Nutrition Considerations for Infants with Congenital Heart Disease

Presenter: Amy R. Gelfand, MS, RDN, CDN – Medical Science Liaison, Nutricia
Live event date: February 16, 2022 - *Recording on NutriciaLearningCenter.com within ~2 weeks of live event*

Learning Objectives:

- Define types of congenital heart diseases (CHD)
- Review nutrition considerations associated with infants with CHD
- Review nutrition considerations associated with infants with CHD

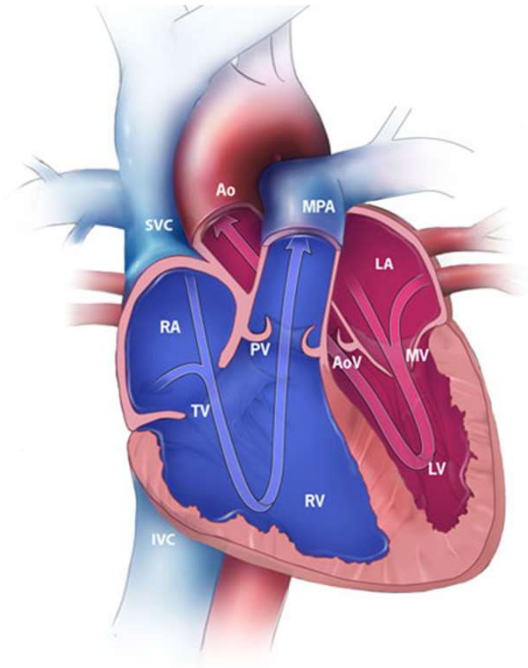
Notes:

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

NORMAL HEART

Function

- Oxygen depleted blood sent to heart→ lungs → heart →
- Oxygen rich blood sent to the body



RA. Right Atrium
RV. Right Ventricle
LA. Left Atrium
LV. Left Ventricle

SVC. Superior Vena Cava
IVC. Inferior Vena Cava
MPA. Main Pulmonary Artery
Ao. Aorta

TV. Tricuspid Valve
MV. Mitral Valve
PV. Pulmonary Valve
AoV. Aortic Valve

Photo credit: Centers for Disease
References: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities
Puri et al Pediatrics in Review Oct 2017

NORMAL HEART
PATENT DUCTUS ARTERIOSUS (PDA)

What is it?

- Normal anatomy present in all infants
- Non-functional within 3-4 weeks after birth
- Patent (open) longer in preterm infants

Clinical Presentation

- In an older infant, if unclosed, MD may hear a murmur
- Indomethacin/ibuprofen
- Surgery

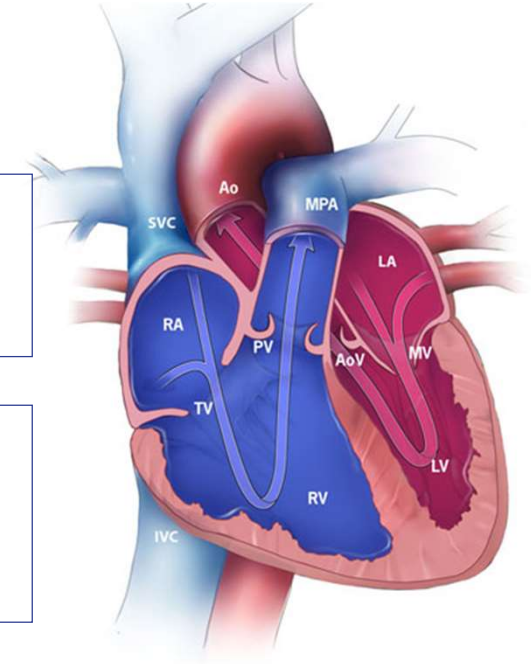


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Photo credit: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities;
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POLL QUESTION
RESPOND IN THE RIGHT-HAND PANEL IN THE LIVE EVENT

Which types of CHD anatomy have you worked with?

(*Choose all that apply*)

A. Single ventricle

B. Ventricular septal defect

C. Coarctation of the aorta

D. Transposition of the great arteries

TYPES OF CONGENITAL HEART DISEASE: ACYANOTIC VS CYANOTIC

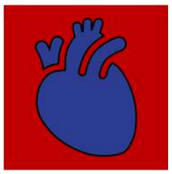
Acyanotic Heart Disease

Atrial septal defect

Ventricular septal defect

Atrioventricular septal defect (AVSD)

Coarctation of the aorta



Cyanotic Heart Disease

Tetralogy of Fallot

Transposition of the great arteries

Hypoplastic left heart syndrome

References: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities
Puri et al Pediatrics in Review Oct 2017

ACYANOTIC HEART DISEASE: ATRIAL SEPTAL DEFECT

What is it?

- A hole that divides the atria of the heart (upper chambers)

Prevalence

- 1 in 1,859 infants annually (CDC)
- 7-10% of CHD (Puri 2017)

Clinical Presentation

- Many infants do not have signs/symptoms at birth
- MD may hear murmur ~4-6 mos of age
- May tire with feeds
- Sometimes not diagnosed until adulthood

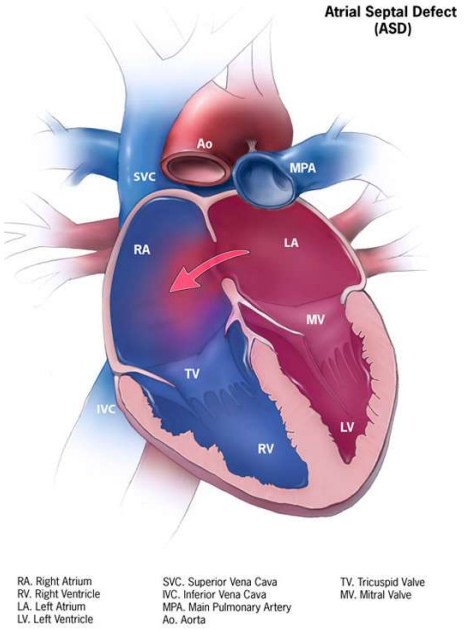


Photo credit: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities;
References: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities
Puri et al Pediatrics in Review Oct 2017

ACYANOTIC HEART DISEASE: VENTRICULAR SEPTAL DEFECT

What is it?

- Holes between the chambers of the R and L sides of the heart
- Valves may not be formed correctly
- Also known as AV Canal defect

Prevalence

- 1 in every 240 births (CDC)
- 50-60% of CHD (Puri et al)

Clinical Presentation

- Size of VSD impacts symptoms
- MD may notice murmur
- Surgical repair
- Infants may tire with feeding, at risk of faltering growth
- Monitor intake, weight gain

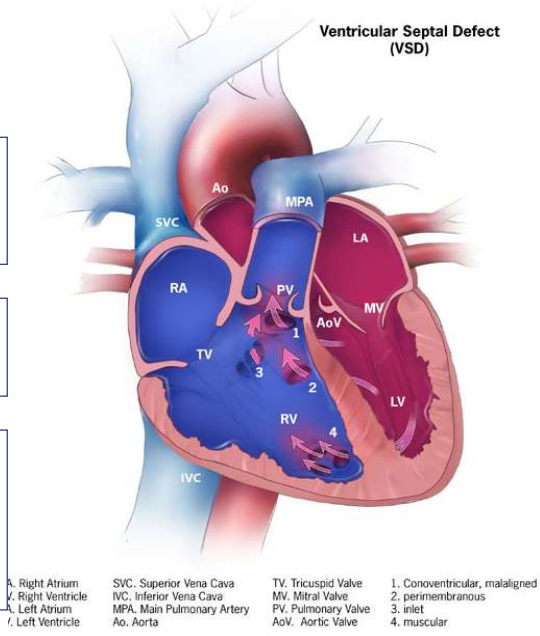


Photo credit: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities;
References: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities
Puri et al Pediatrics in Review Oct 2017

ACYANOTIC HEART DISEASE: ATRIOVENTRICULAR SEPTAL DEFECT

What is it?

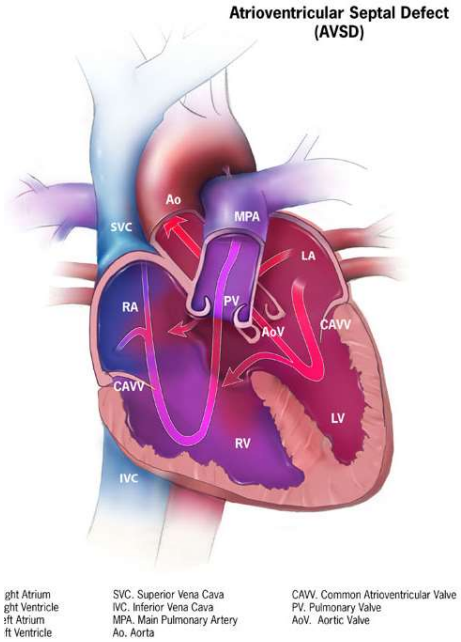
- Holes between the chambers of the R and L sides of the heart
- Valves may not be formed correctly
- Also known as AV Canal defect

Prevalence

- CDC estimates 1 in 1,859 births
- Makes up ~5% of CHD (Puri)
- ~50% of patients with AVSDs have Down's syndrome

Clinical Presentation

- MD may hear murmur, diastolic rumble
- Breathing problems
- Poor feeding, slow weight gain
- Tire easily



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References: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities
Puri et al Pediatrics in Review Oct 2017

ACYANOTIC HEART DISEASE: COARCTATION OF THE AORTA

What is it?

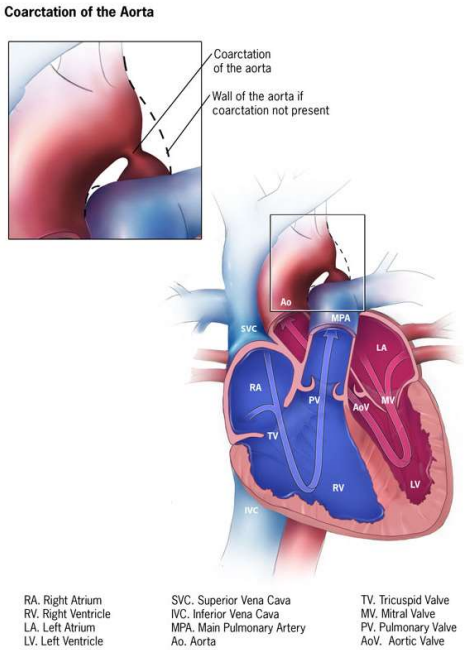
- A narrowing of the aorta
- Critical congenital heart defect

Prevalence

- 1 in 1,800 births
- ~5-8% of all CHDs

Clinical Presentation

- Newborn screening via lower O2 saturations, poor pedal or femoral pulses at first pediatrician visit
- May present at 2-3 weeks with shock, lethargy, feeble pulses, metabolic acidosis, poor feeding
- "PDA dependent"- prostaglandin infusions to maintain the PDA until surgery



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References: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities
Puri et al Pediatrics in Review Oct 2017

CYANOTIC HEART DISEASE: TETRALOGY OF FALLOT

What is it?

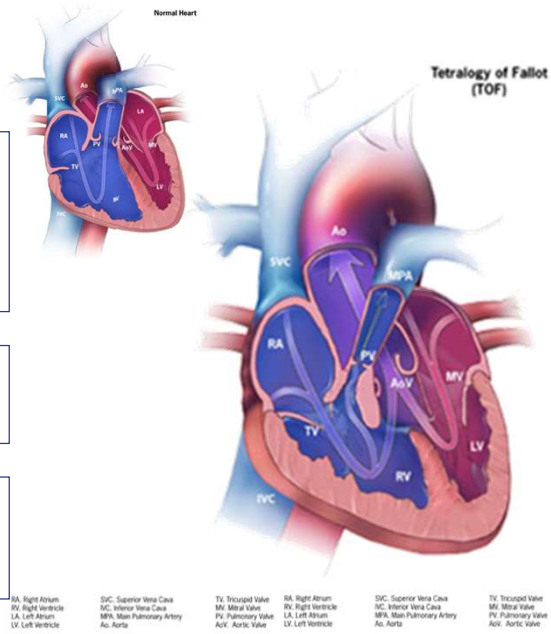
- Critical congenital heart defect
- Comprised of 4 defects:
- VSD
- A narrowing of the pulmonary valve and main pulmonary artery, enlarged aortic valve, ventricular hypertrophy

Prevalence

- About 1 in 2518 births
- Most common cyanotic CHD, about 5% of all CHD

Clinical Presentation

- MD might diagnose prenatally, or as children
- Higher risk of endocarditis, arrhythmia, delayed growth and development



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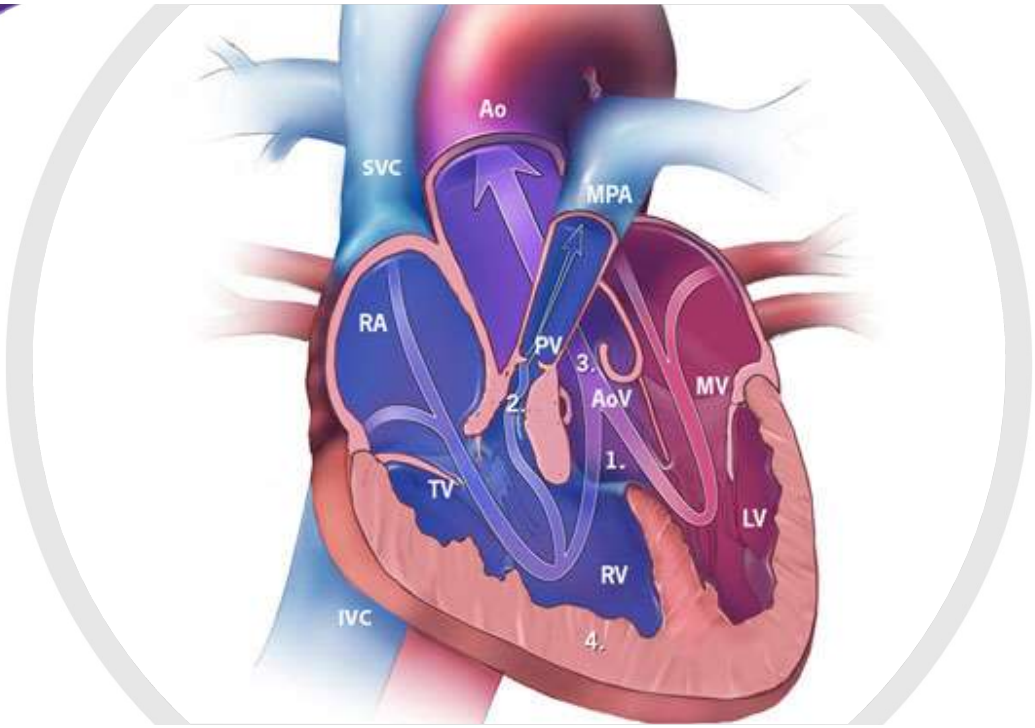


CYANOTIC HEART DISEASE:
TRANSPOSITION OF THE GREAT ARTERIES

What is it?

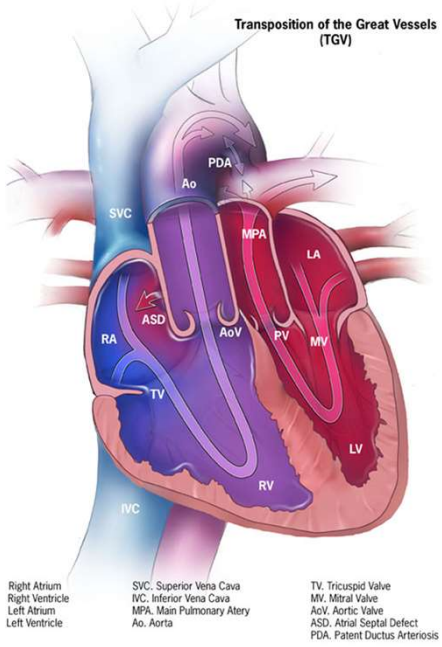
- Critical Congenital heart disease
- Two main arteries are switched (transposed) in position; may also have additional CHD, like a VSD or ASD

Prevalence

- 1 in 3413 births
- Second most common cyanotic CHD ~2% of all CHD

Clinical Presentation

- Cyanotic within first 12 hours of life, not responsive to mechanical ventilation or oxygen
- Prostaglandin to maintain PDA
- Surgical repair- arterial switch



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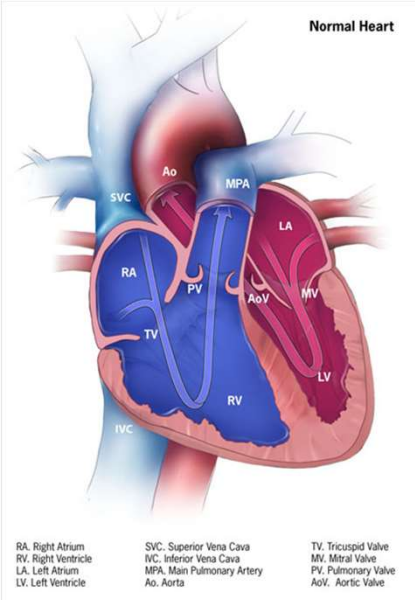
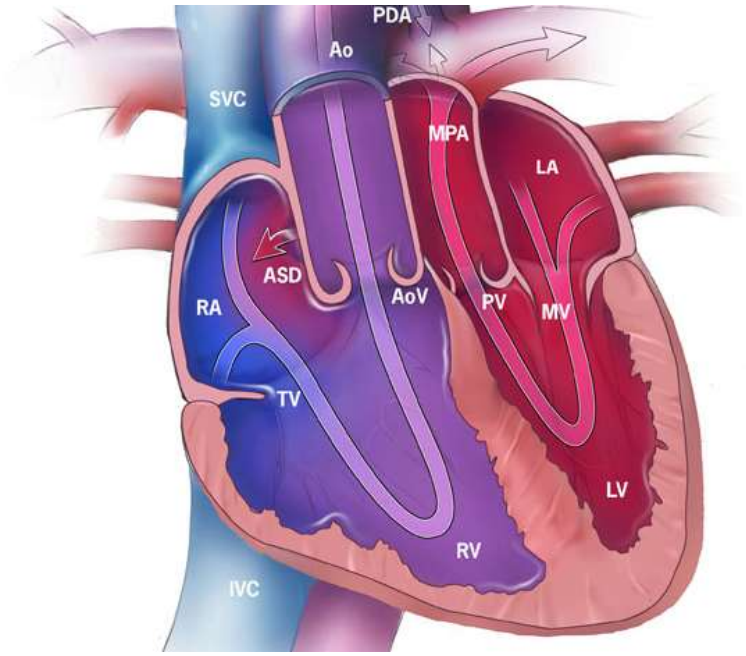




CYANOTIC HEART DISEASE: HYPOPLASTIC LEFT HEART SYNDROME

What is it?

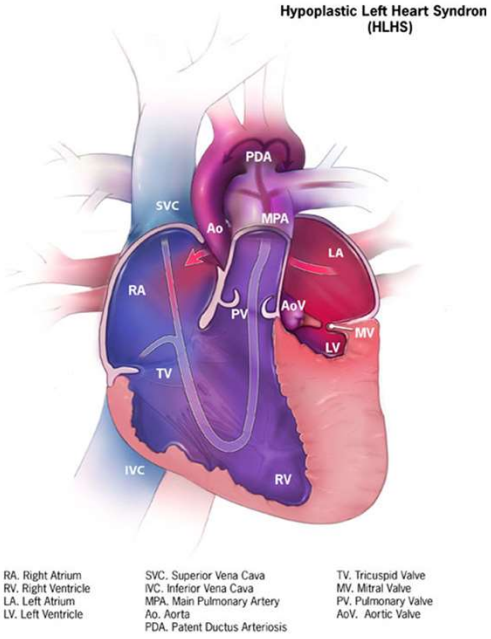
- Critical congenital heart disease
- Affects normal blood flow through the heart
- Deoxygenated blood flows from RV
- Any number of structures on the L side of the heart that do not fully form (e.g., left ventricle, mitral valves, aortic valves aren't formed properly)

Prevalence

- 1 in 3,841 babies

Clinical Presentation

PDA dependent
MD can hear murmur
Shock, tachypnea, respiratory distress
Multiple surgeries
Tire with feeds



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References: Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities
Puri et al Pediatrics in Review Oct 2017

POLL QUESTION

RESPOND IN THE RIGHT-HAND PANEL IN THE LIVE EVENT

How often have you worked with infants with CHD?

A. Never
B. Rarely / a few times a year
C. Periodically / a few days a month
D. Frequently / a few days a week
E. Daily

CASE STUDY: BABY BOY FELIX

First 24 hours of life

- Born at 39+2
- Weight: 3.4 kg
- Birth WAZ: -0.2
- Apgar scores: 9, 10, 10
- Echo within 24 hours:
  - Single Ventricle
  - Pulmonary valve atresia

CASE STUDY: BABY BOY FELIX

First week of life:

- Cardiac catheterization
- Breastfeeding → tachypneic → NGT
- PICU transfer for cardiology management
- Palliative Norwood-Sano shunt at DOL 7

CASE STUDY: BABY BOY FELIX

First 7-14 Days of Life	DOL 14:
• NGT continued • Breastmilk supplemented with energy and nutrient dense formula (ENDF) (50/50)	• 3.63 kg (0.2 WAZ) • 54 cm (1.3 LAZ) • BMI -1.1 z-score

NUTRITION CONSIDERATIONS FOR THE INFANT WITH CHD

WHY IS NUTRITION SO IMPORTANT IN INFANTS AND CHILDREN?

WHY IS NUTRITION SO IMPORTANT IN INFANTS AND CHILDREN?

The first 1000 days [1]

- Critical period of brain growth and development
- Inadequate nutrition

Inadequate Nutrition Support [1]

- Cognitive developmental delays
- Decreased growth potential
- Decreased immune function

Lower HAZ and WAZ in neonates with CHD are associated with[2]**:**

- Increased mortality
- Infection
- Longer hospitalizations
- Adverse surgical outcomes

1 Georgieff MK et al, Acta Paediatr. 2018:107:1310-21
2 Ross et al., Am Heart J 2020;224:85-97

GROWTH FAILURE AND CHD

- Nutrition is important
- Growth failure
- Kcal and protein administration
- NEC

Energy Demand and Expenditure
Vs.
Energy Supply and Intake

GROWTH FAILURE AND DECREASED IN INTAKE

- Nutrition is important
- Growth failure
- Kcal and protein administration
- NEC

Contributing factors to decreased intake

- Gastroesophageal Reflux (GER)
- Tachypnea, poor suck and co-ordination
- Malabsorption
- Intestinal edema, poor perfusion and splanchnic ischemia
- ET tube trauma/Vocal cord injury
- Fluid restriction (medically imposed)

GROWTH FAILURE INCREASED ENERGY EXPENDITURE

- Nutrition is important
- **Growth failure**
- Kcal and protein administration
- NEC

Contributing factors to increased energy expenditure

- Cardiopulmonary bypass (CPB) activates an inflammatory cascade, which in turn increases energy expenditure
- Studies have shown hyper-metabolic state in the first 48 to 72 hours after cardiac surgery
- Controversy still exists about the role of increased energy expenditure in poor weight gain.

Li J et al. Pediatr Crit Care Med 2008:9;55-61
Floh et al., Pediatr Crit Care Med 2015:16(4):343-51

CALORIE AND PROTEIN NEEDS: NEONATES WITH CHD

- Nutrition is important
- Growth failure
- **Kcal and protein administration**
- NEC

ASPEN Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Pediatric Critically Ill Patient

Recommended energy requirement for critically ill children:

"…We suggest that measured energy expenditure by IC be used to determine energy requirements and guide prescription of the daily energy goal."

Minimum recommended protein requirement for critically ill children:

"…we recommend a minimum protein intake of 1.5 g/kg/d. Protein intake higher than this threshold has been shown to prevent cumulative negative protein balance in RCTs."

IC = indirect calorimetry; RCT = randomized controlled trials
Mehta et al., 2017 Pediatr Crit Care 18(7)675-715

POLL QUESTION
RESPOND IN THE RIGHT-HAND PANEL IN THE LIVE EVENT

How do you typically meet energy needs for infants with CHD?

(*Choose all that apply*)

A. Maximize breast milk intake
B. Concentrate powdered formula
C. Use a "base" then supplement &/or fortify
D. Use a higher-calorie formula (e.g. 22, 24 kcal/oz)
E. I don't currently care for or have experience caring for these infants

POLL QUESTION
RESPOND IN THE RIGHT-HAND PANEL IN THE LIVE EVENT

What is your main priority when caring for infants with CHD?

A. GI tolerance of feedings
B. Minimize osmotic load
C. Protein intake
D. Energy intake
E. Fluid intake
F. I don't currently care for or have experience caring for these infants

WHY IS NECROTIZING ENTEROCOLITIS (NEC) A FEEDING CONCERN?

Nutrition is important

Growth failure

Kcal and protein administration

NEC

Fear

- Fear of doing harm
- Fear of feeding
- Fear of advancing feedings

CHD Risk Factor for NEC

- 10-100 times more common among infants with CHD
- Different pathophysiology among CHD vs preterm neonates
- Reduced intestinal perfusion and oxygen delivery
- Higher risk in ductal-dependent anomalies

McElhinney et al., Pediatrics 2000 Nov;106(5):1080-7
Scahill et.al., World J Pediatr Congenit Heart Surg. 2017 Jan;8(1):62-68
Giannone et al., Life Sciences 2008; 82(7-8):341-7

EVIDENCE OF DECREASED NEC AND FEEDING

Nutrition is important

Growth failure

Kcal and protein administration

NEC

Skahill, et al., 2017 *World J Pediatr Congenit Heart* Surg 8(1):62-68	Nordenstrom, et al., 2020 *Arch Dis Child Fetal* Neonatal Ed 105(6):609-614	Kataria-Hale et al., 2019 *Hosp Pediatr* 9(12):998-1006
n=130 (61% with single ventricle physiology; 72% were PDA-dependent) Infants ≤31 days of life requiring neonatal cardiac surgery	Infants with critical congenital heart disease over (n=458; 97% (444/458) fed at least 45 ml/kg/d before cardiac surgery)	Systematic review and meta-analysis evaluating pre-op feedings and ductal dependent heart disease; five retrospective cohort studies were included (high risk of bias)
No associations with preoperative feeding and NEC prevalence (n=130) Prematurity was only variable associated with NEC (P=0.03)	Only 4 cases of NEC out of 458 infants with CCHD (0.9%)	No significant difference in NEC when comparing infants who were fed vs not fed; Authors concluded "insufficient evidence to suggest pre-op feeding adversely influence rate of NEC, LOS or feeding intolerance"

CASE STUDY: BABY BOY FELIX

At a few months of life….

- Increased work of breathing with feeding
- Early satiety
- Increased emesis, disinterest in breastfeeding
- Mom decided to stop BF, full feeds of 50% standard formula and 50% ENDF

CASE STUDY: BABY BOY FELIX

At 8 weeks of life

- Cardiac arrest s/p cardiac catheterization
- PICU→ ventilator x 7 days
- Growth faltered
  - 5kg (-0.63 WAZ)
  - 55.4 cm (-1.25 LAZ)
- Feeds changed to full ENDF

CASE STUDY: BABY BOY FELIX

At 16 weeks of life
• D/c to home, on home monitoring program • Feeding aversion, food refusal • Trial of standard formula to assess if infant could increase volume   • After 5 days, no change in volume intake • Switched back to ENDF with goal of 100 ml/kg as minimum • 17 weeks- complementary oral foods began

NUTRITION CHALLENGES FOR THE INFANT WITH CHD

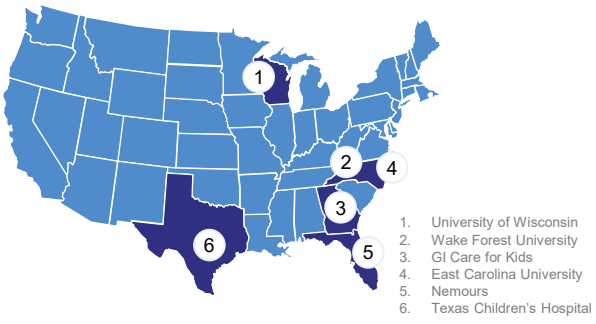
HOW CAN WE OVERCOME THEM?

CURRENT EVIDENCE ON GROWTH FAILURE

Grow-In Study: Long-term US Clinical trial in infants with growth failure

Design

- Prospective, open-label, multi-center study
- Up to 16-week intervention
- Assessments at 0, 2, 4, 8, 12, and 16 weeks



1. University of Wisconsin
2. Wake Forest University
3. GI Care for Kids
4. East Carolina University
5. Nemours
6. Texas Children's Hospital

Study Population

- Infants 1- 8 months old with growth failure due to cardiac and non-cardiac diagnoses

Outcomes

1 – Growth **2 –Tolerance** **3 – Safety**

1. Nutricia North America. https://clinicaltrials.gov/ct2/show/NCT03563391.

Grow-In Study: Formula Composition

Study Formula Composition	
Concentration	**30 kcal/fl oz**
Protein/100 kcal	**2.6 g**
% En as Protein	**10.3%**
Osmolality mOsm/kg	**360**
Nutritionally complete for term infants with FTT	✓

WHO expert guidance:

~9-12% to promote accelerated **weight gain of 5-10 g/kg/d**[1]

En = Energy. **1.** World Health Organization; Food and Agriculture Organization of the United Nations. Protein and amino acid requirements in human nutrition. 2007. 2. Third party laboratory testing of standard infant formulas commercially available in United States. Eurofins, Madison, Wisconsin.

Grow-In Study: Population

- 30 infants enrolled (*Jan 2018 – Jan 2020*)
- Cause of growth failure for all subjects enrolled:

Results: Population Characteristics

Anthropometric Baseline characteristics of infants participating in the Grow-In study

Variable	Result
Gender: n (%) male female	 16 (61.5%) 10 (38.5%)
Gestational age*	37.4 ± 3.2
Age at Visit 1**	22.2 ± 10.5
WAZ at birth (mean)	-0.19
WAZ at baseline (mean)	-2.92

N=26 Per Protocol subjects. WAZ = weight-for-age z-score *Median weeks **Mean Weeks.

RESULTS: ENERGY INTAKE

WHO Recommendations	Total Energy Intake	ENDF Intake
105-126 kcal/kg/d	123±32 kcal/kg/d	116±32 kcal/kg/d

Results: Anthropometrics

Weight-for-age:	Length-for-age:	Weight-for-length:	Head circumference:
+0.86 ±0.74 **mean WAZ from baseline** (*p*=0.0001)	**+0.25** ±0.61 **mean HAZ from baseline** (*p*=0.003)	**+0.77** ±0.81 **mean WHZ from baseline** (*p*=0.0001)	**+0.54** ±0.68 **mean HCZ from baseline** (*p*=0.0001)

Most infants achieved appropriate rate of catch-up growth

Percentage of infants who achieved weight gain velocity >WHO median:

83%
At ≥1 time point

67%
For overall study period

13%
Met criteria for "early success"*

No difference in time to meeting weight gain velocity target by presence of CHD

*Early success = WHZ ≥0 or weight velocity > +2 z-score for age at two consecutive visits: transitioned to lower energy-density formula. Two infants in the PP group withdrew early and are not included.

Grow-In Study: Energy intake reached target range

Total energy intake:
123±32 kcal/kg/d

ENDF intake:
116±32 kcal/kg/d

94.3%
average energy intake from ENDF

WHO expert guidance → **105-126 kcal/kg/d** to promote accelerated **weight gain of 5-10 g/kg/d**[1]

- CHD = congenital heart disease; HCZ = head circumference z-score. WHO = World Health Organization. 1. World Health Organization; Food and Agriculture Organization of the United Nations. Protein and amino acid requirements in human nutrition. 2007.

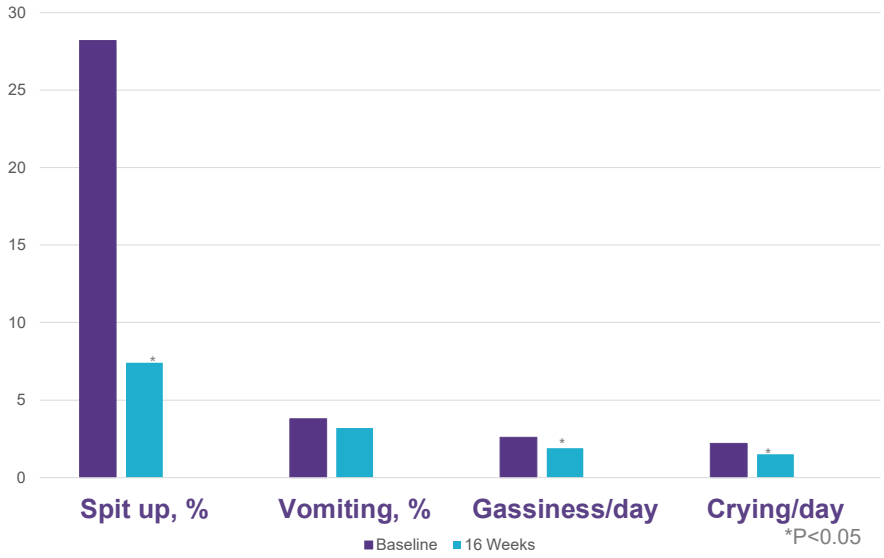
Results: Tolerance

SPIT UP:
28.2% ↓ 7.4%
mean % of feedings

VOMITING:
3.8% ↓ 3.2%
mean % of feedings

GASSINESS:
2.6 ↓ 1.9 times/day

CRYING:
2.2 ↓ 1.5 hours/day



Conclusions

Energy- and nutrient-dense formula:

- Positively impacts growth
  - most infants achieved appropriate rates of growth
- Well-tolerated
- Safe

1. Goday P, et al. ASPEN Conference. 20-23 March; Virtual. JPEN J Parenteral Enter Nutr. 2021;45:S224-5(P143). **2.** Goday P, et al. Presented at Annual Update on Pediatric and Congenital Cardiovascular Disease. 11-14 February; Virtual. Children's Hospital of Philadelphia. 2021. **3.** Manuscript under review by JPEN J Parent Enter Nutr.

CURRENT EVIDENCE ON PROTEIN AND NITROGEN BALANCE

Cui et al., 2018

Design

- Randomized, double-blind controlled trial
- 5-day intervention
- Fed continuously via NG tube
  - Start 12-24 hours post-op at 1 mL/kg/h (24 mL/kg/h), advance 1 mL/kg/h Q6H as tolerated
- Study formulas

Intervention (n = 26)	Control (n = 24)
ENDF • 1 kcal/mL • 2.6 g protein/ 100 kcal (10.4% PE)	SIF • 0.67 kcal/mL • 2.0 g protein/100 kcal (8% PE)

Study Population

- Term infants, 4 weeks -12 months old, post-op for CHD repair (biventricular repairs only)

Outcomes

1 – Nutrition status
- Macronutrient intake
- Daily 24-hr urinary urea nitrogen
- Biochemical

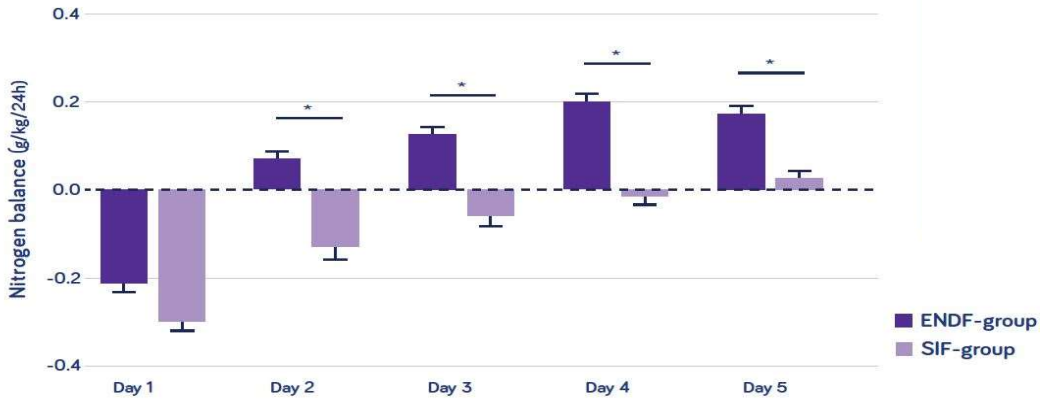
2 – Tolerance
- Emesis + stools
- GRV Q4H
- GI bleeding
- Gastric motor drugs

3 – Outcomes
- Infections
- Length of stay

NG = naso-gastric; SIF = standard infant formula; ENDF = energy- and nutrient-dense formula; CHD = congenital heart defect. 1. Cui Y et al. JPEN J Parenteral and Enteral Nutrition. 2018.

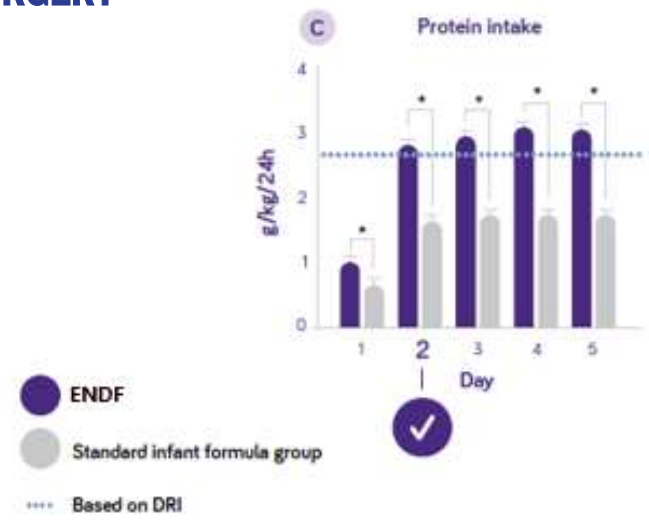
ENDF ENABLED INFANTS WITH A CONGENITAL HEART DEFECT TO ACHIEVE POSITIVE NITROGEN BALANCE JUST 2 DAYS AFTER CARDIAC SURGERY

NITROGEN BALANCE ON DAYS 1–5 BETWEEN ENDF GROUP (N = 26) AND SIF GROUP (N = 24).



Cui Y et al. JPEN J Parenteral and Enteral Nutrition. 2018.

ENDF ENABLED INFANTS WITH A CONGENITAL HEART DEFECT TO ACHIEVE POSITIVE NITROGEN BALANCE JUST 2 DAYS AFTER CARDIAC SURGERY



Cui Y et al. JPEN J Parenteral and Enteral Nutrition. 2018.

WHAT IS AN ENDF?

- 30 kcal/ounce term infant formula
- ↑ protein/nutrient content
  - **(10.3% of energy from protein)**
- osmolality: 360 mOsm/kg
- ready to feed & sterile
- nutritionally complete
- used in Europe for 20+ years
- supported by clinical evidence

ENDF = energy- and nutrient-dense formula

CASE STUDY: BABY BOY FELIX

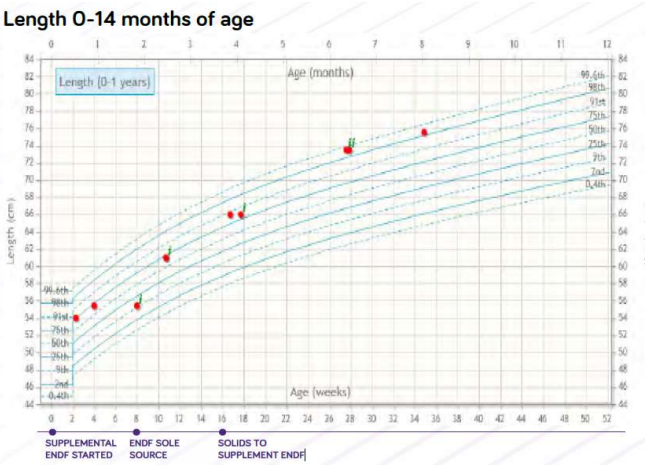
At ~6 months of age
• Began enjoying solid foods • Weekly nutrition reviews with RD • Bi-directional Glenn surgery at 24 weeks of life • Trophic ENDF feeds began 12 hrs post op • Advanced per their high risk abdomen protocol

CASE STUDY: BABY BOY FELIX

At 12-14 months of age	Anthropometrics at 14 mos
• Growth continues within target ranges • Consumes ENDF with family meals	• 11.4 kg (1.53 WAZ) • 82.2 cm (2.71 HAZ) • BMI Z-score now 0.08

CASE STUDY: BABY BOY FELIX

Length 0-14 months of age



IN SUMMARY

- Caring for infants with CHD is hard!!
- CHD severity varies based on defect
- Providing adequate nutrition is challenging
  - Infants tire easily
  - Feeding interrupting
  - Potential malabsorption

Meeting weight gain goals is challenging

- ENDF provides 10.3% energy from protein
- Using an ENDF helps achieve weight gain goals
- Using an ENDF helps achieve positive nitrogen balance post cardiac surgery repair in infants
- An ENDF is well tolerated among critically ill infants

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