ounce; ml = milliliter; kg = kilogram; ENDF = energy- and nutrient-dense formula

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Case Study

Formula	Volume (ml/kg/day)	Energy kcal/kg/day)	Protein (grams/kg/day)
Transitional Formula 24 kcal/oz	75	60	1.6
Transitional Formula 27 kcal/oz	95	85	2.4
ENDF 30 kcal/oz	95	95	2.5
ENDF 30 kcal/oz	110	110	2.9

ENDF = energy- and nutrient-dense formula; mL = milliliter; kg = kilogram; kcal = kilocalorie

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Case Study

NUTRITION THERAPY TIMELINE

11/10: Reassessment – caloric intake improving and tolerating feeds. Supplemental Vitamin D initiated at 200 IU/day. Meeting DRI for other vitamins/minerals

11/14: Patient tolerating goal feeds until extubation.
Fluid status improved; advanced back to standard fluid provision.

IU = international units; DRI = dietary reference intake

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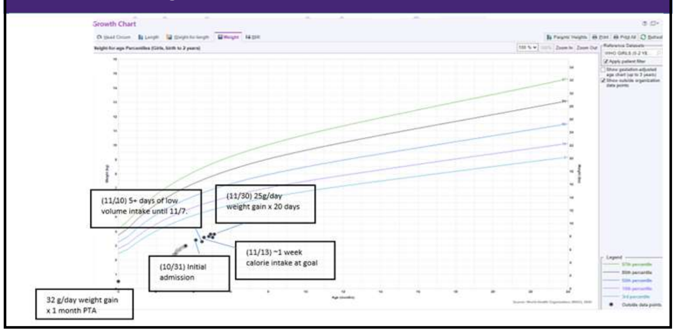
Case Study



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Case Study

CLINICAL OUTCOMES:

- Following 5 days of limited intake, ENDF bridged patient and improved caloric intake through fluid restriction until goal volume achieved again.
- Goal concentration provided at goal volume during and after ICU stay
- Feeds well tolerated in critically ill infant

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Summary

1. Common lung conditions in infancy may have a significant impact on nutrition status and consequently, short and long-term patient outcomes.
2. Provision of appropriate calories, protein, micronutrients and fluid is crucial for this patient population.
3. ENDF provides optimal energy, protein, and micronutrients to support lean tissue gain for catch-up growth and support increased protein needs during critical illness.

ENDF = energy- and nutrient-dense formula

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